Nadina Forest District
Forest Health Strategy
2009-2010

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Ministry of Forests and Range

Nadina Forest District

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FOREST HEALTH STRATEGY

Introduction

This document addresses the management of forest health factors at two levels, the stand management component (non-bark beetle) and the bark beetle suppression component. These components are guided by the priorities and objectives of the Provincial Forest Health Strategy and the Provincial Bark Beetle Management Strategy and maintain the goal *"to protect forest resources from damaging agents that threaten the resources' immediate and long-term value by maintaining a high standard of forest health practice across the land base."* The Nadina Forest District Forest Health Strategy will be updated annually and is intended to guide management of forest health concerns on Crown land within the Lakes and Morice Timber Supply Areas.

Background

The forest health strategy is a document that provides guidance and/or best management practices with regards to forest health factors. The forest health strategy identifies important forest health issues within the Nadina Forest District. This is important information for professionals to consider during planning and operational activities. Although the forest health strategy is not a legally-binding document, having a comprehensive forest health strategy provides information for instances where forest health sections of the *Forest and Range Practices Act* and stocking standards sections in the *Forest Planning and Practices Regulation* may apply.

The implementation of an effective forest health strategy can augment and stabilise the timber supply of a TSA by increasing the success of regeneration practices, increasing the productivity of immature stands, and decreasing losses of mature timber. These benefits imply a reduced risk to silviculture investment and a more stable planning environment, both of which are important to the Ministry of Forests and the forest industry. The early detection of forest health problems and the prompt implementation of scientifically sound solutions will allow forest managers to take full advantage of potential benefits.

Managing for species diversity in regenerating stands is one the most effective means of reducing the risks associated with any one forest health factor. In light of climate change, the MPB epidemic, and increasing damage to plantations due to hard pine rusts, Dothistroma foliar disease, and root collar weevil, it is more important than ever to maximise species diversity in managed stands while maintaining the commercial viability of the long-term timber supply.

Private Land Owners / Woodlot Licensee's

This Forest Health Strategy is intended to guide management of crown land within the Nadina Forest District. For private land owners and woodlot licensees, forest health responsibilities are limited; however, it would be in the best interest of such holders to consider and implement this forest health strategy as it applies. Generally, the results of aerial surveys are available to private land owners and woodlot licensees as the information is collected and summarized.

Budget

In the Nadina Forest District, the implementation of bark beetle suppression activities (limited to spruce bark beetle), as designated by the Provincial Bark Beetle Coordinator, will depend on funding availability through the Forest Investment Account (FIA) and Forest Practices Branch base funding. All other pest monitoring programs (such as Dothistroma and rust) will be undertaken on a priority basis and will be funded through base funding allocated to the District.

Objectives and Potential Actions

The following table, adapted from the Provincial Forest Health Strategy, provides a listing of the primary objectives of the forest health strategy, the potential actions and the agency that would be responsible for their undertaking.

Objectives and Potential Actions	*Government*	*Licensees (includes BCTS)*
Objective 1: Maintain a detection program for damaging agents over the land base.		
Conduct the annual aerial overview survey on all provincial forests.	**X**	
Annually compile and report the results of the provincial aerial overview survey.	**X**	
Conduct detailed aerial and ground surveys in identified areas required to quantify the incidence and intensity of damaging agents to the standard in the appropriate guidebooks e.g. Rust surveys, root collar weevil surveys, etc.	**X**	**X**
Maintain a record of all survey information for the land base.	**X**	**X**
Standardize data collection when required to facilitate strategic objectives.	**X**	**X**
Improve and refine detection methods.	**X**	**X**
Objective 2: Assess current and future stand and landscape level hazard and risk from detected damaging agents, including the impact of forest management practices on resource values.		
Use the best current information to determine hazard and risk and probable impacts for all detected and potential forest health agents on the land-base.	**X**	**X**
Update existing hazard and risk rating as required and as inventories are updated	**X**	
Develop, support and implement modelling of pest dynamics and impact assessments for Timber Supply Reviews.	**X**	
Evaluate and prescribe approaches to deal with introductions of non-native, potentially harmful organisms.	**X**	

Objectives and Potential Actions	*Government*	*Licensees (includes BCTS)*
Objective 3: Identify significant pest risks to resource values and identify appropriate management strategies and tactics, while considering constraints and limitations imposed by other resource management imperatives.		
Develop and follow decision-making guidelines that direct the forest health activities by strategic priority.	**X**	
Consider all scientifically sound forest health management strategies and tactics. New strategies and tactics are always being developed but they must be reviewed by provincial forest health specialists for scientific validity before being adopted as operational practices.	**X**	**X**
Identify knowledge gaps that limit the ranking and assignment of priorities and hinder identifying appropriate management strategies and tactics. Maintain open communication regarding emerging forest health issues.	**X**	**X**
Define provincial performance measures for specific strategies and tactics.	**X**	
Objective 4: Implement mitigating strategies and tactics based on scientifically sound, forest health management practices.		
Assign mitigating strategies where deemed appropriate (include prevention, suppression, exclusion, and eradication through either direct or indirect control tactics). Direct treatment efforts to meet the strategic forest health objectives identified in the Lakes forest health strategy.	**X**	
Quantify (through TSR) the outcome of selected mitigating strategies and tactics, including doing nothing (e.g. change in quantified yields or diminished future management options).		**X**
Accelerate implementation of mitigating strategies and tactics to deal with unforeseen outbreaks of damaging agents in a timely manner.	**X**	
Objective 5: Evaluate results of forest health management practices over the short and long-term and modify practices accordingly.		
Inspect field practices to ensure forest management objectives are met.	**X**	
Target applied research activities to support scientifically based standards of forest practice on Crown lands.	**X**	**X**
Review and revise scientifically sound, forest health management practices, as required.	**X**	

Forest Health Factors – Ranking of Importance

This ranking includes the forest health factors from both the stand management component and the bark beetle suppression component of this forest health strategy.

The ranking of forest health factors is based on the following considerations:

- The knowledge of Regional and Provincial forest health specialists, Nadina Forest District Staff and Licensees;
- Known or suspected impacts to forest resource values;
- Availability of operational detection and treatment methods;
- Costs and benefits of applying detailed detection and treatment activities;
- Overall level of knowledge about the hazard and risk zones;
- Distribution of agent and current incidence levels; and
- Resources required to obtain missing information necessary for management of the forest health agent.

It is recognized that species by species analysis is required to evaluate the relative severity of impact of current and anticipated losses due to some level of plantation failure that potentially results in a change to stand composition and merchantable volume. As information regarding these relative impacts becomes available, it will be incorporated into the ranking of forest health factors.

Table 1 – Ranking of Pests Species by Potential Impact on Forest Management Activities within the Nadina Forest District

Very High	High	Medium	Low	Very Low
Mountain pine beetle	Western balsam bark beetle (Morice TSA)	Tomentosus root disease	Mammal damage	Rhizina root disease
Spruce bark beetle	Hard pine stem rusts	Warren's root collar weevil (Lakes TSA)	Warren's root collar weevil (Morice TSA)	Spruce Leader weevil
			Lodgepole pine dwarf mistletoe	Various insect defoliators (Lakes TSA)
		Various insect defoliators (Morice TSA)	Pine terminal weevil (Lakes TSA)	Butt Rot
			Engraver beetles	Pityophthorus spp
		Various foliar diseases of conifers	Western balsam bark beetle (Lakes TSA)	
			Dothistroma	

Table 2 – List of forest health agents, their current status, and comparison with historical levels for those agents identified in the annual provincial overview flight.

Forest Health Factor	2008 DND (ha)	2007 DND (ha)	2006 DND (ha)	2005 DND (ha)	2004 DND (ha)	2003 DND (ha)	2002 LAKES (ha)	2002 MORICE (ha)	2001 LAKES (ha)	2001 MORICE (ha)	2000 LAKES (ha)	2000 MORICE (ha)
IBM= Mountain Pine Beetle (mature)	859,748	1,140,002	1,186,684	1,226,838	793,6000	506,001	498,057	12,717	247,916	75,800	124,508	2,129
IBM= (immature)	0	3,939										
IBS= Spruce Beetle	1	1	1	1,940	320	19,052	5,556	866	18,568	29816	1,547	12,293
IBB= W. Balsam Bark Beetle	80,738	178,155	41,182	117,328	177, 988	85,591	5,685	22,949	35,335	153,874	1	4,209
IBL= Lodgepole Pine Beetle	0	0	0	0	0	0	628	13	0	0	0	0
ID= Defoliators	0	0	0	0	0	0	211	0	0	0	0	0
IDB= 2 year budworm	0	7,469	0	0	0	2,725	0	0	0	0	0	0
IDL= W. Hemlock Looper	0	0	0	0	0	0	0	0	0	0	0	1,832
IDS= Conifer Sawflies	0	0	0	0	0	43	142	0	0	0	0	0
IDF= Forest Tent Caterpillar	0	0	0	0	0	0	0	0	1,230	0	0	0
IDN= Birch Leaf Miner	0	0	0	0	0	0	0	0	0	0	0	464
IDX= Large Aspen Tortix	21	0	205	0	0	1,524	0	0	0	0	0	0
ID6= Aspen Leaf Miner	3	0	0	0	0	0	0	0	0	0	0	0
NB= Fire	230	0	75	1,072	3,070	0	29	14	0	0	0	0
NW= Windthrow	136	0	59	02,529	0	0	0	0	0	0	1	0
NF= Flooding	64	18	144	126	115	110	89	372	0	24	0	0
NS= Slide	0	7	0	0	0	0	12	0	0	0	0	0
ND= Drought	0	0	64	0	0	0	0	0	0	0	0	0
AP= Porcupine	0	0	0	0	11	99	1	11	0	0	0	0
DFM= Larch Needle Blight	0	0	0	0	0	0	60	0	0	0	0	0
DFL= Pine Needle Cast	14,645	0	0	0	0	0	0	0	0	0	0	0
DLV= Venturia spp.	0	0	0	0	14,817	5,242	12,128	6,191	9,600	1,108	0	0

Source: 2008 Aerial Overview Flight Survey Summary Table, FPB website

STAND MANAGEMENT COMPONENT

Overview

The stand management component of this strategy is intended to provide a ranking of non-bark beetle forest health factors in the Nadina Forest District and to outline strategies for reducing the risk of impacts arising from those factors. These strategies should conform largely to strategies addressed by forest health guidebooks or Ministry of Forests (MoF) guidelines.

Ranking Rationale and Management Tactics

Hard pine rusts

Comandra Blister Rust - *Cronartium comandrae*
Stalactiform Blister Rust - *Cronartium coleosporioides*
Western Gall Rust - *Endocronartium harknessii*

Ranking Rationale

Lakes TSA

Hard pine rusts are currently considered the most serious disease of managed stands in the Lakes TSA. The impact of rusts on stand productivity has been estimated at 7.2% (Woods et al. 2000). The incidence of rusts in young pine stands in the Lakes TSA has been assessed by District Staff since the mid-1990's. The results of the combined rust surveys for the past 10 years have been compiled and a map has been produced (**Appendix 1**).

The TSA scale map illustrates the ubiquitous nature of rusts throughout the landscape but it also suggests that there are some areas that potentially have a lower incidence of hard pine rusts. For example, Lodgepole pine stands in the ESSF biogeoclimatic zone are largely rust-free. With the exception of the Binta Lake area, the Marilla area and East Ootsa Camp, pine stands south of Francois Lake also appear to be at a low risk of rust infection.

North of Francois Lake, there is no apparent pattern to the distribution of high rust incidence and approximately ½ of the stands are in that class (i.e. >20%). This area is considered high risk for hard pine rusts. The map of rust incidence (**Appendix 1**) will be updated periodically as more rust surveys are completed and changes to the high hazard rust areas will be made where warranted.

Morice TSA

Hard pine rusts are a high priority forest health factor that can result in significant damage and mortality losses in pine, particularly those stems in the seedling to pole size range. Although the losses due to rusts in young pine stands in the Morice TSA are not as great as those suffered in the Lakes, some geographic locations that have been severely impacted include the Gold Creek, Buck Flats, Parrott Lakes and Chapman areas. In the summer 2008, 81 blocks were randomly surveyed throughout the Morice TSA for Western Gall Rust, Comandra Blister Rust and Stalactiform Blister Rust. The results showed that 99% of the blocks had some level of incidence of rust and that 42% of the blocks could be categorized as 'high' incidence as >20% of the host trees were affected. The leading rust type was Western Gall, followed by Comandra and Stalactiform.

Management Tactic

Currently, the most effective management tactic for hard pine rusts is to reforest with non-host species, often through planting. This tactic is not always possible due to dry site conditions. In areas that are too dry to plant non-susceptible species such as spruce or balsam, greater initial densities of pine should be established. Experience with pine plantations that have failed in high hazard rust areas suggests that initial densities of 2200-2500 stems/hectare are required for a stand to become free growing and remain productive into the future. This suggestion is backed by the Northern Interior Regional Pathologist and recorded in FREP report #13 "Are Free-Growing Stands Meeting Timber Productivity Expectations in the Lakes Timber Supply Area?" (See **Appendix 6**). Consideration should also be given to planting non-host species, as these species could provide increased diversity and stand resiliency in high hazard rust areas.

Silviculture surveys, particularly free-growing assessments, in pine-leading plantations should be conducted within the rust sporulation window (i.e. from June thru July). Spacing of pine dominated stands in known rust areas should not occur (See **Appendix 2**: Guidelines for Spacing of Lodgepole Pine).

