British Columbia

<u>Ministry of Forests, Lands, & Natural Resource Operations</u>

Cariboo Region

Forest Health Strategy

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Acknowledgements: This document was modelled 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 Forest Health Strategy outlines the current forest health policy, conditions, best management practices, and forest health hazards and risks in the Cariboo Region. It also summarizes non recoverable losses currently accounted for in the timber supply reviews for the three timber supply areas in the Cariboo Region. The report also outlines the risks associated with forest health factors that may be associated with climate change and provides a justification for current forest health spending in the region. Currently the highest ranked forest health agents for the Cariboo Region are: Western Spruce Budworm, Douglas-fir beetle, and Spruce beetle. The Cariboo Region faces future uncertainty in terms of mid-term-timber supply and the impacts of climate change. Now more than ever investments are required for cost effective forest health treatments and monitoring in order to minimize pest losses and reduce the likelihood of another forest health epidemic, such as the recent mountain pine beetle epidemic.

A. Purpose

The Cariboo Forest Health Strategy is a guiding document for Forest Health Management within the Cariboo Forest Region. The Cariboo Forest Region comprises three Forest Districts/Timber Supply Areas: Quesnel, Cariboo/Chilcotin (Williams Lake TSA), and 100 Mile. The purposes of this document are to:

1) Provide guidance to Forest Managers on the best forest health management strategies in the Cariboo Region
2) Outline the legal and government policy framework for forest health management in the Cariboo Region
3) Provide a rationale for practising proactive forest health management in the Cariboo Region
4) Outline the current knowledge with regards to the impact of forest health factors on timber supply
5) Identify knowledge gaps when it comes to forest health management in the Cariboo Region

B. Planning Framework

1) Legal Framework

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

The Ministry of Forests Act outlines that, the purposes and functions of the Ministry of Forests include, encouraging maximum productivity of forest and range resources and to manage, protect, and conserve forest and range resources in B.C. In the Forest and Range Practices Act (FRPA) there are few direct forest health provisions. Under existing provisions, many deal with allowing for exemptions as a result of forest health occurrences but there are few specific requirements for license holders to deal directly with forest health issues unless specifically directed by the Minister. Section 26 of the Forest and Range Practices Act 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 are causing damage to a forest. If no proposal is made or if the proposal is not carried out to the satisfaction of the Minister, they may order measures to be carried out to control or dispose of the forest health factor.

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 Licence holders that harvest timber to address forest health concerns except through the requirement to establish a free growing stand. Under Section 26 of the Forest Planning and Practices Regulation, stocking standards proposed under an FSP must meet several key tests that adequately address immediate and long term forest health risks. In 2012, the director of resource practices branch/deputy chief forester put out a memo entitled Guidance for assessing FSP stocking standards alignment with addressing immediate and long term forest health issues.
http://www.for.gov.bc.ca/hfp/silviculture/Guidance%20for%20assessing%20FSP%20stocking%20standards%20June%2021%202012.pdf.
Section 169 of the regulation gives the chief forester powers to establish or revoke standards respecting stocking standards required for a free growing stand. 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. 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. This is one of the few instances, where the legislation provides clear and specific measures to deal with a specific forest health issue.

2) Government Policy

The Ministry of Forest, Lands and Natural Resource Operations (FLNRO) Service Plan outlines the key challenges and opportunities faced by the Ministry and sets the objectives and priorities for the Ministry. There is nothing in the plan that deals directly with forest health, with the exception of Objective 2.2 that 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 and 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 Strategy http://www.for.gov.bc.ca/hfp/health/Strategy/FH%20Strategy.pdf 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 BC forests & prioritize management treatments.

4) Regional and District Forest Health Roles & Responsibilities

The Forest Health Implementation Strategy:
http://www.for.gov.bc.ca/hfp/health/Strategy/FH%20Impl.%20Strategy.pdf lays out 11 functions of the forest health program, which are grouped into three areas of emphasis: Legislation & Policy Support; Program Delivery, and Adaptive Management (Table 1). Functions 5 (pest detection) and function 6 (treatment of pest outbreaks) account for 22% and 66% of the operating budget, respectively. Regional and district roles and responsibilities are outlined in Table 2. Under this framework 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 & treatments, and providing support for regional forest health activities. Regional staff consisting of a full time entomologist and a pathologist (that is shared with the Kamloops Region) are responsible for the regional defoliator program and aerial overview surveys, overseeing gypsy moth monitoring, providing technical advice, developing best management practices, providing training and extension, providing forest health information for timber supply review, developing hazard and risk ratings, and conducting monitoring and operational research trials. Outside of government, licensees play a critical role in conducting and carrying out forest health activities.

Table 1: The 11 key functions of the MFLNRO Forest Health program (source Forest Health Implementation Strategy)

Legislation & 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 & 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 & Evaluate Treatment Regimes

Adaptive Management

10. Extension
11. Operational Research

Table 2: Simplified Regional & District Responsibilities (see Forest Health Implementation Strategy for more detailed list)

Function	Region	District
1.FH Strategy	-Provide regional FH strategy if needed -Provide guidance and review for District FH strategies -identify regions specific research topics -participate in climate change committees -develop & implement regional standards & procedures	- Lead in preparation of TSA or District FH Strategy -Identify priority research topics in District FH Strategy -Incorporate climate change advice into District Strategy -review FSPs -provide feedback for FREP
2. Interagency	-Participate in committees and task forces	-liaison with other agencies
3.Decision Maker Support	-Help interpret policy and technical matters pertaining to forest health -improve forest health management -host forest health training and workshops	-support DM, supervisor, & others -promote forest health training and workshops
4.Program Planning & Implementation	-plan and administer regional budgets and projects -plan and allocate district bark beetle funding -carry out defoliator management program	-set priorities for beetle management units (BMUs) and surveys -submit district funding proposals -manage forest health contracts -integrate forest health with other programs such as small scale salvage
5. Pest Damage detection, assessment, & prediction	-contract out and oversee aerial overview survey for region -support TSR -forecast epidemic pest outbreaks -update hazard & risk rating -develop standards for and conduct monitoring surveys	-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 SDM
6. Treat Pest Outbreaks	-treat native defoliators -assist in BMU strategy setting -assign mitigating strategies where appropriate through District FH Strategy	-define treatment regimes in conjunction with the region (e.g. bark beetles) -develop and implement contracts to deal with infestations
7. Manage Endemic Pests	- provide technical input for best management practices & mitigating strategies & tactics	- provide local advice to implement & develop best management practices (e.g. trap trees)
9. Monitor	-coordinate regional monitoring	-assist region in monitoring