Any stands submitted for FG declaration that fall within the following mapsheets will be reviewed in light of rust management strategies in the known high risk areas:

LAKES TSA – high risk				
93F052	93F073	93K003	93K031	93K042
93F053	93F074	93K011	93K032	93K043
	93F081	93K012	93K033	93K072
93F062	93F082	93K013	93K034	
93F063	93F083	93K022	93K035	93E098
93F064		93K023	93K039	93E099
93F065	93F091	93K024	93K040	93L009
	93F092	93K025	93K041	
	93F093	93K030		

MORICE TSA – high risk		
93L008	93L027	93L097
93L017	93L037	93L098
93L018	93L046	93L088
		93L089

Tomentosus Root Disease (Inonotus tomentosus)

Ranking Rationale

Tomentosus root disease is a low priority forest health factor in the Nadina Forest District. Although the BC Ministry of Forests and Range inventory appears to account for the mature volume loss in its yield model VDYP, this volume loss estimate illustrates the potential for increased stand productivity if tomentosus root disease is proactively managed. Estimates of the non-recoverable losses from tomentosus root disease range from 62,500 m^3 to 151,000 m^3annually[1]. The impact of Tomentosus root disease on the productivity of second growth stands is being investigated by the Regional Forest Pathologist, MOFR.

Management Tactic

Maximizing species diversity in plantations is considered one of the most effective means of managing this disease. The strategies and tactics for Tomentosus root disease management outlined in the FPC's Root Disease Management Guidebook should be considered. (http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/root/roottoc.htm)

Warren's root collar weevil (Hylobius warreni)

Ranking Rationale

This insect is considered a medium priority forest health issue in plantations of pine and spruce in the Lakes TSA, and a low priority forest health issue in the Morice TSA. While the losses resulting from Warren's root collar weevil have historically been considered minor, recent experience indicates there is an increased risk of seedling loss in plantations that are adjacent to Mountain Pine Beetle killed stands. This is related to migration of adult weevils from dead stands into adjacent plantations.

[1] Tomentosus Root Disease Impact Estimate for Morice TSA; Alex Woods, 1999

Monitoring of damage caused by root collar weevil is currently underway at the MOFR Region and District levels. Based on monitoring results, the ranking of this forest health agent may increase in the future. In addition to District monitoring, a UNBC research project has also been started in the Lakes TSA. This research project will help determine the impact and duration of Warren's root collar weevil populations on plantations adjacent to MPB killed stands.

Management Tactic

Due to the increased risk to seedling mortality anticipated with this weevil, more intensive surveys will be required in areas heavily impacted by MPB. Spacing of pine in plantations adjacent to MPB killed stands should be avoided. Currently, the most effective management tactic for Warren's root collar weevil is to plant a combination of non-host species.

Lodgepole Pine Dwarf Mistletoe (Arceuthobium americanum)

Ranking Rationale

Lodgepole pine dwarf mistletoe is a low priority forest health factor in the Nadina Forest District. Prior to MPB, mistletoe existed in patchy distribution. Currently, with the majority of the host tree dead, mistletoe incidence should be on the decline.

Management Tactic

With the widespread mortality of the host tree in the Nadina Forest District, a realistic tactic is to monitor susceptible stands. Where incidences of mistletoe are found, follow the tactics outlined in the Dwarf Mistletoe Management Guidebook.

http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/dwarf/dwarftoc.htm

Various Foliar Diseases of Conifers

Ranking Rationale

Foliar diseases are considered **medium** priority forest health factors in the Nadina Forest District. However, the example of Dothistroma needle blight of lodgepole pine in the Northwest should be seen as a warning of the potential risk that foliar diseases may pose. This risk may well intensify given current predictions of climate change. Recent aerial surveying of 78 randomly selected openings in the Morice TSA indicated that 35% of these blocks have some level of Dothistroma. See **Appendix 3** for general locations. Other foliar diseases of increasing concern are *Phaeoseptoria contortae and Lophodermella concolor* on lodgepole pine, *Rhizosphaera kaukhoffii* on spruce, and fir-fireweed rust (*Pucciniastrum epilobii*) on true firs. Of the 78 blocks, 33% had some level of *Lophodermella* either alongside *Dothistroma* or on its own. Refer to **Appendix 4** for a pamphlet on characteristics for field identification of common foliar diseases in the Nadina Forest District. Refer to **Appendix 5** for the method of determining the level of foliar damage on conifers.

Management Tactic

Incidence levels should continue to be monitored and their priority reassessed at the annual review stage. Encourage species diversity in plantation establishment. In addition, note the importance of site selection when planting pine. Areas that are likely to have higher relative humidity, such as the wetter ecosystems, areas with increased moisture due to terrain features, and areas with higher brush hazards (which help maintain relative humidity) are more prone to Dothistroma disease. Given the wet conditions in 2007, foliar disease will be a concern in the future and should be monitored annually.

Various Insect Defoliators

Ranking Rationale

There are several defoliating insects that are considered **medium** priority forest health factors in the Morice TSA, and **low** priority forest health factors in the Lakes TSA. These insects tend to have cyclical populations that can rise to high levels in some years, resulting in significant damage to host tree species.

Management Tactic

It is important to inform the MoFR of defoliation as early as possible, as these outbreaks are usually of short duration. Damaged timber may be prioritized for harvest; otherwise the management tactics should conform to those tactics outlined in the Defoliator Management guidebook. Encourage species diversity in plantation establishment. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/defoliat/defoltoc.htm

Mammal Damage

Ranking Rationale

Currently, mammal damage is considered a low priority forest health factor in the Nadina Forest District. Vole and hare populations, and the potential damage their feeding can cause, are cyclical. There is the potential for mammal damage to increase, as populations of hares and voles can cause significant damage to plantations.

Management tactic

Incidence levels should continue to be monitored and their priority reassessed at the annual review stage. In areas of increasing hare populations, planting below a canopy can lead to greater hare damage due to limited predator access. Predator interactions in areas with strong mammal prey populations are also to be considered (e.g. WTP planning).

Butt Rot (Fomitopsis pinicola, Phaeolus schweinitzii)

Ranking Rationale

Butt rot is a low priority forest health factor in the Nadina Forest District. Mature and over-mature stands of spruce affected by butt rot are often mistaken for stands infected by Tomentosus root disease. There is no known relationship between mature stand infections and subsequent risk to plantations.

Management Tactic

Incidence levels should continue to be monitored and their priority reassessed at the annual review stage.

Engraver beetles (Ips spp.)

Ranking Rationale

This insect is considered a low priority forest health issue in young pine plantations. Engraver beetle populations increase significantly following MPB epidemics, which could have implications for young pine stands in the Nadina Forest District. Recent experience in the Vanderhoof District indicates that there is an increased risk of significant loss in plantations that are adjacent to MPB killed stands.

Management Tactic

Due to the increased risk associated with this beetle, more intensive surveys will be required in areas heavily attacked by MPB. Spacing in plantations adjacent to MPB killed stands should be avoided. See **Appendix 2** for guidelines on spacing in lodgepole pine.

Pine Terminal Weevil (Pissodes terminalis)

Ranking Rationale

This insect is considered a low priority forest health factor in pine plantations.

Management Tactic

Incidence levels should continue to be monitored and their priority reassessed at the annual review stage.

Rhizina Root Disease (Rhizina undulata)

Ranking Rationale

The risk of plantation failures due to Rhizina root disease have all but disappeared due to a decrease in the use of broadcast burning for site preparation. Consequently, Rhizina is considered a very low priority forest health factor.

Management Tactic

Avoid broadcast burning in areas with a history of Rhizina root disease. Incidence levels should continue to be monitored and their priority reassessed at the annual review stage.

Spruce weevil (Pissodes strobi)

Ranking Rationale

Spruce weevil is a very low priority issue in the Nadina Forest District. This weevil is only a concern in plantations with a high spruce component.

Management Tactic

Incidence levels should continue to be monitored and their priority reassessed at the annual review stage.

CLIMATE CHANGE

Overview

Climate change impacts include climate-related damage (e.g. frost and drought) and forest health agent-related damage (e.g. foliar diseases, MPB, hard pine rusts and warren's root collar). Climate change is important to consider when managing for forest health agents and in planning and implementing silviculture activities. The climate change document recently published by the Ministry of Forests and Range (May 2006) titled "*Preparing for Climate Change: Adapting to Impacts on British Columbia's Forest and Range Resources"* outlines some concerns related to forest health, and outlines some possible mitigative actions.

(http://www.for.gov.bc.ca/mof/Climate_Change/Preparing_for_Climate_Change.pdf)

The following is an excerpt from the document that is applicable to management activities in the Nadina Forest District:

Forest Health

There is general agreement that temperatures are increasing both globally and regionally due to climate change. Increasing temperatures will lead to range expansions for both hosts and their pests. As many insect pest life cycles are degree-day dependent, it is logical that increases in temperatures could shorten insect life cycles. This in turn could lead to more rapid increases in insect populations resulting in more damage to forest resources.

Warmer temperatures would result in plants breaking dormancy earlier in the year. This could increase the risk of damaging frosts if warming is not sufficient to ensure late spring temperatures remain above zero (Cannell and Smith 1986). This in turn could make the trees more susceptible to pest damage.

Changes in precipitation regimes, though much more difficult to predict than changes in temperature, will also have significant consequences for forest pests, their hosts and forest management in BC. Evidence of climate change already affecting these complex relationships in the forests of BC has recently been published. The mountain pine beetle epidemic throughout the interior of the province has in part been caused by increases in mean winter temperature (Carroll et al. 2004). A recent marked increase in mean summer precipitation in northwest BC has been linked to an unprecedented Dothistroma needle blight epidemic in the area (Woods et al 2005).

The Dothistroma example highlights the uncertainty regarding forest pests and their hosts throughout much of the province. The climate changes that have recently occurred in northwest BC, specifically increased summer

precipitation, should have been beneficial to tree growth (Rehfeldt et al 1999, Nigh et al 2004). Instead that increased summer precipitation favoured the development of a pathogen that eliminated any growth benefits that might have occurred. Dothistroma needle blight has gone from relative obscurity in the province to the best known forest pathogen in less than five years. Such changes to host/pest relationships make predictions difficult. A list of other potential forest health risks in response to climate change is included in **Appendix 7**.

The combinations of hosts and their suite of pests will, of course, be different depending on location throughout the province. However, the scientific fact remains that short-lived insects and fungi will be able to adapt to new environmental conditions under climate change much more quickly than their long-lived hosts. How these relationships will play out is unknown. In some cases, new relationships could be positive for some forest resources. In others, there is a high probability that these new relationships will be negative, particularly in terms of timber productivity. As a result, strategies are required to prepare for a range of scenarios, and diversify managed stands in order to make them more resilient.

Adaptive Responses:

- Implement silviculture strategies that reduce susceptibility of forests to insects and pathogens (e.g., increase species diversity in managed stands to cope with uncertainty and increase resiliency).

- Plant species suited to projected future climate conditions (e.g. facilitated migration)

Possible Actions:
i) short-term

- Identify and assess silviculture strategies that can reduce the potential impact of forest health risks. (see example of a forest health risk assessment in **Appendix 8**)

ii) longer-term

- Monitor success of mixed species managed stands and modify species composition of newly created plantations as climatic conditions change.

- Incorporate climate change into provincial and timber supply area Forest Health Strategies.

Potential Leads:

- Forest Practices Branch, Regional Forest Health Specialists.

BARK BEETLE COMPONENT

Background

The Nadina Beetle Management Unit Strategy Map (**Appendices 9 and 10**) outlines the strategies employed in each BMU in the District. For MPB, the entire Lakes TSA is following the Salvage strategy, while the majority of the Morice TSA is currently following the Salvage strategy, with 3 BMUs in the Holding strategy. For SBB, both TSAs are in Suppression.

As the MPB epidemic spreads throughout the District, it is apparent that we must expand our tactics to more fully reflect stewardship and social considerations in the context of the increased rate and scale of salvage operations. Planning and harvesting of stands affected by MPB needs to maintain other resource values, as well as protect mid-term timber supply values.

Management objectives concerning MPB include:

- Ensure that Holding and Salvage strategy targets are met;
- Continue annual monitoring of beetle spread;
- Reduce negative impacts of bark beetle infestations and salvage operations on biodiversity and other forest values;
- Manage for the highest value from damaged timber;
- Direct as much harvest as possible into high risk pine stands that are under attack;
- Retain attacked stands that have a secondary structure component that makes them viable in the mid-term;
- Ensure immediate reforestation of attacked areas.

These objectives are consistent with the Provincial *Mountain Pine Beetle Action Plan,* the goals and management direction of the Morice and Lakes LRMP, and the draft Nadina Mid-Term Mitigation Strategy.

Tactical Options

The selection of tactics will attempt to balance the risk from beetle infestations and the need to maintain other resource values. To facilitate this balance, particularly where there are constraints due to other resource values, tactical matrices for mountain pine beetle and spruce beetle have been developed. These matrices identify the range of tactical options available to address beetle suppression.