Treatments	program and provide training and support for SDM	-conduct FREP SDM surveys
10. Extension	-communicate innovative practices -update guidebooks -conduct training	-facilitate courses set up by regional specialists
11.Pest Behaviour Monitoring	Design and conduct operational applied research -develop & refine hazard & risk models	-establish district operational trials -identify district research needs -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 practices in relationship to other forest management programs. Presently, only the Cariboo Chilcotin District has a full time forest health specialist to carry out district forest health functions. In the other districts, the stewardship forester and/or stewardship officer are responsible for forest health functions. Typically people in these positions do not have the time or resources to adequately deal with forest health issues or administer forest health budgets or contracts. Regional staff may be able to provide assistance to districts in carrying out district forest health responsibilities in the future, although this will require transfers of funding and additional staff in order to properly carry out these new roles and responsibilities.

C. The Need for Forest Health Strategies

An increase in the frequency and severity of pest outbreaks in recent years and decreased funding for natural resource management as a whole has highlighted the need for a risk management approach to forest health. British Columbia has adopted the National Forest Pest Strategy, which bases national priorities for pests on a formal pest risk assessment framework which is outlined in the Forest Health Implementation Strategy. Part of the Risk Assessment involves an economic impact assessment or return on investment study for carrying out forest health treatments. Forest Health has lagged behind other fields, such as silviculture, in assessing the costs and benefits of treatments. The Forest Health Implementation Strategy outlines the progress that has been made for some of the major pests in BC. Economic analyses have been done for many of the important defoliators and mountain pine beetle but are lacking for spruce and Douglas-fir bark beetles and for most forest diseases.

One of the key components of risk management is risk communication. Forest Health Strategies are key documents in communicating the risk posed by local forest health factors.

D. Components of a Forest Health Strategy

The Forest Health implementation Strategy lays out the four components of a TSA strategy:

1. A list of priority forest health agents;

2. An assessment of the risk posed by various forest health agents and the specific management objectives for each agent;
3. A description of the extent and significance of the major forest health agents and their impact on timber supply;
4. Strategies for dealing with specific forest health factors.

While these components are meant for TSA Forest Health Strategies they are applicable to other forest documents such as Regional forest health strategies.

E. Priority Forest Health Factors in the Cariboo Forest Region

Table 3 provides rankings of the current relative importance of various forest health factors throughout the Cariboo Region, although the rankings may not reflect the priorities within a specific TSA as determined by local districts. 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. There have been major outbreaks of western spruce budworm in the Williams Lake and 100 Mille TSAs in recent years, but none in the Quesnel TSA. In table 3, the *probability* represents the likelihood of damage occurring while *severity* indicates what the relative severity of the impact is likely to be. The overall ranking or risk is a combination of the two. For an overview of current pest conditions as determined from aerial overview flights refer to the 2012 Overview of Forest Health for Southern British Columbia (this report only details with those pests that can be easily detected from the air): http://www.for.gov.bc.ca/hfp/health/overview/overview.htm.

Table 3. Important forest health factors in the Cariboo, the risk they pose, and the management objective currently been used to address them.

Forest Health Factor	Probability	Severity	Ranking	Management Objective	Comments
Insects					
Western Spruce Budworm	High	Mod	High	Spray areas with moderate to high risk of defoliation with Btk.	No recent outbreaks in Quesnel or west of Puntzi Lake in the Chilcotin.
Spruce Beetle	Mod	High	Mod-High	Sanitation and salvage harvest in unconstrained areas to recover losses and reduce populations. Monitor in constrained/inaccessible areas.	Very active in 100 Mile and parts of the Cariboo.
Douglas-fir Beetle	Mod	Mod-High	Mod-High	**Reduce existing populations through**	Active in 100 Mile and in and around

Forest Health Factor	Probability	Severity	Ranking	Management Objective	Comments
				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.	fires in the Cariboo Chilcotin. Some localized populations around Blackwater River in Quesnel.
Mountain Pine Beetle	Low	Low	Low	Salvage in accordance with Chief Foresters guidelines.	Mountain pine beetle is still active in the southern Chilcotin.
Balsam Bark Beetle	Mod	Low	Low	Monitor.	Mostly at higher elevations.
2-year cycle budworm	Mod	Low	Low-Mod	Monitor, develop treatments.	Higher risk in even years.
Hemlock Looper	Low	Mod	Low - Mod	Monitor. Treat outbreaks with Btk when warranted.	Historically outbreaks have been confined to relatively small areas.
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 impacting aspen.
Black Army Cutworm	Low	Low	Low	Prevent, monitor.	2012 outbreaks around Pelican Fire.
Gypsy Moth	Low	High	High	Detect new occurrences.	No recorded occurrences.
Lodgepole pine terminal weevil	Mod	Low	Low	Monitor.	Widespread but impacts generally low.
Spruce Weevil	Mod	Low	Low-Mod	Mitigate impacts, monitor.	Can cause moderate impacts in high hazard areas.
Warren’s Root Collar Weevil	Low	Low	Low	Mitigate impacts, monitor.	Higher hazard in Quesnel TSA.

Forest Health Factor	Probability	Severity	Ranking	Management Objective	Comments
Diseases					
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.	Spruce, impact under estimated.
Lodgepole pine dwarf mistletoe	Mod	Low-Mod	Low-Mod	Mistletoe eradication.	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	Low	Low	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	Low-mod	Monitor.	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 porcupine damage on lodgepole pine in ICH.
Abiotic Damage					
Fire	Mod	Mod-High	High	Depends on risk.	
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

Forest Health Factor	Probability	Severity	Ranking	Management Objective	Comments
					soil and climate.
Snow press	Mod	Low	Low-mod	Monitor.	Lodgepole pine and Douglas-fir in parts of the SBS & ICH.
Winter desiccation	Low	Low	Low	Monitor.	

F. Hazard Rating

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 the proximity of the forest health factor and its incidence. As an 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.