Mountain pine beetle (Dendroctonus ponderosae)

Ranking Rationale

Mountain pine beetle is considered a very high priority forest health factor in both the Lakes and Morice TSA's. Approximately 51% of the stands in the Morice Timber

Harvesting Landbase (THLB) are dominated by pine, and 76% of the stands in the Lakes THLB are dominated by pine. The majority of these stands are greater than 60 years of age and are susceptible to MPB attack (if not already attacked). The provincial overview flight estimated that 1.2 million hectares in the District were affected by MPB in 2005 and 2006 and 1.1 million in 2007 which may indicate the epidemic has peaked in the Nadina.

Management Tactics

Management of mountain pine beetle should conform to those tactics outlined in the Provincial Bark Beetle Management Technical Implementation Guidelines and the Bark Beetle Management Guidebook. In addition, the harvest priorities outlined in Table 3 should be considered when planning and harvesting MPB-attacked stands which will aid towards achievement of the management objectives listed above.

Table 3 – List of BMUs, their management strategies, and corresponding harvest priorities.

BMU Strategy	Performance targets *	Management Strategy	Harvest Priority	Harvest Postponed for Future Use
Holding **(Fulton, Granisle,** **Morrison)**	50-70%	Use a mix of small and large blocks to maintain the infestation in a static mode by targeting infested stands. Operations within holding BMU's need to be consistent with the Lakes and Morice LRMPs, *Guidance on Landscape and Stand Level Structural Retention in Large-Scale MPB Salvage Operations – December 2005, and Nadina Mid-Term Mitigation Strategy.* If the infestation continues to expand, then the management strategy for salvage must be applied.	Attacked, pine-leading stands: > 70% Pli ≥ Age Class 4	●Stands ≥ 5 hectares with secondary structure meeting the following criteria: Min. 700 WS/ha ≥6 metres ht Min. 900 WS/ha ≥ 4 metres ht ●Sx/Bl leading stands
Salvage **(all of the Lakes TSA & all of the Morice TSA with the exception of the holding units)**	<50 %	Minimize unsalvaged losses by harvesting beetle-killed trees through large-scale operations. Salvage operations need to be consistent with the Lakes and Morice LRMP's, *Guidance on Landscape and Stand Level – Structural Retention in Large Scale Mountain Pine Beetle Salvage Operations – Dec., 2005, and Nadina Mid-Term Mitigation Strategy.*	Attacked, pine-leading stands: > 70% Pli ≥ Age Class 4	●Stands ≥ 5 hectares with secondary structure meeting the following criteria: Min. 700 WS/ha ≥6 metres ht Min. 900 WS/ha ≥ 4 metres ht ●Sx/Bl leading stands

refers to number of sites treated before the next flight. The intent of the Holding strategy is to maintain beetle populations at a level that can be dealt with annually without huge expansion; little or no use of single-tree treatments. The priority of the Salvage strategy is to salvage timber previously attacked to minimise value loss.

The MPB tactical matrices are based on the following tactics:

- Tactic 1: single tree harvesting of infested trees.
- Tactic 2: small patch sanitation (< 1.0 hectare patches)
- Tactic 3: small clear-cut (between 1.0 and 5.0 hectares **or** less than 2000m^3 **or** a non-clear-cut system)
- Tactic 4: standard harvest practices (clear-cut and clear-cut with reserves)
- Tactic 5: no treatment; leave as is

Mountain Pine Beetle Tactical Matrices

Area Type
Deferred Areas Within Prescriptions
Comments: • Applies to leave areas **available** for harvest later in the rotation where adjacent harvested areas have not met green-up. • Where patch size limits can be met, tactic 4 is available, otherwise use tactics 1-3 and retain 40% basal area.
SMZ/Connectivity Corridors
Comments: • Tactics 1-5 are available.
Ungulate Winter Habitat
Comments: • As per Notice – *Indicators of the Amount, Distribution and Attributes of Wildlife Habitat Required For the Winter Survival of Ungulate Species in the Lakes (Morice) Timber Supply Area.* • Tactics 1-5 are available.
Visual
Comments: • All tactics available as long as Visual Quality Objectives are met.

Area Type in blocks previously harvested
• For all Area Types: Tactic 5
Area Type in blocks yet to be harvested
Riparian Reserve Zones (streams, lakes, wetlands)
Comments: • Leave intact. • Tactic 5 is available.
Riparian Management Zones - Lakes
Comments: • Leave intact. • Tactic 5 is available.
Wildlife Tree Patch (outside of riparian reserve)
Comments: • Prefer tactic 5. • If the WTP is not tied to a resource feature, then look for replacement location first, providing it is required to meet stand level biodiversity targets.
Wildlife Trees
Comments: • Tactic 5 is available.

Spruce Beetle (Dendroctonus rufipennis)

Ranking Rationale

Spruce beetle is considered a very high priority forest health factor. The current MPB epidemic has placed a much greater reliance on spruce to mitigate timber supply impacts in the mid-term.

Management Tactic

Management of spruce beetle should conform to those tactics outlined in Bark Beetle Management Guidebook.

Hazard – Spruce

Hazard Class	*Criteria*
Extreme	- Spruce Leading Species (>50%) - Age Class 7, 8 or 9 - Site Index >= 15
High	- Spruce Leading Species - Age Class 7, 8 or 9 - Site Index < 15
Moderate	- Spruce Secondary Species (21 – 49%) - Age Class 7, 8 or 9 - Site Index - all
Low	- Spruce Leading - Age Class 5 or 6 - Site Index - all

Risk Rating – Spruce

Risk Rating	***Description***
Very High	Infestations within 2 km of a high or extreme hazard stand (>5 yellowing/red topped spruce).
High	Infestations within 2 km of a moderate hazard stand (>5 yellowing/ red topped spruce).
Moderate	Infestation between 2 and 10 kilometres of a high or extreme hazard stand (>5 yellowing/red topped spruce).
Low	Infestations within 2 km of a low hazard stand (>5 yellowing/red topped spruce).
Very Low	Infestations more than 10 km from a high or extreme hazard stand (>5 yellowing/red topped spruce).

The spruce beetle tactical matrix is based on the following tactics:

- Tactic 1: Fall and Burn
- Tactic 2: conventional trap trees
- Tactic 3: single tree harvesting of infested trees
- Tactic 4: small patch sanitation (< 1.0 hectare patches)
- Tactic 5: small clearcut (between 1.0 and 5.0 hectares or greater than 500m^3 and less than 2000m^3).
- Tactic 6: standard harvest practices (clearcut and clearcut with reserves)
- Tactic 7: no treatment

Spruce Beetle Tactical Matrix

Constrained Areas					
Area Type	***Risk Rating and Treatment Tactics***				
	Very Low	***Low***	***Mod***	***High***	***Very High***
Deferred Areas Within Prescriptions	1,3,7	1,3,7	1-6	1-6	1-6
Comments: • Applies to leave areas **available** for harvest later in the rotation where adjacent harvested areas have not met green-up. • Where patch size limits can be met, tactic 5 is available, otherwise use tactics 1-4 and retain 40% basal area, on a deferred area basis					
SMZ/Connectivity Corridors	1,3,7	1,3-6	1,3-6	3-6	3-6
Comments: restrictions as per LRMP					
Ungulate Winter Habitat	1-7	1-6	2-6	2-6	2-6
Comments: • As per Notice – *Indicators of the Amount, Distribution and Attributes of Wildlife Habitat Required For the Winter Survival of Ungulate Species in the Lakes (Morice) Timber Supply Area(s)*					
Visual					
Comments: • All tactics available as long as Visual Quality Objective is met.					

Riparian Features in Previously Harvested Blocks					
Area Type	***Risk Rating and Treatment Tactics***				
	Very low	***low***	***Mod***	***high***	***Very high***
Riparian Reserve Zones – streams, lakes, wetlands	7	7	7	7	1,3,7
Comments: • Maintain the integrity of the reserves. Meet the riparian objectives of the FSP. • Do not use conventional trap trees or pheromone baits within the riparian reserve.					
Riparian Management Zones – streams, lakes, wetlands	7	7	1,3,7	1,3,7	1,3,7
Comments: • Meet riparian management zone objectives of the FSP.					

Riparian Features in Blocks yet to be Harvested						
Area Type		***Risk Rating and Treatment Tactics***				
		Very Low	***Low***	***Mod***	***High***	***Very High***
Riparian Reserve Zones – streams, lakes, wetlands		7	7	7	7	1,3
Comments: • Target removal of current attack and Y1's. • The removal of incidental trees to facilitate this target should be kept to a minimum. • Do not use conventional trap trees or pheromone baits within reserve zone.						
Riparian Management Zones – streams, lakes, wetlands		7	1,7	1,3-6	1,3-6	1,3-6
Comments: • Do not use conventional trap trees or pheromone baits within the management zone. • Target beetles while maintaining the riparian objective of the FSP.						
Wildlife Tree Patch (Outside of riparian reserve)		7	7	1,3-6	1,3-6	1-6
Comments: • Depending on the size of the infestation, a number of options are available ranging from single-tree treatment to full removal of the patch with substitution. • If the WTP is not tied to a resource feature, then look for replacement location first, providing it meets stand level biodiversity targets in the FSP.						
Wildlife Trees		7	7	7	7	7
Comments:						
Coarse Woody Debris		—	—	—	—	—
Comments: Do not use green spruce to meet CWD objectives.						

Western balsam bark beetle (Dryocoetes confusus)

Ranking Rationale

Western balsam bark beetle is considered a high priority forest health factor in the Morice TSA, and a low priority forest health factor in the Lakes TSA. However, the current MPB epidemic may place greater reliance on balsam to mitigate timber supply impacts in the mid-term, therefore the priority of this factor may be increased in the future.

Management Tactics

The attack dynamics of balsam bark beetle do not lend themselves to direct control actions. Therefore, no tactical matrix has been developed for this beetle. Management will continue to be restricted to the harvest of infested trees as they occur within harvest settings resulting from typical development planning activities. Balsam bark beetle infested trees will not be explicitly targeted.

A study measuring the extent of losses due to western balsam bark beetle in the Morice TSA was initiated by the Ministry of Forest and Range's Regional Entomologist in 1999. Ongoing monitoring of these permanent sample plots will provide information regarding levels of IBB attack and losses.

MSMA (monosodium methanearsenate)

The use of MSMA in the Nadina Forest District ceased in 2004. The Ministry of Forests has made the decision that it will no longer use this chemical and that existing stock will be disposed of. A policy was developed in light of Forest Practices Board Audit that outlines management practices for the legacy MSMA-treated trees left in the forests.

The policy is located in **Appendix 12** along with a legacy-tree management brochure in **Appendix 13**. The main intent of the policy is to develop a provincial database that will detail the locations of legacy trees; that outlines a reporting system for when legacy trees are encountered; and states that legacy trees are to be left standing and conspicuously marked.

More information can be found at http://www.for.gov.bc.ca/hfp/health/MSMA.htm

TACTICAL PLAN 2009-2010

Spruce Bark Beetle BMUs

The tactical plan for IBS is (a) detection, thru ground and aerial recces, and (b) treatment thru the harvest salvage program, NRFLs and regular cutting permits. Reports of IBS activity by the public and tenure holders will be followed-up by District staff and an appropriate action plan devised. Given the limited funding for this season, single-tree treatments are not an option.

Mountain Pine Beetle BMUs

The majority of BMUs in the Nadina Forest District are Salvage with the exception of 3 Holding units in the north Morice TSA. The only work that will take place this year by the District is an annual aerial overview flight in the fall to update the strategies for the Emergency Bark Beetle Management Area focusing on the 3 holding BMUs.