More work is needed to identify the hazard from various forest health agents as it relates to biogeoclimatic (BEC) subzone and site series in the Cariboo Forest Region. Long term monitoring data from the Forest and Range Evaluation Program's stand development monitoring program, as well as maps showing the reported incidence of pests in the RESULTS database should be helpful in developing better hazard ratings in the Cariboo Region. Experiments which measure pest incidence over a range of biogeoclimatic subzones can also be used to determine hazard rating by BEC. Hazard ratings for a variety of pests in each BEC was compiled from a number of sources, including forest practices code guidebooks and Forrex stand establishment decision aids (SEDAs) (Table 4). Some of this information is based on anecdotal information rather than actual data. Never the less, this information is a good starting point for assessing pest hazard based on BEC. Hazard ratings of the forest health factors are also compiled by BEC zones (Table 5). The absence of information for a specific pest or BEC zone does not necessarily mean that the hazard is low, only that there is no good information currently available. Certain BEC zones/subzones have a high hazard for a number of different forest health factors. This is particularly true for some Sub boreal spruce (SBS) and Interior cedar hemlock (ICH) BECs, which is supported by the findings of Heineman et al. 2010 and Westfall & Brooks 2001. Higher stocking standards may be warranted in these BECs to compensate for high pest losses.

Table 4: 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		Through-out host range	H	Bark Beetle FPC

Damaging Agent	BEC zone	BEC subzone	Hazard	Source
(IBS)				Guidebook
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
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 dk4 mw2 ww xh2 xm xw	H M M H H H MH	Forrex 3 Forrex 4 Forrex 3 Forrex 3&4 Forrex 3 Forrex 3 Forrex 3
2- year budworm	ESSF	wc3	MH	Personal Observ.
Spruce Weevil (IWS)	ICH	dk mk3 mw3 wk2 wk4	MH H H H H	Forrex 2 Forrex 2 Forrex 3 Forrex 2 Forrex 2
	SBS	dw1 dw2 mc1 mc2 mh mw wk1	H M MH MH M H H	Forrex 2 Forrex 2 Forrex 2 Forrex 2 Forrex 2 Forrex 2 Forrex 8
Lodgepole Pine terminal weevil (IWP)	ESSF	xc3 xv1	M M	Forrex 1 Forrex 1
	IDF	dk3 dk4	H H	Forrex 1 Forrex 1
	MS	xk	M	Forrex 1
	SBPS	xc	M	Forrex 1
	SBS	dw1 dw2	M M	Forrex 1 Forrex 1

Damaging Agent	BEC zone	BEC subzone	Hazard	Source
Warren's Root Collar Weevil (IWW)	ICH	dk mk3 mw3 wk2 wk4	M MH M H H	Forrex 7 Forrex 2 Forrex 7 Forrex 7 Forrex 7
	SBS	dk dw1 dw2 mc mh mw wk1	MH M M H M H H	Forrex 2 Forrex 2 Forrex 2 Forrex 7 Forrex 7 Forrex 2 Forrex 7
Armillaria Root Rot (DRA)	ICH	mk3 wk2	H H	Root Disease FPC Guidebook
	IDF	dk3 mw2	H H	Root Disease FPC Guidebook
	SBPS	mk	H	Root Disease FPC Guidebook
	SBS	dw1	H	Root Disease FPC Guidebook
Laminated Root Rot (DRL)	CWH	ds1 ms1	M M	Forrex 5 Forrex 5
	ICH	mk3 mw wk2 wk4	H H H MH	Forrex 2 Forrex 6 Forrex 2 Forrex 2
	IDF	dk3 dk4 dw mw ww	M M M H M	Forrex 2 Forrex 2 Rusch obs. Forrex 6 Forrex 5&6
Tomentosus Root Rot (DRT)	ESSF	wk1	H	Root Disease FPC Guidebook
	ICH	mk3 wk2	M M	Forrex 2 Forrex 2
	SBS	dw mc1 mc2 wk1	H M M MH	Root Disease FPC Guidebook Forrex 2 Forrex 2 Forrex 2
Dwarf Mistletoe (DMP)		Through-out host range	H (except for MS & wetter ESSF)	Forrex 1
Western Gall Rust	ESSF	dc2	MH	Forrex 1

Damaging Agent	BEC zone	BEC subzone	Hazard	Source
(DSG)	ICH	mk3	MH	Forrex 1
	IDF	xm	H	Forrex 1
		xw	H	Forrex 1
		dk3	H	Forrex 1
		dk4	H	Forrex 1
		dw	H	Forrex 1
		mw2	H	Forrex 1
	MS	xk	MH	Forrex 1
	SBPS	xc	H	Forrex 1
		dc	H	Forrex 1
		mc	H	Forrex 1
		mk	H	Forrex 1
	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) & Stalactiform Rust (DSS)	ICH	mk3	H	Forrex 1
		wk	MH	Forrex 1
	MS	xk	MH	Forrex 3
	SBPS	dc	MH	Forrex 1
		mk	M	Forrex 1
	SBS	dw1	H	Forrex 1
		dw2	M	Forrex 1
		mc2	H	Forrex 1
		mw	MH	Forrex 1
Atropellis Canker (DSA)	SBPS	dc	M	Forrex 2
		mk	MH	Forrex 2
		xc	MH	Forrex 2
	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
	SBS	dw1	H	Forrex 1
		dw2	H	Forrex 1

Damaging Agent	BEC zone	BEC subzone	Hazard	Source
		mc1 mc2	H H	Forrex 1 Forrex 1
Lophodermella needle cast (DFL)		mh mm mw wk1	H H H H	Forrex 1 Forrex 1 Forrex 1 Forrex 1
Drought Damage	IDF	xm		

Forrex 1 Swift et al. 2002. Forest Health Stand Establishment Decision Aids, BC J. Eco. Man. 2(1)

Forrex 2 Swift et al. 2002. Forest Health Stand Establishment Decision Aids, BC. J. Eco. Man.. 2(2)

Forrex 3 Stock et al, 2005. Forest Health Stand Establishment Decision Aids, BC. J. Eco. Man. 6:56-73.

Forrex 4. Heppner, D. & Turner, J. Spruce Weevil & Western Spruce Budworm Forest Health Stand Establishment Decision Aids. BC J. Eco. Man. 7(3): 45-49

Forrex 5. Sturrock et al. Laminated Root Rot Forest Health Stand Establishment Decision Aid. BC J. Eco. Man. 7(3):41-43.

Forrex 6. 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

Forrex 7. McCulloch, L., B.Aukema, K. White, & M. Klingenberg. 2009. British Columbia's northern interior forests: Warren Root Collar Weevil Stand Establishment Decision Aid. BC Journal of Ecosystem Management 10(2):105-107.