Dothistroma

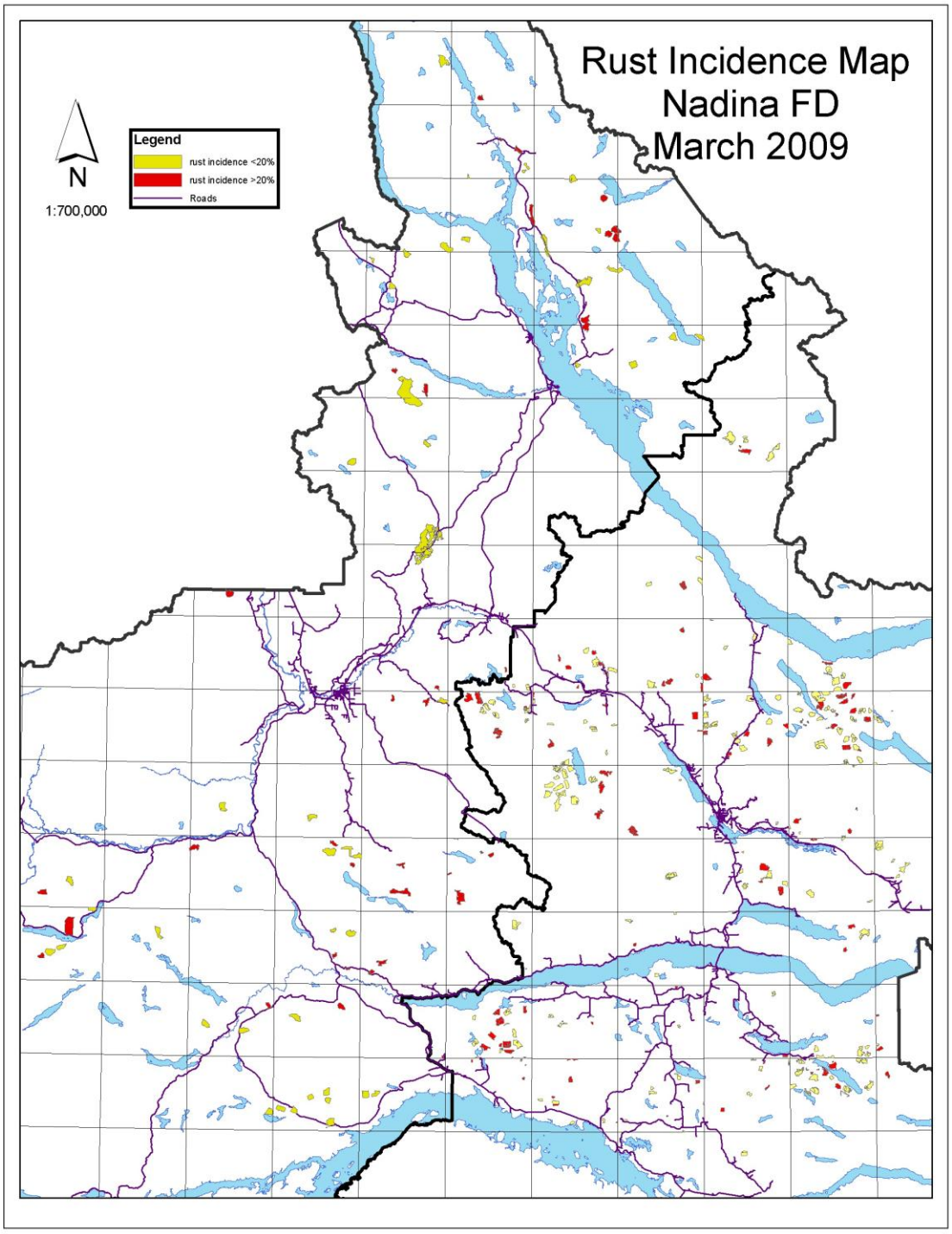
In May 2008, 78 randomly selected openings in the Morice TSA were sampled by low-level helicopter and ground-truthing. The results of the aerial survey indicate that 35% of these blocks have some level of Dothistroma. This information will provide a base for which to monitor the speed and magnitude with which this foliar disease is infesting pine stands.
In June 2009, 10 Permanent Sample Plots will be established the Morice TSA to monitor Dothistroma.

Rust Map update

Randomly selected plantations in the Morice and Lakes TSAs will be surveyed to measure current rust incidence and severity. This information will be used to generate an updated version of the Rust Map in **Appendix 1**.

APPENDICES

Appendix 1: Rust Risk Map



Appendix 2: Guidelines for Spacing of Lodgepole Pine

Date: Aug. 23, 2005

Background:

The current large outbreak of mountain pine beetle is unprecedented in the history of the province. This wide scale infestation is killing vast areas of mature and overmature lodgepole pine in most areas of the central interior. Estimates indicate that the outbreak will not subside until most mature pine has been killed. This will likely result in significant wood supply shortfalls in the mid-term.

A possible method to alleviate at least some of this mid-term shortage is to implement a large scale spacing program in juvenile stands of lodgepole pine. This will effectively accelerate their growth and may replace critical wood supplies lost to the beetle. Planning for such a program is being contemplated. Through the Forests For Tomorrow initiative.

However, there are risks associated with such a broad program. Inappropriate or mis-timed spacing operations may well lead to accelerated mortality in the treated stands due to mountain pine beetle and other agents such as *Ips*. The guidelines outlined below are intended to provide an acceptable risk level to spacing operations.

General Concerns:

- Recognize that spacing at certain times of the year may aggravate such agents as *Ips*
- Recognize that mountain pine beetle can and will attack small diameter stems when more preferred hosts are unavailable. While the pine beetle will likely not do well in these stands, they will kill the trees and continuing influxes from surrounding active infestations may lead to almost complete stand mortality.
- It is quite likely that spacing in areas of high beetle activity (pine beetle or *Ips*) may actually increase levels of mortality. Close spaced young stands with thin bark and phloem would have a higher resistance - spacing such stands may induce a shock to the stand for a year or so and may also increase susceptibility to beetles due to release.
- If a spacing program were to be put in place, it should be well at the rear of the infestation front (possibly locations such as Burns Lake or Vanderhoof), then move south and east over time.
- I*ps* populations are also increasing in many stands co-infested by mountain pine beetle, so *Ips* mortality to young stems may occur without there being large amounts of slash/debris that is usually necessary for *Ips* to build-up in
- Recognize that spacing programs in MPB areas are carried out under the principle of acceptable risk

Guidelines:

Regardless of where spacing is contemplated, all spacing operations should be carried out in late summer or fall, not in the spring. This timing will serve to minimize breeding sites for *Ips.* Further, spacing programs should be planned after consultation with Forest Health specialists; this is particularly necessary when spacing is contemplated in areas experiencing high levels of mountain pine beetle activity.

Areas selected for spacing in any given year but not treated in that year, must be re-evaluated in the following year prior to continuation of the treatment.

There are two general cases for spacing pine stands: stands that are in active Suppression areas where pine has not yet been overrun; and, stands in Holding or Salvage areas where high beetle populations still exist but where the beetle has subsided in some areas. Guidelines for these two cases are given below:

I. Suppression areas

- Anywhere after consultation with Forest Health specialists
- Re-evaluate annually
- Requires stringent application of "suppression" designation to ensure that beetle populations are not excessive
- Note the "final cautions" below

II. Holding and Salvage areas

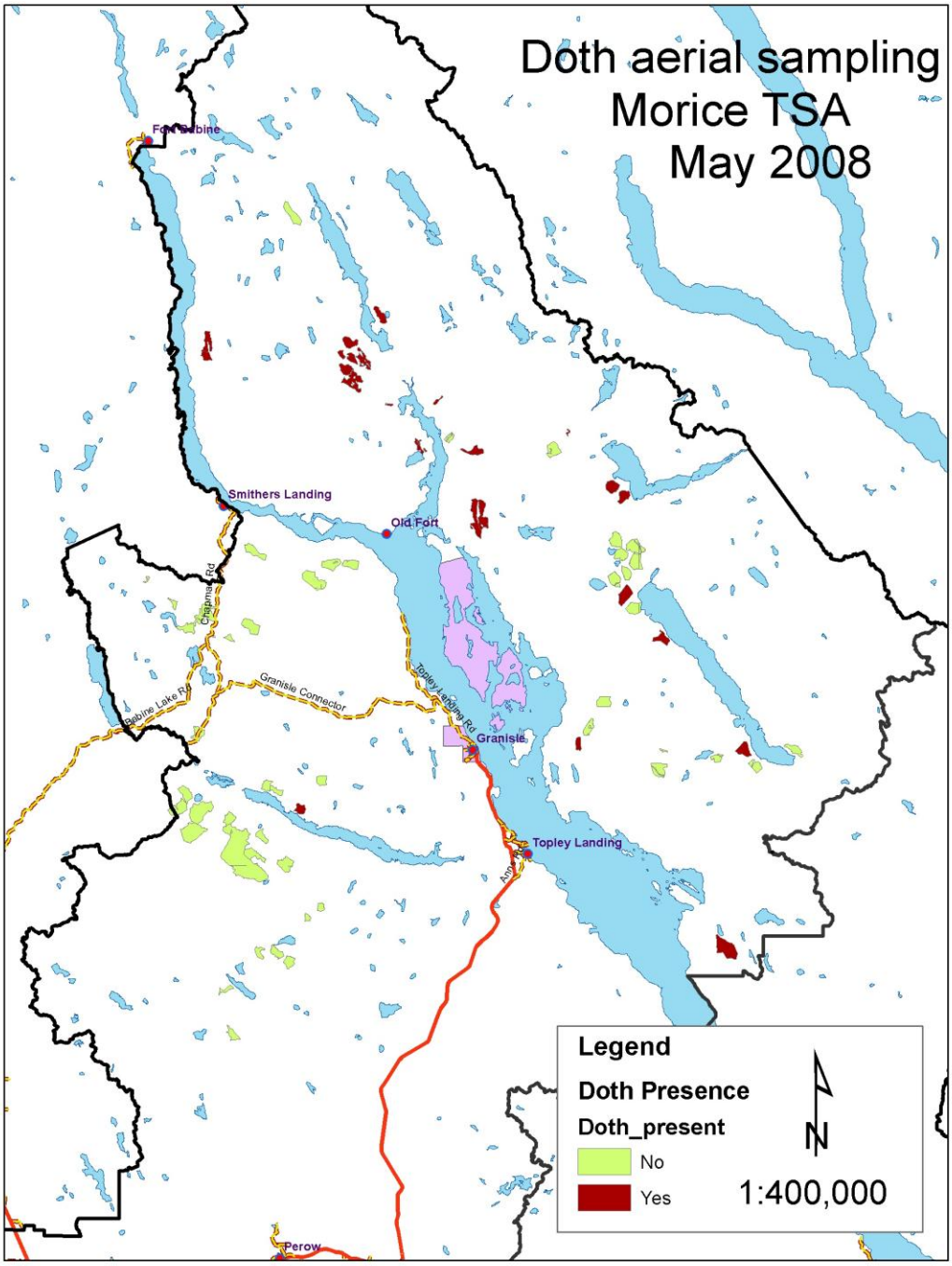
- As a general principle, spacing should occur at the back of the leading edge of the beetle outbreak in an area, well away from the beetle activity on the leading edge.
- Space with extreme caution; while such a program may be necessary, efforts must be taken to ensure resulting risk of loss is acceptable.
- Spacing plans to be formulated after consultation with Regional Forest Entomologists to ensure that estimates of beetle activity levels are appropriate.
- No spacing should be done within 1 km of an area where there is/was an active mountain pine beetle infestation within the previous 3 years
- Treatment of stands with a high intensity of rusts (as defined in the appropriate Guidebook) should be deferred for 2 more years
- Standards can be somewhat relaxed if species other than lodgepole pine comprise >60% of the stand.

Final Cautions:

1. There is some risk that thinning in suppression areas may predispose treated stands when outbreaks in the area intensify.
2. "Moving" stands into higher dbh classes may yield higher risk of subsequent beetle attack.
3. Depending on weather patterns, thinning may cause shock to the treated site for 1 or a few years which may predispose stems to attack by damaging agents.

Peter M. Hall
Lorraine Maclauchlan
Leo Rankin

Appendix 3: Dothistroma Incidence Map



Appendix 4: Characteristics of Common Foliar Diseases

Characteristics for field identification of

Common Foliar Diseases in the Lakes TSA

Dothistroma Needle Blight (aka: Red Band Needle Blight)

(*Mycosphaerella pini, aka Dothistroma septospora*)

Host Species: All native and non-native pines (of any age) are susceptible

What to look for:

- Red bands on dead, brown needles
- Small black fruiting bodies are visible once the outer layer of the needle epidermis is ruptured
- Infections occurring in the lower crown, or in older needles (giving the visual effect of having been burned from the bottom up)
- Older infected needles are usually shed in the summer or over winter, leaving a "tufty" or "Lion's Tail" look to the remaining healthy branches
- Infected needles initially show yellow-brown spots or bands and eventually turn reddish-brown

Dothistroma needle photos: Dave Weaver, BC Ministry of Forests and Range

Pine Needle Cast (aka: Lophodermella)

(*Lophodermella concolor, aka Hypodermella concolor*))

Host Species: Lodgepole Pine (usually young stands) is the primary host; restricted to "hard" pines.

What to look for:

- Needles infected in the previous year turn reddish-brown in the following spring and by summer turn straw coloured
- Fruiting bodies (small, oval depressions) are inconspicuous as they are the same colour as the infected needles
- Often found in association with *Hendersonia pinicola* (fruiting bodies appear as small, black dots on infected needles)
- Old infected needles are usually shed in the summer or over winter, leaving a "tufty" or "Lion's Tail" look to the remaining healthy branches

Lophodermella needle photo: Bob Erickson, Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Centre

Characteristics for field identification of

Common Foliar Diseases in the Lakes TSA

Hendersonia (aka: Needle Cast Parasite)

(*Hendersonia pinicola*)

Host Species: Pine

What to look for:

- Central half of infected needles bleached white
- Black stains on the bleached white portion of the infected needles (stains left behind from spore tendrils)
- Often found in association with Lophodermella concolor (in already infected needles)




Hendersonia photos: Natural Resources Canada, Great Lakes Forestry Centre Photo Archive

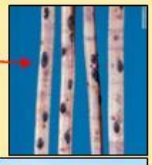
Lophodermium Needle Cast

(*Lophodermium pinastri, and Lophodermium seditsiosum*)

Host Species: All 2 or 3 needle "hard" pine species ("soft", "white" or "5-needle Pines" seem resistant).