Forrex 8. Hodgkinson, R., K. White, & A. Stock. 2011. British Columbia's Northern Interior Forest Region: Spruce/White Pine Weevil Stand Establishment Decision Aid. BC Journal of Ecosystems and Management 11(3):51-54

Table 5: Landscape level hazard by biogeoclimatic zone and subzone for forest health agents within the Cariboo Region.

BEC zone	BEC subzone	High	Moderately High	Moderate
CWH	ds1		IDW	DRL
	ms1			DRL
ESSF	dc3			
	mv1			
	wc3	IBB, IBS, IDB	DRT	
	wk1	IBB, IBS		DRT
	xc3			IWP, DMP
	xv1	IBB, IBM, IBS		IWP
	xv2	IBB, IBM, IBS		
ICH	dk		IWS	
	mk3	IBB, IBD, IBS, IDA, IWS, DMP, DRA, DRL, DSC, DSS	IWW, DSG	DRT
	mw3	IDA, IWS, DRL, DRR		IDL, DRB, IWW
	wk2	IDL, IWS, IWW, DRA, DRL, IWW	IDA,	DRT, DSC, DSS
	wk4	IBB, IBS, IWW, DMP, DRL	IDL	DSC, DSS
IDF	dk3	IBD, IDW, IWP, DFL, DFE, DMP, DRA, DSG		DRL
	dk4	IBD, IWP, DFL, DFE, DMP, DSG		IDW, DRL
	dw	IBD, DMP, DSG		DRA, DRL
	mw2	DRL, DSG	IDW	DRA

BEC zone	BEC subzone	High	Moderately High	Moderate
	ww	IBD, IDW		DRL
	xh2	IDW		
	xm	IBD, IDW, DMP, 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, DMP		
SBPS	xc	IBM,IBS, DFL, DFE, DMP, DSG	DSA	IWP
	dc	IBM,IBS, DFL, DMP, DSG	DSC, DSS	DSA
	mc	IBM,IBS, DFL, DMP, DSG		IWW
	mk	IBM,IBS, DFL, DMP, DRA, DSG	DSA	DSC, DSS
SBS	dk		IWW	
	dw1	IBM,IBS, IWS, DFL, DMP, DRA, DRT, DSG, DSC, DSS		IWP, IWW, DSA
	dw2	IBM,IBS, DFL, DMP, DRT, DSG		IWP, IWS, IWW, DSC, DSS
	mc1	IBM,IBS, DFL, DMP, DSG		IWW, DRT
	mc2	DFL, DSG, IWW	IWS	DSA, DRT
	mc3	IBM,IBS, DMP, IWW		
	mh	IBM,IBS, IWS, DFL, DMP, DSG		IWS, IWW
	mm	DFL, DSG		IWW
	mw	IBM,IBS, IWW, DFL, DSG	DSC, DSS	DSA
	wk1	IBM,IBS, IWS, DFL, DSG	DRT	IWW

G. Pest Profiles

1. Insects

a) Bark Beetles

Mountain Pine Beetle
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 operation should be consistent with guidance provided by the Chief Forester http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/Chief_Forester_Hydrology_200703.pdf, recommendations pertaining to watershed planning http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/, and the beetle action plan http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/. 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
Dendroctonus pseudotsugae (Hopk.)

Douglas-fir beetle has been an on going 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 650-1200 stems/ha (Ministry of Forests, 1995). Douglas-fir bark beetle management consists of doing detailed helicopter surveys and ground surveys and then following up with treatments where necessary. Treatments include sanitation harvesting, trap trees, anti-aggregation pheromones, and fall and burn. Treatment options are generally determined based on beetle management units (BMU) . A BMU is given a strategy 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). Guidelines for bark beetle sanitation harvesting in old growth management areas can be found in the Regional Biodiversity Conservation Strategy Update Note # 7b. http://www.env.gov.bc.ca/wld/documents/wha/Amendment_ShallowModerate_Feb07_Ord.pdf. 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 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 moderately severity fire damage are being decimated 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 exasperates 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 health Douglas-fir stands adjacent to the fires. Where feasible and appropriate, it is critical to try and prevent large build ups of beetles as soon as possible after a fire by aggressively managing for Douglas-fir beetle through the use of trap trees, fire salvage, fire guard salvage, and anti aggregation pheromones. 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. Funnel traps have 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.
http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/guidetoc.htm

Spruce Beetle
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 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 index (Ministry of Forests 1995). Spruce beetle can be contained within a planned cut block until harvest through the use of baiting or trap trees.

References:

Ministry of Forests. 1995. Bark Beetle Management. Forest Practices Code Guidebook.
http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/guidetoc.htm

Western Balsam Bark Beetle

Dryocetes confusus (Swaine)

The area infestated 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.

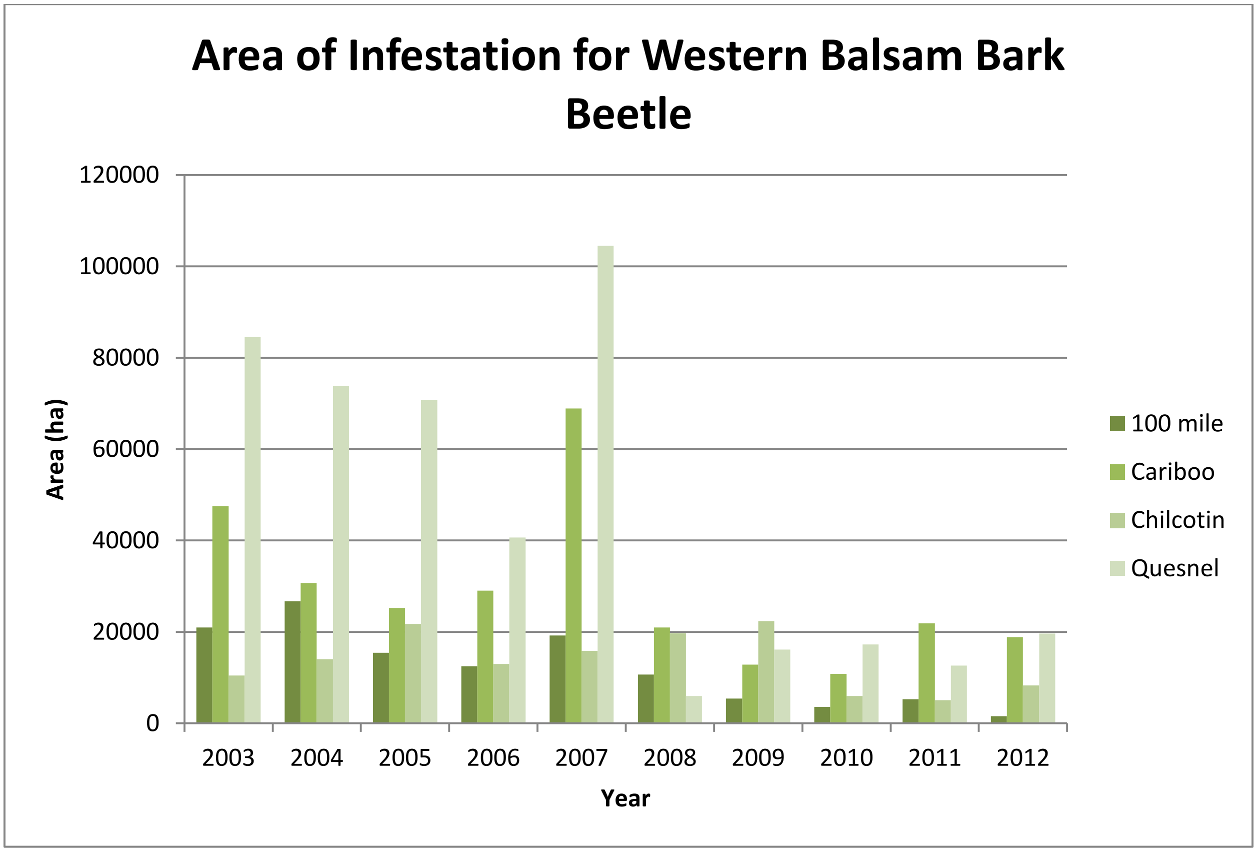

Fig. 1. Area of infestation for western balsam bark beetle by forest district based on aerial overview survey data

b) Defoliators

Western Spruce Budworm

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 has been 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
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 most of the damage occurs in *even* years. There was over 40,000 ha of light and moderate defoliation (mostly in the Quesnel TSA) 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
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
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 tussockosis.
http://www.for.gov.bc.ca/rsi/foresthealth/PDF/DFTM%20tussockosis.pdf

Historic Western Hemlock Looper 1937-2011

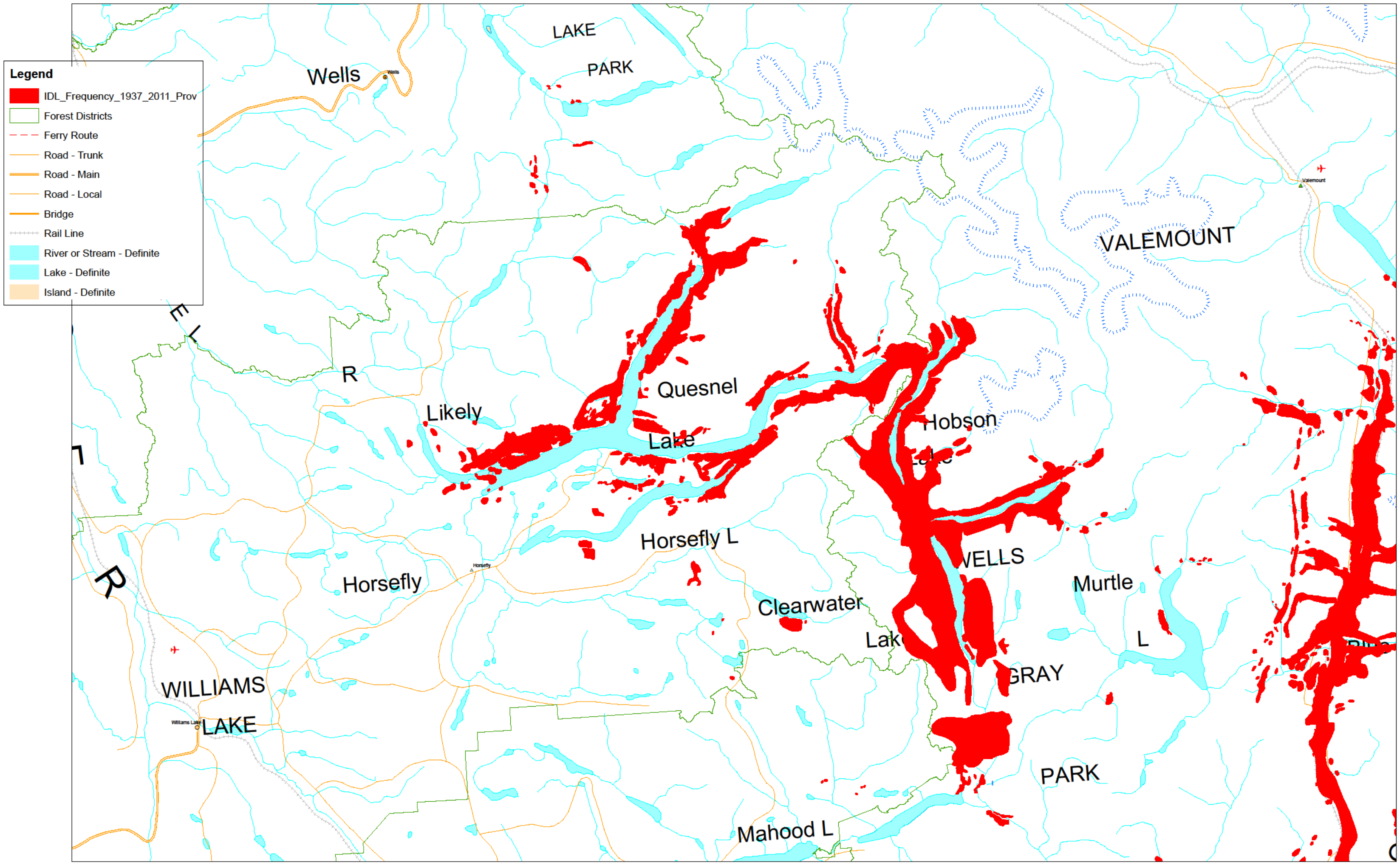

Fig. 2. Historic occurrence of Western Hemlock Looper in the eastern Cariboo

Forest Tent Caterpillar
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. 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
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 6. 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. Ilnytzky. 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
Phyllocynistis 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 patter, 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
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)

Spruce Weevil
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 at the following site.
http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Forest_Health/RESULTS%20incidence%20maps/
These maps reflect 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
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.