What to look for:

- Needles have pale spots in early summer, and turn yellow to brown, giving a mottled appearance, eventually turning completely brown
- Oval, grey or black fruiting bodies (resembling a plastic change purse) scattered over dead needles
- In late summer look for characteristic narrow, black bars (only in *L. pinastri*) on the dead sections of infected needles; bars maybe accompanied by minute black spots. *L. seditsiosum* does not have these lines

Lophodermium photo: Natural Resources Canada, Great Lakes Forestry Centre Photo Archive

Characteristics for field identification of

Common Foliar Diseases in the Lakes TSA

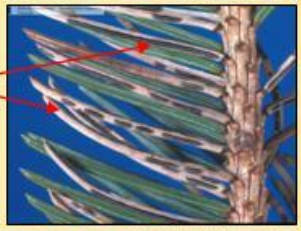
Spruce Needle Cast (aka: Lirula Needle Cast)

(*Lirula macrospora*)

Host Species: White, Black, Sitka and Engelmann Spruce

What to look for:

- The previous year's growth is affected (visible) due to a 2-year life cycle of the pathogen, current year's growth is usually not affected
- Fruiting bodies appear as elongate black lines, often running the full length of needles
- Dead needles are not shed and can stay on the tree for up to 2-3 years
- Needles start to turn brown in spring, eventually turning entirely brown, and then grey
- Infections are most common in the lower crown



Needle and Branch Photo: Natural Resources Canada, Great Lakes Forestry Centre Photo Archive Twig photo: Paul E. Hennon, USDA Forest Service, United States

Rhizosphaera (aka: Needle Blight)

(*Rhizosphaera kalkhoffii*)

Host Species: Spruce, (White Spruce, Engelmann Spruce and Colorado Blue Spruce are the most susceptible, Black Spruce, Sitka Spruce and Serbian Spruce are also affected, Norway Spruce seems to be resistant.)

What to look for:

- Infections in current season's needles on lower branches (as spores are dispersed by dripping water)
- Infected and healthy branches appear together
- During late summer and early autumn, infected needles are yellow and mottled in appearance, eventually turning brown or purplish brown in colour

Rhisophaera photo: Natural Resources Canada, Great Lakes Forestry Centre Photo Archive

Characteristics for field identification of

Common Foliar Diseases in the Lakes TSA

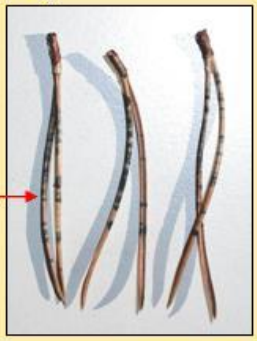
Phaeoseptoria (aka: no common name)

(Phaeoseptoria contortae)

Host Species: Pine

What to look for:

- Red needles with black, transverse tiger stripes
- Current year's needles infected/attacked after full leaf-out



Phaeoseptoria photos: Alex Woods, BC Ministry of Forests and Range

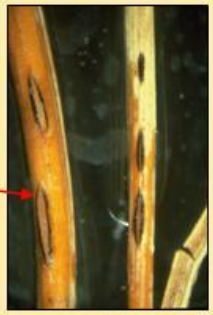
Elytroderma Needle Cast

(Elytroderma deformans, aka Hypoderma deformans)

Host Species: Lodgepole and Ponderosa Pines; restricted to "hard" pines

What to look for:

- Elongated, black fruiting bodies of various lengths (average 10mm) forming ridges and streaks on freshly killed red-brown needles
- Needles become straw-coloured when fruiting bodies are mature
- Groups of infected needles turn red and form conspicuous flags in the spring
- Infections can cause stunted growth or witch's brooms on infected branches



Elytroderma photo: Natural Resources Canada, Great Lakes Forestry Centre Photo Archive

Characteristics for field identification of

Common Foliar Diseases in the Lakes TSA

Davisomycella (aka: Tar Spot Needle Cast)

(*Davisomycella ampla, aka Hypodermella ampla*)

Host Species: Lodgepole Pine in BC, Shore Pine

What to look for:

- White, light, or straw-coloured infection areas are often separated from green tissue by an orange-brown band
- Oval, black fruiting bodies form on straw-coloured portions of needles.
- Fruiting bodies are relatively large, roughly the size/diameter of pencil lead.

Davisomycella photos: Natural Resources Canada, Great Lakes Forestry Centre Photo Archive

APPENDIX 5: FOLIAR DISEASE FREE GROWING DAMAGE STANDARD FOR DETERMINANT GROWTH CONIFERS

2004 11 02

The following Free Growing Damage Standard applies to determinant growth conifer species including true firs, spruce, pines, and Douglas fir. This standard does not apply to hemlocks and cedars that exhibit an indeterminant growth pattern. With determinant growth species it is possible to count internodes or years of growth. This standard is based on a comparison of the number of years of healthy needle retention, or healthy internodes, to an assumed healthy average of four years of needle retention. Determinant growth conifer species vary considerably in their ability to retain needles but for this standard, it is assumed that 4 years is the healthy benchmark.

The Free Growing Damage Standard for defoliation covers damage caused by both defoliating insects and foliar diseases. For all insect defoliators and all but one foliar disease, the damage threshold is 20%. Dothistroma* needle blight is the sole exception. Recent experience in northwest BC has shown that a 20% threshold for foliar retention is too low to define a **healthy** tree. The Free Growing Damage criteria for Dothistroma in the ICH, CWH and SBS is 50% foliar retention. Based on current observations of Dothistroma dynamics, a foliar retention threshold of 50% represents a more realistic threshold at which there is a reasonable likelihood that the stand will remain in a free growing condition.

The pattern of defoliation varies widely among different damaging agents. Some foliar diseases, for example, attack only the current year's growth while others attack everything but. The three steps outlined below should guide surveyors to an appropriate call regardless of the pattern of damage.

The following steps should be followed to estimate the extent of healthy foliage. If a tree contains **more than** 2**0%** of its foliage (more than 50% for Dothistroma) it is believed that the tree has a good chance of recovery if the foliar disease or defoliating insect infestation were to subside, and so will be considered **Free Growing.**

Step 1. Estimate the % Live Crown

Visually draw a line perpendicular to the stem at the lowest point a green internode exists. A green internode is one in which > 50% of the needles in the internode are healthy. Estimate to the nearest 10% the extent of live crown. At age 10-15 healthy well-spaced conifer trees should normally have green needles close to the ground or 100% Live Crown.

Step 2. Estimate the % of Healthy Internodes

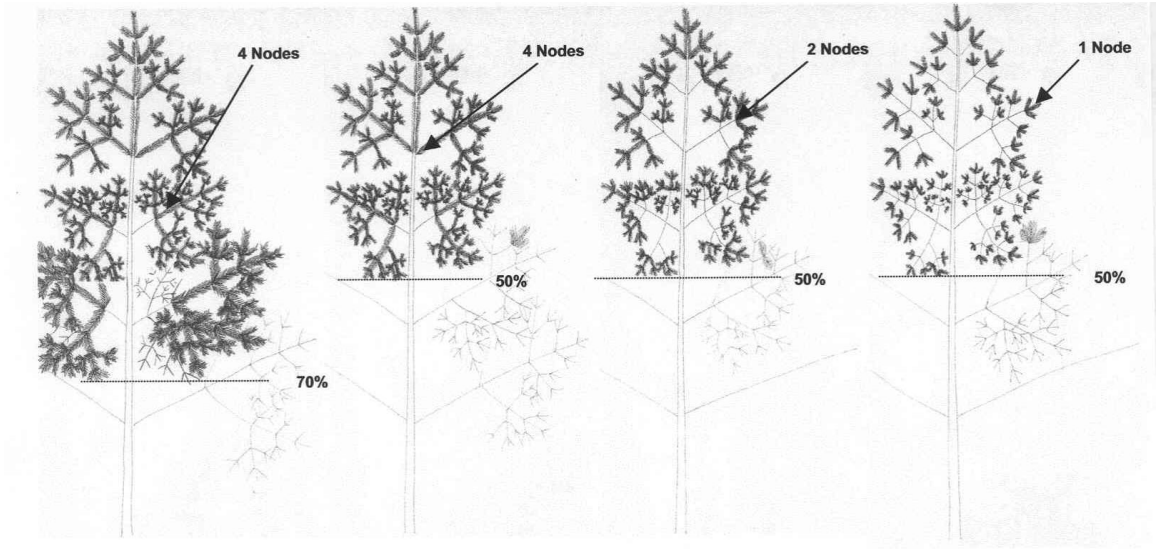
Normal healthy conifer species trees should have a full needle compliment on 4 elongated internodes. If the survey is conducted prior to bud set (July 15) the current year's growth is not included. Surveys conducted after July 15th will include the current year's growth. Assess a representative branch from the midpoint of the live crown (as determined in Step 1). Determine how many of the four internodes have greater than 50% undamaged needles. Damaged needles are defined as needles that are not green. In order for an internode to be considered healthy, more than half of the needles in that internode must be green. Determine the % healthy internodes by dividing the number of healthy internodes by 4 and multiply by 100. In cases where the number of healthy internodes varies from branch to branch at a given whorl choose a representative one. (ie. Do not attempt to pass (or fail) a tree by choosing an unrepresentative branch).

Step 3. Estimate Extent of Foliage %

Multiply the % Live Crown estimated in Step 1 by the % healthy internodes in Step 2, the product is the extent of Foliage. If this value **exceeds 20%** the tree is Free Growing, provided it passes all of the other Free Growing Damage standard criteria. In the case of trees attacked by **Dothistroma** needle blight this product must exceed **50%**.

*Dothistroma needle blight symptoms include a scorched appearance with most damage occurring at the base of trees and progressing upwards. On individual needles bright red bands typically form at the interface between damaged and green foliage. Fruiting bodies often form within these red bands and consist of small black ball-like structures that cause small rips and raised flaps in the epidermis of dead needles.

Examples



a)	b)	c)	d)
70% Live Crown	50% Live Crown	50% Live Crown	50% Live Crown
4/4 Healthy Nodes	4/4 Healthy Nodes	2/4 Healthy Nodes	¼ Healthy Nodes
70% X 100%	50% X 100%	50% X 50%	50% X 25%
= 70%	**= 50%**	**= 25%**	**= 12.5%**

Appendix 6: Are Free-Growing stands meeting timber productivity expectations?

FREP

REPORT SUMMARY #16

April 2008

ARE FREE–GROWING STANDS MEETING TIMBER PRODUCTIVITY EXPECTATIONS IN THE LAKES TIMBER SUPPLY AREA

Prepared by
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Wendy Bergerud, Senior Biometrician, Research Branch, Victoria, B.C

EXECUTIVE SUMMARY

The current administrative milestone for ensuring effective reforestation is the free-growing declaration. When the free-growing milestone is achieved, it is assumed that the young managed stand is on a trajectory that will result in a productive mature stand. Currently, no monitoring procedures are in place to determine if free-growing stands are meeting these expectations. This study examines whether the reliance that has been placed on this policy is supported by stand performance from a timber yield perspective.

Sixty randomly sampled free-growing stands were evaluated in the Lakes Timber Supply Area (TSA) in central British Columbia. Sample stands were grouped into two classes based on the number of years since free-growing declaration: half were declared between 1987 and 1994 (early), and the other half were declared between 1995 and 2001 (late). All sampled stands were greater than 15 ha in size, and were surveyed using fifteen 3.99 m radius survey plots.

We used the silvicultural planning model TIPSY to estimate projected volume at a rotation age of 80 years. The mean projected volumes at rotation based on free-growing declaration values were not significantly different from volume projections based on 2005 stand attributes for either the early or late groups. Based on declaration attributes, the mean projected volumes for the early and late groups were 327 and 316 m^3/ha, respectively. Using 2005 stand attributes, projected volume for the early and late groups were 324 and 314 m^3/ha, respectively. These projected values closely match the projected values from the most recent timber supply data package for the Lakes TSA. The mean density of both well-spaced and free-growing stems has remained relatively stable since declaration with both the early and late groups at or close to 1000 well-spaced stems per hectare.

The only significant difference for the late group was the marked increase in forest pest incidence, which was also found in the early group. Over 27% of all declared free-growing, pine-leading stands had greater than 20% hard pine rust incidence, with pine-leading stands representing 90% of the sampled managed stands. The increase in pest incidence is probably due to a combination of increased recognition, as well as real increases in forest pests. The

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To be a world leader in resource stewardship monitoring and effectiveness evaluations; providing the science-based information needed for decision-making and continuous improvement of British Columbia's forest and range practices, policies and legislation.
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vast majority (84%) of pest-affected trees in stands that no longer pass the minimum stocking level (i.e., 700 free-growing stems per hectare based on the lower confidence limit test) are in the 4 m+ height class. In 2005, one of the stands in the early group was identified as being attacked by mountain pine beetle, with 70–75% of the trees infested. As of November 2007, mountain pine beetle had attacked an additional 10 stands in the early-declared group. The incidence of red-attack in these stands ranged from approximately 1% to close to 20%.

Conclusions

Our analyses suggest that free-growing declarations may occur too early in the life of stands to provide an accurate projection of future stand productivity. The likelihood of making overly optimistic projections of stand productivity increases the earlier stands are declared free-growing, as the influence of forest health factors is not yet realized. Our study involved an intensive examination of stand conditions on the ground and demonstrates the importance of more intensive monitoring of free-growing stands. A mid-rotation assessment of stand productivity and forest health would provide more confidence particularly in light of climate change. A program to survey post-free growing managed stands should be developed. We intend to conduct similar assessments in other timber supply areas.

Recommendations

Management of forest and range resources is a complex process that often involves the balancing of ecological, social, and economic considerations. Many FREP monitoring reports represent a single facet of this process. Based on monitoring data and analysis, we offer the following recommendations for consideration to those who develop and implement forest and range management policy, plans, and practices.