2) Diseases

a) Root Rots

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

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 treatement 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* (sufur 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 inoculums 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 fasiculare* 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
Phellinus weirii (Murr.) Gilbertson (Douglas-fir type)
= *Phellinus sulphurascens* (Murrill) Gilbertson
= *Inonotus weirii* (Murrill) Kotl &Pouzar
= *Inonotus sulphurascens* (Pilat) 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. In the ICH, western red cedar is often associated with root rot centers. 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
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. 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. 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.

It is very important to include root rot survey results when filling out information in RESULTS. Because root rots are diseases of the site (they persist on the site for as long as susceptible tree species are present) this data can be very useful for recording where root disease occurs and will remain relevant for many years after the survey is completed.

References:

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

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. Squirrel feeding is often associated with rust cankers. 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 can be used to predict areas that may have a high rust hazard in the future (one example is shown in Fig. 4). Not all stands with high rust incidence are within high rust hazard zones, rather the high rust hazard areas represent areas where there have been a number of stands with documented high rust incidence in the past. 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 higher stocking standards be used to account for losses due to rusts. 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%

References

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

Comandra Blister Rust
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.

.

The sum of: DSC (Comandra Blister Rust *Cronartium comandrae*), DSG (Western Gall Rust *Endocronartium harknessii)* and DSS (Stalactiform Blister Rust *Cronartium coleosporioides*) for Quesnel Forest District

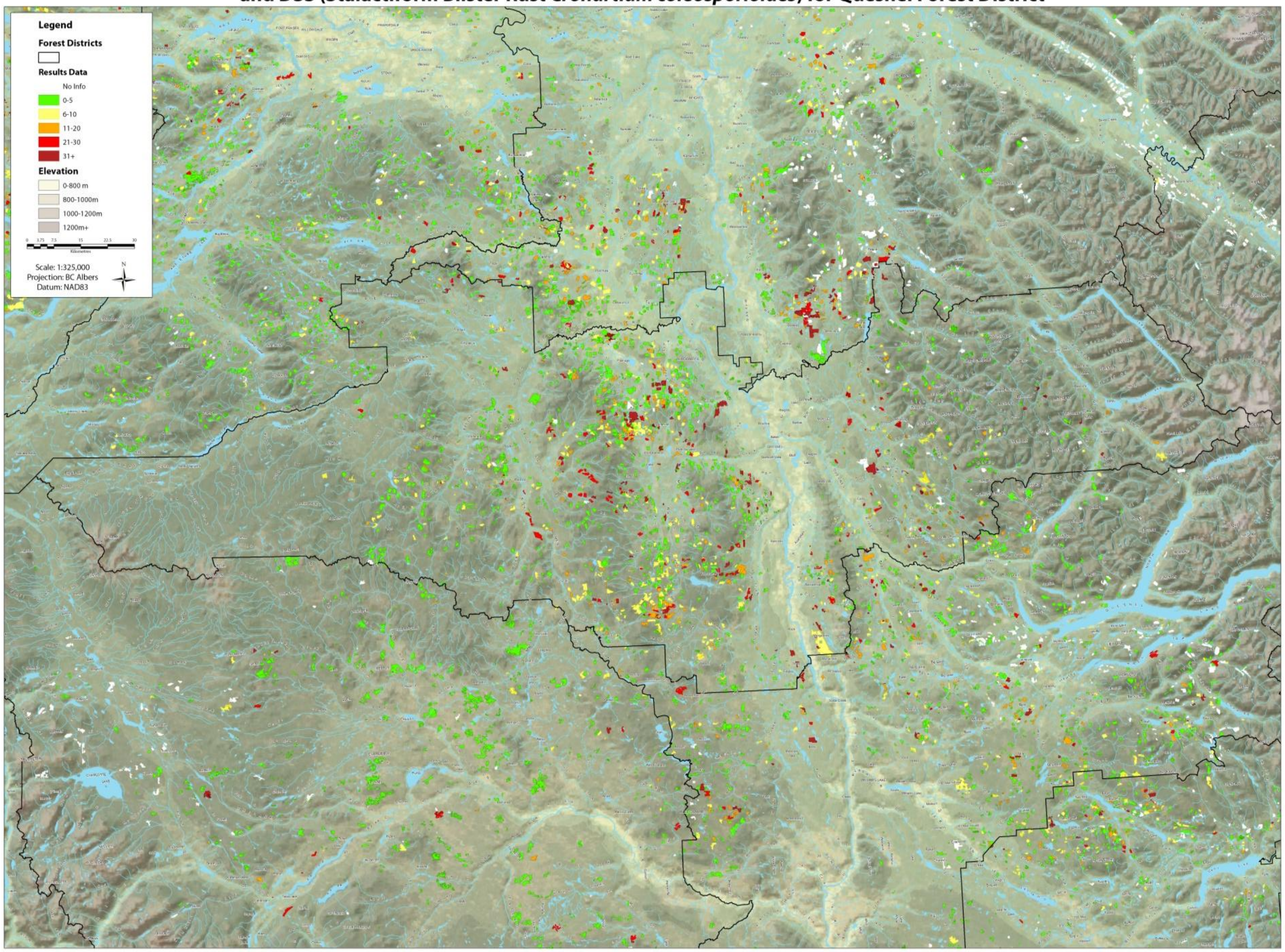

Fig. 3. Combined incidence of western gall rust and comandra rust in the Quesnel District based on RESULTS data (courtesy of Richard Reich)