1. Although the majority of free-growing stands in the Lakes TSA are currently meeting timber productivity expectations, those that are not are dominated by lodgepole pine and have low initial densities, which are further compromised by forest health agents. In areas where species options are limited to lodgepole pine, increasing initial planting densities should be considered[1]. In areas where species options are not limited, we recommend increased species diversity.
2. Silviculture survey training and accreditation should include a mandatory update of forest health agent field identification training to ensure that free-growing surveys accurately capture the incidence of forest pests. We also recommend closer field inspections of contract survey work to ensure forest health agents are properly identified.
3. Mid-rotation field assessments of stand productivity and comparison of current volume with TASS/TIPSY projections would improve the level of confidence in timber supply projections and help refine the TASS/TIPSY models. Methods specifically designed to accomplish this need to be developed. This would include developing a field protocol for the collection of data suitable for input into TASS/TIPSY as well as possible modifications to TASS/TIPSY to facilitate these assessments.
4. For a stand to be declared free-growing, the 90% lower confidence limit (LCL) associated with the estimate of the mean should be greater than the minimum acceptable stocking level. Using the LCL decision rule would significantly reduce the liability of the Crown when accepting understocked stands as free-growing.
5. TSA performance measures could include a requirement for an acceptable minimum proportion of stands to remain free-growing. To accomplish this, a minimum stocking threshold for post–free-growing stands should be established that better represents stands at this stage of development (i.e., a minimum of 700 free-growing stems per hectare may not be appropriate for a 35-year-old stand).
6. Our analyses suggest that free-growing declarations occur too early in the life of stands to provide an accurate projection of future stand productivity. A mid-rotation assessment of stand productivity and forest health would provide more confidence. A program to survey post-free growing stands should be developed. Survey results should populate a new inventory of managed stands in the province.
7. Policy-makers should consider how well free-growing policy will continue to uphold the B.C. Ministry of Forest and Range's stewardship mandate, given the uncertainty associated with the direct and indirect effects of climate change. A free-growing designation presupposes that young trees will continue to grow and thrive in a relatively stable environment.

More Information

For additional information on FREP, please refer to our website at: *http://www.for.gov.bc.ca/hfp/frep/index.htm*

1 In lodgepole pine dominated stands where hard pine rust incidence is high, initial planting densities of 1600 sph too often lead to insufficiently stocked stands post free-growing. Based on local experience the Regional Pathologist recommends 2500 sph.

FREP Forest & Range Evaluation Program

The FREP Report Summary is a regular publication of the Forest and Range Evaluation Program designed to inform stakeholders on program development and implementation, and report on the results of evaluation projects.

Appendix 7: Forest Health Risks to Commercial Tree Species

From Alex Woods' email to Forest Heath specialists April 11, 2005.

Possible Climate Change Impacts on Commercial Tree Species

Lodgepole pine:

- virtually all known pest risks associated with the species will increase under CC
- MPB is obvious
- changing pathosystems for DSG and DSC with possibility of increasing frequency of wave years with higher than normal spring and early summer precip
- behaviour of pathogens that we thought we understood now changing, eg high risk period for rusts extending, no longer safe after age 15.

Douglas-fir:

- biggest issue in the past with Fd in MS and SBS ecosystems has been growing season frosts
- will Fd be able to replace Pl in SBS as the latter species suffers increasingly from pests under CC
- need to look at the frequency of late spring growing season frosts in most recent decade and compare to the 1961-1990 normals to see if CC is affecting that frequency
- Budworm could be a bigger problem further N if Fd was deployed to a greater extent
- Armillaria and P. weirii could and probably will move north under CC
- foliar pathogens could be more of a concern in future under CC
- Fd will be drought stressed in drier ecosystems (summer drought), which can lead to bark beetle attack and mortality [stressed fir is both more attractive and less resistant to bark beetles] - this in turn will lead to ecosystem changes (e.g. expansion of PP).

Western hemlock:

- A. Hamann's work suggest conditions for Hw will improve throughout current SBS under CC
- Hw can't handle summer drought but if mean summer precip will increase as most recent decade indicates for western SBS then could be deployed further
- Hw within drier variants (and on shallow soils) within CWH have shown effects of summer drought (die back and mortality)

Larch, western and Siberian:

- better set for colder environments but possibly could handle drought too and possibly help replace Pl in SBS as environments change
- Gerry Rehfeldt has done considerable work on larches, need to tap into that
- Research group in Kamloops has been cautioning about use of Lw in Lilloet (very light demanding, have to watch species mix)

Spruce:

- increased losses due to leader weevils - increased range and hazard of spruce weevil
- increased losses to foliar disease (Rhizosphaera kaukhoffii) etc.
- spruce beetle lifecycle completed in one year = increased attack

Western redcedar:

- could be deployed to greater extent under CC in NIFR
- Cw is showing more promiss for dealing with Arrmillaria

- as Armillaria moves N probably need to move Cw N
- increased foliar disease in current range of Cw under CC
- Cw slowly dropping out of CDF as a result of summer drought

True firs:

- subalpine -fir range will shrink as tree line goes up under CC
- foliar diseases will increase under CC
- increased risk of balsam woolly adelgid spreading into interior forests

Broadleaf species:

- die-back issue with drought for Ep
- At better adapted for drought
- foliar diseases have been a concern recently in NW where increased summer precip has occurred.

Possible Climate Change Impacts on Pests

- Armillaria will move N
- Budworms will flourish
- Leader weevils will flourish and spread
- rusts and foliar diseases will flourish if spring and fall moisture increases
- Pythiums and Phytopthoras in seedlings in spring will get worse in young stands
- SOD and other nasty diseases will become more prevalent
- P. weirii will move N as drought conditions move N and favour this pathogen that is very responsive to moisture
- Tomentosus may be displaced by Arm. and Phellinus however if we end up with more spruce due to reductions in Pl deployment we could have more Tomentosus
- expansion of insect ranges northward and up in elevation
- BEC variant boundaries are probably changing; trees within these margins will find that the conditions under which they established and grew are changing; these changing environmental conditions will stress them; stressed trees are generally more susceptible to pests.

Appendix8: Example of Decision-Focused Risk Assessment

A Decision-Focused Risk Assessment for Forest Health under Climate Change

(AJ. Woods, with input from A. Britneff, P. Hall, S. Hoyles, L. MacLauchlan, L. Rankin, K. White, D. Wilford, and S. Zeglen.)

"The overall risk varies…the primary determinants of risk are the potential for a high magnitude impact coupled with scientific uncertainties that prevent precise forecasting of the situations that will be highly risky." Compass Resource Mangement Ltd. 2004

"Focus on the decision process.
Science serves decisions; it does not make them.
A better decision process will lead to more transparent and defensible decisions (withstand public, auditor, regulatory scrutiny).
Decision makers must commit to a more active role." Compass Resource Mangement Ltd. 2004

"Risk assessment is the process of estimating the consequences of defined management options on defined management endpoints, with explicit expression of the uncertainties in these estimates." Compass Resource Mangement Ltd. 2004

Introduction:
The scientific uncertainty surrounding the specific direction of climate change, particularly regarding precipitation, has significant consequences for forest pests, their hosts and forest management in BC. Climate change will directly affect the environment which will indirectly affect the host, the damaging agents (insects or fungi) and the resulting damage (Figure 1).

Figure 1. The disease triangle altered to account for both disease and insects.

Published scientific evidence of the unpredictability of the behaviour of forest pests under changing precipitation regimes (eg. Dothistroma needle blight (Woods et al 2005)) illustrates this vulnerability. To date, other examples of the impacts of climate change on the forests of BC have been more predictable. One would expect trees in areas of the southern interior to eventually succumb to drought if the drought was severe and prolonged. Similarly, one would expect that mountain pine beetle populations could again reach epidemic levels in the absence of killing winter conditions given the preponderance of over-mature lodgepole pine throughout much of the interior and the history of such occurrences (Safranyik 1988). That said, the extent and the duration of this epidemic is beyond almost everyone's expectations. In the case of Dothistroma, a relatively small increase in the frequency of warm-rain events coupled with a recent increase in mean summer precipitation tipped the scales in favour of the pest. That pest has in turn had devastating consequences for lodgepole pine dominated plantations in the ICH zone of northwest BC. This result was not so predictable. One would have expected that lodgepole pine would benefit from increased precipitation and warmth during the growing season (Rehfeldt et al. 1999). Our past experience with Dothistroma in BC would not have led us to predict the current situation.

The Dothistroma example highlights the uncertainty regarding forest pests and their hosts throughout much of the province. The combinations of hosts and their suite of pests will of course be different depending on location but the scientific fact remains that short-lived insects and fungi will be able to adapt to new environmental conditions under climate change much more quickly than their long-lived hosts. We don't know how these relationships will play out but we predict they will occur. In some cases these new relationships could be positive for some forest resources. In others there is a high probability that these new relationships will be negative, particularly in terms of timber productivity. This reality coupled with the inherent uncertainties associated with global climate change places forest management under a significant cloud of uncertainty.

The indirect impacts of climate change on BC's forests orchestrated by forest pests will present varying opportunities for management intervention. In mature unmanaged forests our options for interventions will be confined to being reactive rather than proactive as the forests, their species mixes and genetic diversity, are set. We will have to wait and see what the next pest outbreak or environmental stressor will be, and then react. In contrast, the establishment of new forests can be managed proactively. We can increase diversity both in terms of genetics and species, we can also adjust establishment densities to increase the resiliency of managed stands and to reduce the risk associated with climate change and its indirect affects on pest/host interactions. For this reason in this example we have chosen to focus the Decision-Focused Risk Assessment for Forest Health on young managed stands.

The Forests For Tomorrow (FFT) initiative provides an opportunity to implement forest management recommendations with a longer term focus. The stands established under FFT are predicted to experience significant environmental changes over their rotation due to climate change, see Hamann and Wang (in press). The FFT program could demonstrate measures that could be used to improve the resiliency and adaptive capacity of forests throughout BC.

Decision-Focused Risk Assessment for Forest Health

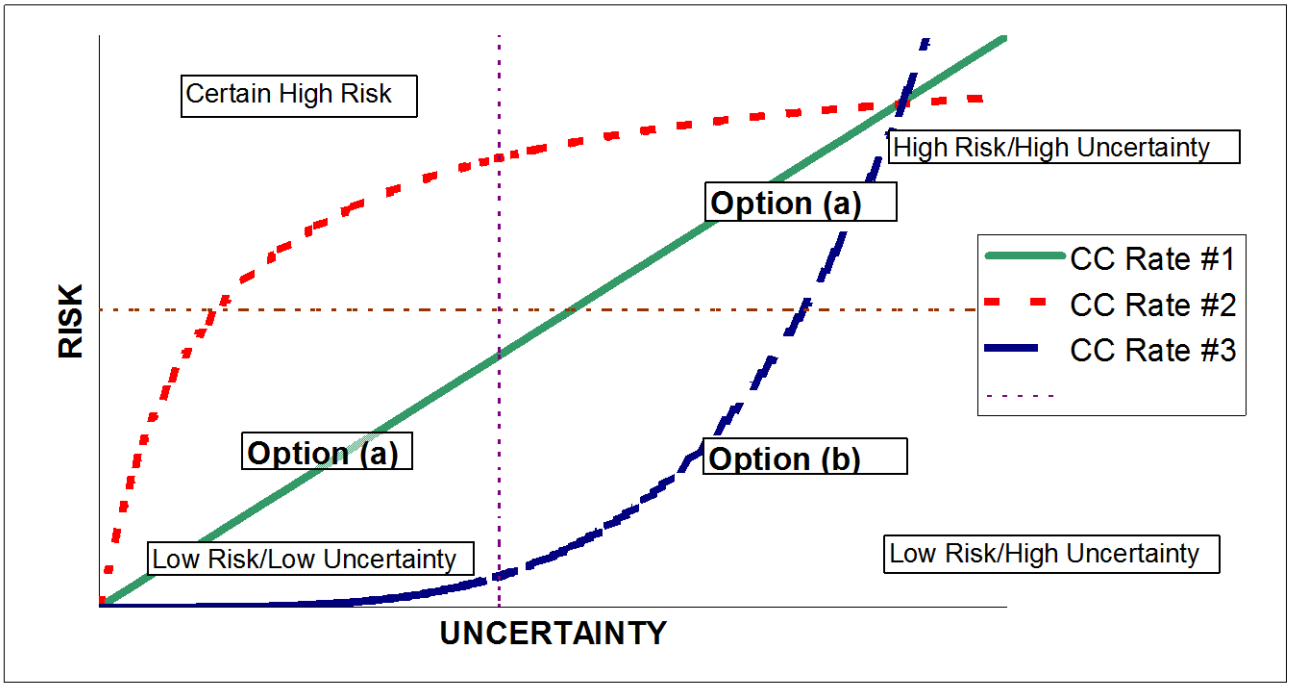
Question:	What is the predicted impact of Climate Change on: • managed stand resiliency, • forest management sustainability, • timber supply predictability, • managed stand productivity, • multiple use availability, and • community stability. considering CC's relationships with Forest Health agents if we: (a) follow current practices regarding species selection and stocking standards until direction of CC is more clear, or (b) increase species and genetic diversity at the stand and landscape level by ensuring that all currently preferred and acceptable tree species are incorporated into intimately mixed plantations **AND** application of the projections of changes to BEC boundaries predicted by Hamann and Wang (in press) to incorporate a proportion (up to 20%) of the dominant commercial tree species from the 2025 projected BEC zone distribution?	
Objectives and Endpoints	• Resilient managed forests capable of coping with uncertainty of CC, • Sustainable forest management, • Stable, predictable Timber Supply, • Productive managed stands, • Maintenance of diversity of uses for forest land,	