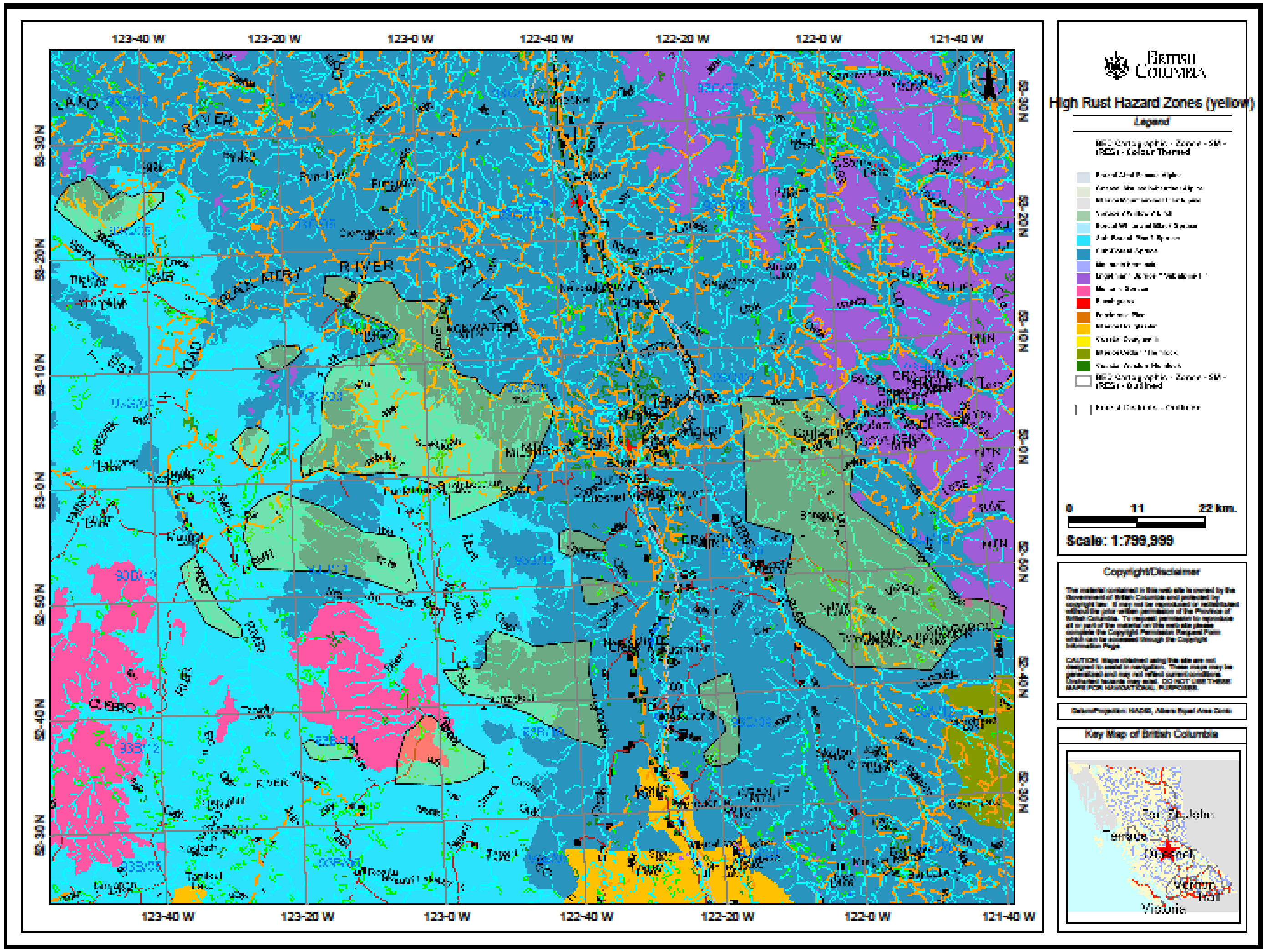

Fig. 4. High Rust Hazard Polygons in the Quesnel TSA (yellow) overlaid on BEC map

Stalactiform Blister Rust
Cronartium coleosporioides Arthur

Stalactifrom blister rust tends to be less common in the Cariboo compared to the other stem rusts but high incidences are still possible. There are 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. Stalactifom 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
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 only occur on the current year's leader.

c) Cankers
Atropellis Canker
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).

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

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

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.

More work needs to be done to identify areas within the Cariboo Region that have a high incidence of Elytroderma needle cast and measure the impact that is having on growth. Ground observations by the regional pathologist have noted heavily impacted lodgepole pine stands in the eastern part of the Chilcotin District and in areas around Meadow Lake in the 100 Mile District. There are currently no control treatments. Repressed pine stands and pine stands scheduled for spacing treatments should be carefully assessed for Elytroderma needle cast before carrying out spacing treatments.

References:

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

e) Dwarf Mistletoe

Lodgepole Pine Dwarf Mistletoe

Arceuthobium americanum Nutt. ex Engelmann

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:

Hawkworth 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.

Rankin, L. J. Westfall, J. Brooks. 2011. Lodgepole pine dwarf mistletoe trial assessment. Forest Health Project 6 in 2011 Summary of Forest Health Conditions in British Columbia. Ministry of Forest Lands and Natural Resource Operations, Victoria BC. 78pp.

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.

H. Impact of Forest Health Factors on Timber Supply

Forest health factors are usually accounted for in Timber Supply Review (TSR). Endemic pest levels are often already accounted for in growth model yield estimates. In unmanaged stands, yield estimates are made using the Variable Density Yield Projector (VDYP) which includes the impacts of pests because the model uses data collected from unmanaged stands that have experienced pest damage during their development. 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)/Table interpolation from Stand Yields (TIPSY) programs. A third method of accounting for pests is through non recoverable (or unsalvaged) losses (NRLs).

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 accounts for factors that increase over time such as the impact from decay, waste, and breakage or forest health factors such as root disease. The default value for OAF 2 (which only accounts for decay, waste, and breakage) is 5%.

NRLs are often used for catastrophic events such as fires, blowdown, or beetle outbreaks. NRLs are generally calculated as a running average based on the last several years (generally the last 5-15 years). Aerial overview survey data is commonly used to estimate NRLs.

Non recoverable losses used in the latest Timber Supply Reviews in the Cariboo Region are listed in Table 7, and non recoverable losses as a percentage of the TSA AAC in January 2013 are listed in Table 8. Losses due to mountain pine beetle are dealt with separately from other bark beetles; instead of using non recoverable losses mountain pine beetle impacts are modelled using the BC Mountain Pine Beetle

Model http://www.for.gov.bc.ca/hre/bcmpb/. The non recoverable loss numbers used in TSR are estimates based on the annual overview survey results. Overview survey results cover the entire land base, whereas TSR estimates only take into account the timber harvesting land base (THLB). Table 9 shows the 5-year average losses based on annual overview survey results from 2007-2011 and includes areas outside of the THLB. There is a large amount of variation in the numbers for different TSAs which may not necessarily be reflective of actual differences in losses among the TSAs, but is partially due to the different methods used to calculate the numbers in different TSAs and when the analyses took place. Information on the methods used to calculate NRLs is described in the individual TSA data packages. It is important to clearly indicate in the data packages how NRL estimates were derived. Starting in 2012, the non recoverable losses will be calculated provincially. This should add some consistency to the way NRL's are calculated in different TSAs and allow for better comparisons across TSAs.

Table 7. Unsalvaged (Non-recoverable) losses used in most recent timber supply reviews.

Species	Cause	Unsalvaged Loss by TSA (m3/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

Table 8. Unsalvaged (non-recoverable) losses as a percentage of AAC in Jan 2013

Species	Cause	Unsalvaged Losses as a % of AAC		
		Quesnel (4,000,000 m3/yr))	100 Mile (2,000,000 m3/yr.)	Williams Lake (5,770,000 m3/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 9: Mean hectares affected from the Aerial Overview Survey 2007-2011. For bark beetles severity is the % of trees recently killed where T<1%, L=1-10%, M=11-29%, S=30-49%, and VS>50%. For spruce budworm T is not applicable, L=barely visible from air, M=Top third of many trees severely defoliated, S=completely defoliated tops and most tree >50% defoliation, and VS not applicable.

Forest District & Damaging Agent	Area (ha)					
	Trace	Light	Moderate	Severe	Very Severe	Total
Douglas-fir Beetle						
100 Mile House	6973.6	2435.4	245	6		9684.4
Quesnel	1853.2	718.4	483.4	122.8	20	3197.4
Williams Lake	26510.8	10487.8	2498.2	406.2	27	39930.6
Spruce Budworm						
100 Mile House		100826.2	7216.2	364.2		108406.8
Quesnel		7189.4	810			7,999
Williams Lake		234148.6	30625	2185.2		266958.8
Spruce Bark Beetle						
100 Mile House	1800.6	1478.4	1211	407.6	7.6	4905.2
Quesnel	306.8	270.4	21	44		642
Williams Lake	4261.2	3399.8	1654.6	1056.6	16.2	10386.6

Mountain Pine Beetle Impact in Young Stands

The approach taken for assessing the impact of mountain pine beetle in young stands varies within the Cariboo Region. In the 100 Mile TSA the OAF1 was reduced by 20% (for a total value of 0.65). Table 10 summarizes the impacts of mountain mine beetle in young stands as determined from sampling (Maclauchlan 2008). The percent of impacted stands was multiplied by the average percentage of attack and rounded to the nearest 5% to derive an estimated % volume loss. Over time this volume impact will be reduced as a result of natural ingress. Since 2007, the provincial aerial overview survey has mapped visible young pine damage that has been attributed to mountain pine beetle. The survey data can be used to inform Forest for Tomorrow investment decisions by identifying heavily impacted stands.

Table 10: Impact of mountain pine beetle in young stands in the Cariboo Region. (Columns 1-3 are taken from Maclauchlan 2008)

TSA & Stand Age	% stands impacted	Average % attack (reds & greys)	% Volume loss
100 Mile House			
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
Central Cariboo			
20-25	88	25	20

TSA & Stand Age	% stands impacted	Average % attack (reds & greys)	% Volume loss
26-30	96	38	35
31-40	100	40	40
41-50	100	42	40
51-55	100	38	40
Quesnel			
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

I. Climate Change

Some consider climate change, together with forest health to be 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. The recent mountain mine beetle epidemic and northern range expansion, Dothiostroma needle blight in north western BC, and the recent outbreaks of western spruce budworm in the Cariboo 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 Strategy:
http://www.livesmartbc.ca/attachments/Adaptation_Strategy.pdf
, and the Forest Stewardship Action Plan for Climate Change Adaptation:
http://www.for.gov.bc.ca/ftp/HFP/external/!publish/ClimateChange/Adaptation/MFLNR_CCAdaptation_Action_Plan_2012_final.pdf.

A familiar concept in forest health is the concept of the pest triangle. Host, pest, and environment make up the three corners of the triangle. A change in any one 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 make it easier for some exotic pests to become established, particularly those originating from warmer climes.

The biggest impact of climate change from a forest health perspective is that it adds a great deal of uncertainty 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, we don't even have a clear idea of how temperature and precipitation impact 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.

J. The Case for Forest Health Spending in the Cariboo Region

This document endeavours to communicate the risks posed by various forest health factors in the Cariboo Region and to promote a proactive approach to forest health management. The Cariboo Region is expected undergo a major decline in mid-term timber supply as a result of the mountain pine beetle epidemic. Large investments in silviculture and changes in land use policy have been proposed to offset this decline, but relatively little attention has been focused on forest health. This lack of attention is particularly concerning given that the major declines in timber supply are a direct result of an insect outbreak. Modest investments in forest health treatments and monitoring could go a long way to protecting mid-term timber values and reducing the risks posed by future insect or disease outbreaks. The risks from forest health agents vary from year to year depending on when insect outbreaks occur and the specific location being considered. The majority of forest health spending in the Cariboo Region has been focused on treating western spruce budworm with Btk, conducting the annual aerial overview survey, performing detailed aerial mapping of spruce and Douglas-fir bark beetles, and performing ground surveys and treatments for Douglas-fir beetle.

The cost for treatment of the western spruce budworm is low ($30/ha), in most cases only a single treatment is needed, and the benefits of spraying are well documented. . The investments in the annual aerial overview survey is critical for tracking and documenting the occurrence of insect outbreaks over time and calculating non recoverable losses for use in timber supply planning. The cost of the annual aerial overview survey had been estimated to be $0.01/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 insect but detailed studies comparing treated and untreated areas are lacking. More research is required to measure the efficacy of Douglas-fir beetle treatments and their effectiveness in reducing overall beetle populations.

Despite knowledge gaps in the efficacy of beetle treatments, the losses to Douglas-fir beetle and spruce beetle within the Cariboo Region are significant. Spruce and Douglas-fir beetle NRLs account for 1.2% of the AAC in 100 Mile TSA and 0.8 % of the AAC in the Williams Lake TSA. 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. All of this volume was in the form of non recoverable losses. 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). The post harvest basal area target for low stand structure Habitat Class stands in the IDFxm is 6m2/ha.

In the last two 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 were rated as having a low fire severity. In the Chilcotin and parts of the Cariboo in 2012 almost all of the surviving merchantable Douglas-fir trees within areas of low burn severity 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.

References:

Heineman, J.L, D.L. Sachs, W.J. Mather, & S. Simard. 2010. Investigating the influence of climate, site, location, and treatment factors on damage to young lodgepole pine in southern British Columbia. Can. J. For. Res. 40: 1109-1127.

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

Westfall, J. & J. Brooks. 2001. Cariboo Forest Region Pests of Young Pine Stands: Incidence and Impact 1996-1999. BC Ministry of Forests