	• Stable forestry dependent communities • Minimal disruption/cost to forest industry.	
Information on Impacts Information on Impacts	**(1) Likely impacts of alternative (a): follow current practices regarding species selection and stocking standards until direction of CC is more clear:** **Resilient managed forests**: Our current practice regarding species selection and stocking standards is based on the philosophy that there is a "best" species or combination of species which in turn is based on years of experience under relatively stable climatic conditions and the assumption that environmental conditions including host/pest relationships are stable. Given our current understanding of Climate Change and our experience with host/pest interactions thus far, following (a) could delay the creation of resilient managed stands because we may well continue to choose the wrong "best" species or the wrong "best" provenance of a species until it is clear we have made a mistake. **Sustainable Forest Management**: We have seen what can occur when a change in the climate favours a pest (Woods et al 2005). We also have published science (Hamann and Wang 2005) that predicts the climatic conditions that resulted in managed stand failures in the ICH could occur in large portions of the SBS by 2025. We do not know precisely what will happen under CC but we do know that large-scale plantation failures are possible in the ICH because we have already seen it happen. Other areas of the province are predicted to become drier. It is possible that if we continue to follow option (a) in those areas, less drought resistant species may continue to be planted until it is obvious that moisture deficits will threaten their survival. Under option (a) we would wait until a predicted result becomes a reality and then change. This option may hamper our ability to achieve the objective of Sustainable Forest Management if the climate continues to change at current rates. **Stable, predictable Timber Supply:** If rotation periods for our commercial tree species were much shorter (25 years?) we could follow option (a) and achieve the objective of a predictable Timber Supply, adjusting species preferences to maintain stability as new evidence of CC/Forest Health impacts became apparent. In general we do not currently manage for short rotation species nor are most of our current commercial species suited to such management, with the exception of some deciduous species. If, however, the climate does not change as quickly as predicted we will have sufficient time to adapt to new conditions under option (a). **Productive managed stands**: Evidence that suggests that FH/CC interactions are already leading to less productive managed stands is mounting. Lodgepole pine is no longer a preferred species in the NW ICH because of Dothistroma needle blight (Woods et al 2005). Young lodgepole pine mortality due to Warren's root collar weevil has increased, to the point that stand rehabilitation is required in some stands (MPB epidemic is forcing the weevils out of mature forests into managed stands, MPB epidemic has been linked to CC (Carroll et al. 2004)). The incidence of hard pine rusts in pine stands of central BC has increased significantly over the past two decades based on a review of published articles (van der Kamp and Spence 1987, Woods et al. 2000). Foliar diseases that historically have been so insignificant that identification guide books do not include them as pests in BC are frequently being reported in Free Growing surveys in central BC (eg. *Phaeoseptoria contortae*, *Rhizoshaera kaukhoffii*). If we continue under option (a) until it is even more evident that climate change may be affecting our ability to maintain productive managed stands, we forego potential increases in productivity that we might have	

Information on Impacts	been able to obtain through the use of a mix of potentially pest and climate change resistant species. **Maintenance of diversity of uses for forest land**: Our ability to achieve this objective is likely similar under both option (a) and (b). If timber productivity is the priority for an area option (a) is the most vulnerable option to the indirect impacts of Climate Change on host/pest interactions. Other resource values such as range, recreation and biodiversity may benefit under option (a) or at least be neutral. **Stable forestry dependent communities**: Forest pests are just one of many factors influencing community stability. Following option (a) perpetuates the reactive management approach which can lead to boom-bust situations such as the current MPB epidemic. If we wait until there is another obvious problem before we adjust practices we inevitably experience greater instability in terms of timber supply which in turn affects community stability. If Climate Change does not occur as quickly as predicted the difference between option (a) and (b) diminishes as does the respective affect on community stability. **Minimal disruption/cost to forest industry**: Option (a) results in no disruptions to current practice and no increase in cost to industry in the short term. In the short term option (a) is lowest risk because current species selection guidelines are based on past experience regarding tree species and their favoured environmental conditions, conditions that are assumed to be relatively stable. If the trajectory of current climate change projections and indirect impacts on forest health agents become reality, costs to industry could rise sharply as efforts required to reforest areas increase due to plantation failures and poorly adapted provenances. The increased uncertainty associated with climate change could lead to an extension of the Free Growing obligation period, as high-risk species become less acceptable to grow. If climate change does not occur as quickly as predicted option (a) is least cost. **(2) Likely impacts of option (b) increase species and genetic diversity at the stand and landscape level by ensuring that all currently preferred and acceptable tree species are incorporated into intimately mixed plantations AND application of the projections of changes to BEC boundaries predicted by Hamann and Wang (Ecology, in press) to incorporate a proportion (up to 20%) of the dominant commercial tree species from the 2025 projected BEC zone distribution** **Resilient managed forests**: Increasing the diversity of species deployed in plantations through the use of intimately mixed plantations will inherently increase the resiliency of managed stands. The probability of a single forest pest having the ability to severely impact the productivity of a stand is virtually zero if that stand is made up of intimate mixes of a variety of host and non-host species. Under option (b) managed stands would be more resilient and more capable of coping with the indirect affects of climate change whatever the next pest outbreak may be. Following option (b) also reduces the probability of creating non-productive areas. **Sustainable Forest Management:** Increasing diversity in plantations through the use of intimately mixed species and families within species (option b) will improve our chances of achieving the objective of sustainable forest management. The current MPB epidemic has emphasised the importance of diversity in the landscape	

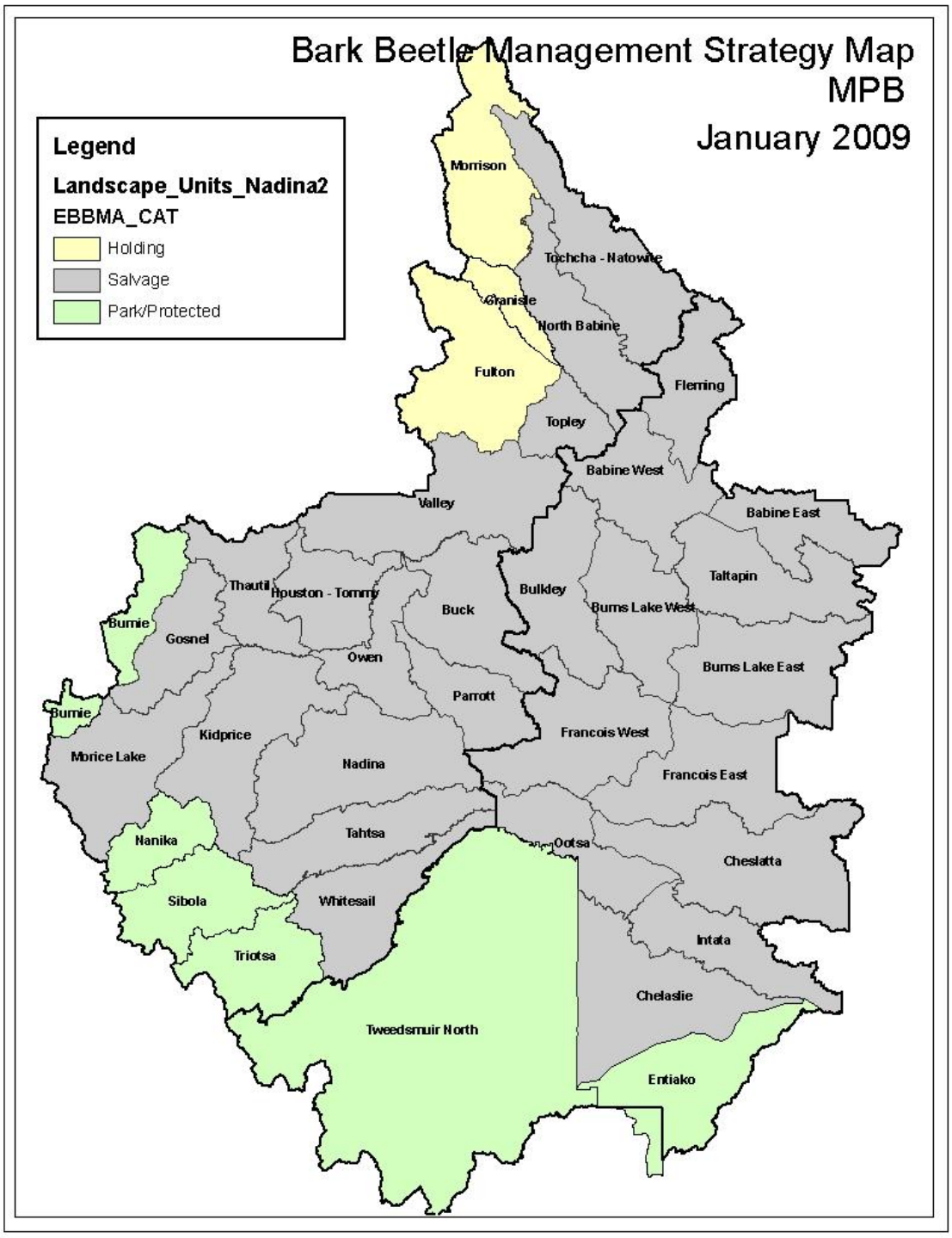
	and the role of diversity in the achievement of sustainability. A diversity of age classes within a single host species dominated landscape would have resulted in a forest that can be managed more sustainably. In the post MPB situation, under the cloud of uncertainty attached to Climate Change, a diversity of species, intimately mixed, and a diversity of stand structures offers a better chance of achieving sustainability. **Stable, predictable Timber Supply**: Experience thus far with the affects of Climate change on host/pest interactions suggests that the stability and predictability of timber supply will be challenged regardless of the option chosen. Though timber supply modelling may be more difficult under option (b), stability and predictability may improve under this option as the probability of plantation success improves despite the myriad combinations of host/ pest interactions under climate change. Some productivity loss is implied by including acceptable species as well as preferred in option (b). **Productive managed stands**: The speed at which the climate is predicted to change over the next rotation will compromise the productivity of managed stands regardless of the option chosen. Currently preferred species will be challenged by novel host/pest and climate interactions. Some species will cope better than others but we do not know how these new interactions will play out. If we follow option (b) we have a higher probability of having some trees that do cope better. As we see the new host/pest interactions develop we can adapt species mixes to maintain productivity of managed stands on the land-base. Having the variety of species already deployed in intimately mixed plantations buys time and provides an opportunity to have a scientific basis for management decisions (adaptive management). **Maintenance of diversity of uses for forest land**: Our ability to achieve this objective is likely similar under both option (a) and (b). If timber productivity is the priority for an area option (b) is the least vulnerable option to the indirect impacts of Climate Change on host/pest interactions although there are some implications for timber supply due to increased use of alternate species. **Stable forestry dependent communities**: Following option (b) allows for greater adaptability and promotes a more proactive forest management approach which should lead to more stability in timber supply and related community stability over the mid to long term. Overall volume will most likely drop due to climate change under either option but option (b) may limit the extent of the drop. **Minimal disruption/cost to forest industry**: Option (b) would require change to current forest practices which would result in increased costs to industry in the short-term. It is likely that a new silviculture survey approach would be required - one that would consider the diversity of species and genetics within species as the primary goal rather than achieving a minimum height in a minimal period of time. The short-term increase in costs associated with option (b) would result in less disruption/cost to industry over the mid- long term provided climate change and the indirect impacts of climate change on forest health agents occur as predicted (Logan et al. 2003).	
Decision Guidance	There are inherent risks associated with both options due to the degree of uncertainty associated with climate change. The magnitude of the risks depends a great deal on the rate at which the climate changes (Figure 2). If the climate changes more quickly than predicted there is a high degree of certainty that forests will be at very high risk not only from forest health agents but from fire, floods and many other	

	factors regardless of the option chosen. If the climate changes more slowly than predicted there should be sufficient time to alter species selection and stand management practices to adapt to the new environments under option (a). Hansen et al. (2005) suggest that the climate is already changing and that given the inertia within the system, this change will continue even if we were able to immediately cut greenhouse gas emissions entirely. The predicted changes to BEC zone boundaries of Hamann and Wang (in press) are based on several "middle of the road" projections of the rate of climate change. These predicted changes have significant implications for forest health and forestry management in general. Option (b) may not go far enough to provide sufficient managed stand resiliency if the climate changes too quickly but it does provide a less risky option than (a). The Forest Health group recommend option (b) be implemented through FFT.	

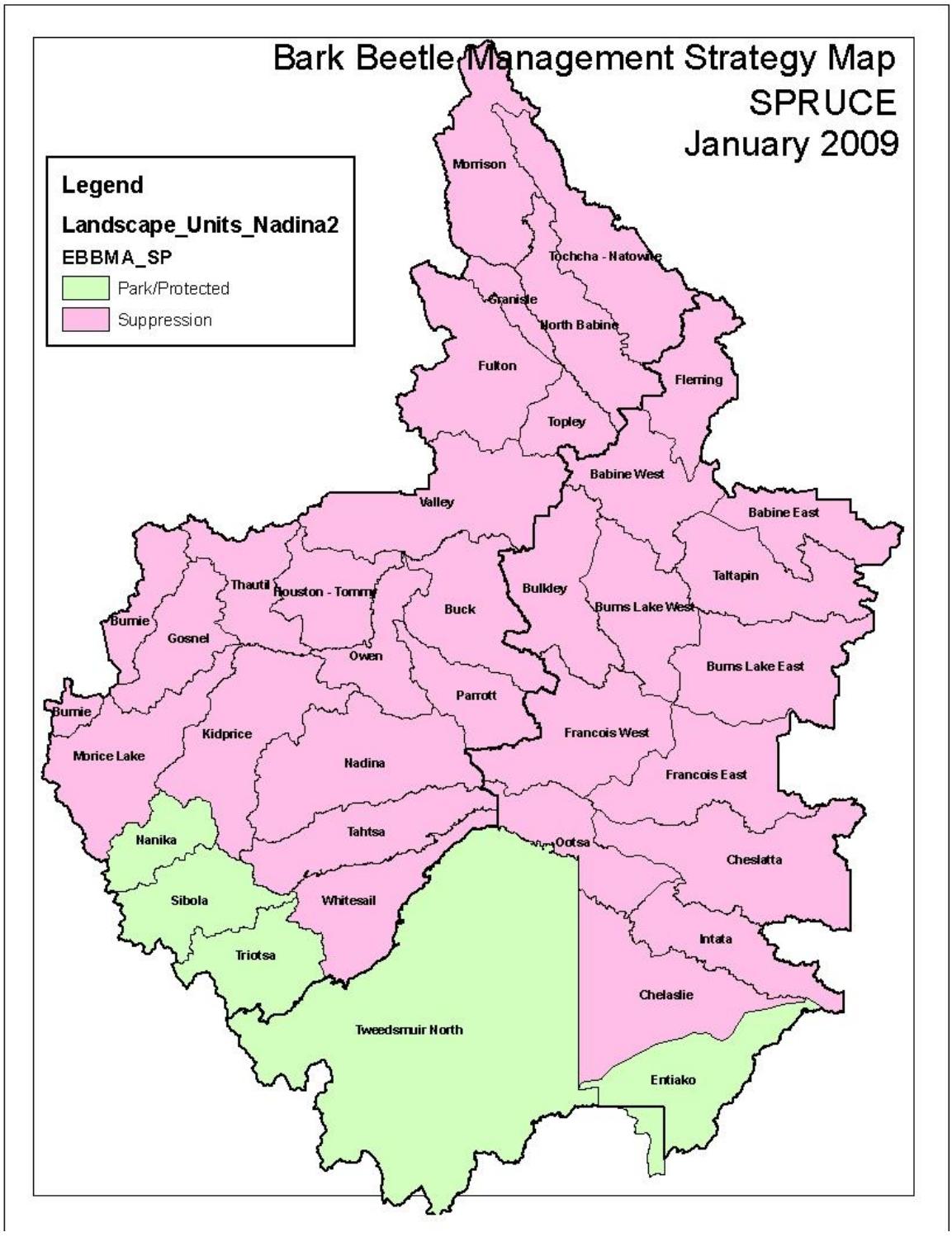


(c) **Figure 2**. Conceptual framework for assessing risk associated with option (a) follow current practices regarding species selection and stocking standards until direction of CC is more clear, or option (b) increase species and genetic diversity at the stand and landscape level by ensuring that all currently preferred and acceptable tree species are incorporated into intimately mixed plantations **AND** application of the projections of changes to BEC boundaries predicted by Hamann and Wang (in press) to incorporate a proportion (up to 20%) of the dominant commercial tree species from the 2025 projected BEC zone distribution. (graph by Stefan Zeglen and Erin Hall)

Appendix 9: BMU Map for Pine



Appendix 10: BMU Map for Spruce



Appendix 11: Standards for Detection and Treatment

Detailed Aerial Survey

1. Spot infestations locations will be collected as point features. The species and number of (red) attack trees containing 3 or more IBM or 10 or more IBS will be entered.

2. Larger, continuous patch infestations will be collected as polygon features, and the percentage of year one and year two attack (red) trees in the polygon will be entered. These polygons will be generated at a collection rate of one point per second and provide as digital polygon data in shape file format.

3. GPS settings will conform to the Ministry of Forests GPS standards, except for a reduced masking angle of 10 degrees to reduce down time and increase satellite availability.

4. Map tracking software will be used during the detailed aerial detection flights to ensure adequate coverage. A shape file with the flight path will be provided within 72 hours of completion of the flight. Aircraft crew, and GPS time will be included in this file.

5. The datum to be used will conform to the standards on the following web page. http://www.for.gov.bc.ca/hfp/forsite/fhdata/detailed_digital_stds.htm.

Probing Specifications

a) Ribboning and Establishment:
- GPS locate a POC to a known survey point or an aerial photo tie such as road junctions, creeks, road and block junction, etc. Mark the POC with a **blazed, painted**, **ribboned tree and metal tag** which states site number(s), date, bearing of first segment of line and crew person's initial's.
- Survey lines will be clearly marked with designated probe ribbon at intervals not greater than 15 meters. Line junctions and bearing changes will be marked with **three ribbons**.
- At each infestation centre, a station will be established and GPS located. An unattacked tree shall be **blazed, painted, ribboned and metal tagged**. The tag shall indicate site number, distance from POC, number and classification of infested trees found, date, and crew's initials. On the painted blaze, the site number, and the number and classification of trees found shall be written in black felt pen.

b) Recording:

❖ Crews are responsible for noting the following information from survey lines on field traverse sheets:
- The distance and compass bearing of all access and survey lines,

- Site infestation centres (Waypoint ID),
- Location of treatment trees with respect to the infestation centre,
- Creeks and swamps,
- Blowdown,
- Percent of slope at 100 metre intervals, if more than 10%,
- Percent of slope at the centre of each infestation,
- Topography,
- Other pest activity,
- All field notes must be legible, have a POC, bearing change, UTM coordinates and any other pertinent information as required.

❖ Probe cards may be supplied to tally the status and number of trees found at each infestation site:
- All susceptible spruce trees within a **100 metre** radius of any red or green attack tree must be assessed for beetle activity,
- Other pest activity,
- Access problems for treatment types (i.e. fall and burn, logging etc),
- Recommended treatments,
- Average DBH, height, and volume.

❖ Level 1 CMT Recording Form shall be filled out should CMT's be encountered during the probing phase.

❖ Unmapped trees:
- Wherever unmapped trees are found along the line, a new infestation centre (Waypoint ID) shall be established. This new centre shall be GPS located in the same manner as indicated above and numbered with the same Waypoint ID, but alphabetically, (i.e. L082-198A, L082-198B etc.),
- All infestation sites must be tied into:
  -probe lines,
  -infestation centres (Waypoint ID),
  -POC or known survey point.

❖ All beetle attacked trees which are found in the survey will be classified and noted as follows:

Attack	**Code**	**Tree Characteristics**
Pitch-out	P/O	Unsuccessful current attacked trees shown by external pitch tubes, pitch-filled galleries and no brood production. Trees have green foliage.
Current Attack	C	A tree which has been successfully attacked in the current year on more than 50% of the bole. Foliage is green.
Red Attack – Spruce	S1	Yellow or red foliage; contains brood that is in their 2nd year cycle; may also contain 1st year brood
Grey Attack – spruce	S2	No beetle or larvae present; 3 or more years after attack

- ❖ All **current (C)** and **S1** coded trees will be marked with a single fluorescent orange paint ring at DBH or higher and sequentially numbered.

- ❖ All S1 coded trees will be marked with 2 fluorescent orange paint rings at DBH or higher.
- ❖ Forked trees – a fork below DBH (1.3 meters) shall be considered two trees.
- ❖ Pitch-out trees shall be marked with "**P/O**" using fluorescent orange paint to show that they have been examined. Pitch-outs do not need to be sequentially numbered.
- ❖ Green trees, which have survived an attack, and have no evidence of remaining beetle or larvae, or have other pest activity shall be marked "**X**" to indicate that it has been inspected.

c) Final product:

- ❖ Digital submission of a 1:10,000 scale map plus shape files that show the following:
    - Accurate plotting and labelling of infestation centres (Waypoint ID), probe lines, POC and sites, complete with distances and bearings,
    - Other topographic information such as roads, terrain, swamps etc.,
    - Geographic location,
    - Air photo numbers,
    - UTM's
    - DBH and slope,
    - Mapsheet number,
    - Date and crew initials,
    - #C, #Y1, #Y2, #SBB,
    - Access.

- ❖ The contractor will submit a digital copy of a summary report (As directed by the Contract Officer) with at least the following information:
    - Mapsheet Number
    - Infestation site number (Waypoint ID),
    - Pest type,
    - Status and total numbers of trees found,
    - Average diameter (DBH),
    - Average Height,
    - Slope %,
    - Aspect,
    - Number of pre- or post- 1842 CMT's
    - Probe Date,
    - Crew Initials,
    - Timber Type,
    - Recommended treatment,

- Comments.

Discovery of Unexpected Features:

If any archaeological sites or other resource-based infrastructure/activities are discovered during probing, it is the field person's responsibility not to move or damage the item(s) and to record the location and description of the item(s). The licensees designated supervisor must be notified immediately of any such discovery.

Fall and Burn

Method*:*

- All Current and S1, trees marked with a **single**, **orange paint ring** shall be felled, bucked into blocks, piled and burned up to a point three (3) metres beyond the last visible beetle entry hole or presence of larvae. The remainder of the tree shall be bucked into 2' sections to facilitate drying of the cambium.
- Upon the written direction of the Contract Officer, any Current or S1 that has **not been marked** or identified for treatment shall be bucked into blocks, piled and burned up to a point three (3) metres beyond and visible evidence of larvae under the bark. The remainder of the tree shall be bucked into 2' sections to facilitate drying of the cambium
- All trees scheduled to be piled and burned shall be burned so that all of the bark including the cambium layer is completely destroyed.
- Wherever possible, stumps shall be burned by locating burn piles on top of them.
- No stumps shall exceed 30 cm in height.
- All stumps of all marked trees shall be stripped of their bark to mineral soil unless burned.
- Fall and burn operations are to be carried out with minimal disturbance to the site and to non-infested trees.
- All burning activities may be suspended or restricted at anytime due to burning bans. It is the Contractor's responsibility to be informed of the venting conditions each day by contacting the BC Environment Air Quality Information Line for the Skeena Region at 1-888-281-2992.

Discovery of Unexpected Features

If any archaeological sites or other resource-based infrastructure/activities are discovered during probing, it is the field person's responsibility not to move or damage the item(s) and to record the location and description of the item(s). The licensees designated supervisor must be notified immediately of any such discovery.

Pheromones

Bait Placement on Trees

1. Mark date and agency initials on bait.

2. Place baits in prescribed pattern at specified intervals unless advised otherwise.

3. Select large un-attacked healthy spruce trees (greater than 20 cm dbh).

4. Place lure on north side of tree above understory and brush with minimum height of 2 meters above ground.

5. Clearly identify baited tree with flagging tape, consistent with Licensee's field marking SOP.

6. Do not place baits within riparian reserve or management zones of any riparian feature.

7. Do not place baits in areas that are not feasible to harvest.

Conventional Trap Trees

- Trees should be felled between March and the end of April and removed the following winter before they become covered with excessive snow and frozen in place.
- Sites should be clearly flagged and must be mapped to facilitate felling and subsequent harvesting.
- Trees must be uninfested, have a thick bark and the bigger the diameter the better
- Where possible, fell trees into the direction that provides the most shade as possible without compromising the eventual skidding opportunities.
- Stumps must be 30 cm or less
- Do not buck or limb
- Trees should be felled as close to the infestation as possible and no farther away than 0.8 km.
- Fresh spruce blowdown may be incorporated into the site
- Trap tree patches are usually 12-25 trap trees felled into standing timber in a single, narrow, and shaded group adjacent to a road, to facilitate eventual skidding and hauling. Of all the deployment tactics, trap trees felled in patches have the best shading and there fore, have been the most effective at absorbing spruce beetle adults.
- Pre-felled road rights-of-way, landings, and cutblocks strips can be used during cutblocks pre-development as relatively large scale conventional trap tree programs. Their sheer numbers can usually compensate for lack of ideal shading.

Appendix 12: Policy for Management of MSMA-treated Trees in British Columbia

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Forests and Range — Forest Practices Branch — MEMORANDUM

File: 18818-01

July 25, 2007

Management of MSMA-treated Trees in British Columbia

APPLICATION AND SCOPE

This policy shall apply to Forest Service staff in all Forest Regions and Forest Districts and Timber Sales Business Areas and shall come into force on the date of its signing. An implementation plan will be developed and will be carried out within a reasonable time frame.

The implementation of this policy will be monitored and the policy shall be reviewed periodically to determine the degree to which the guidelines are being implemented. Revisions will be made as deemed appropriate. Specifically, implementation of this policy will be reviewed within two years of its signing.

BACKGROUND

Monosodium methanearsenate (MSMA) is an arsenical pesticide that has been used to treat single trees for small incipient outbreaks of mountain pine beetle and to create lethal trap trees for spruce beetle. This pesticide has been federally registered for use against bark beetles in Canada under the trade name Glowon®.

The federal registration for Glowon® has expired; the supplier will not pursue re-registration due to data needs and projected market size. The Ministry of Forests and Range will not pursue re-registration of this material. The Ministry of Forests and Range has made the decision that it will no longer use Glowon® and that all existing stocks of the material will be disposed of.

The Forest Practices Board Audit of the bark beetle practices in the Nadina Forest District (2004) made the following recommendation: "The Ministry of Forests provide provincial policy for tracking MSMA-treated trees to ensure that treated trees are not harvested and milled." This policy sets out guidelines for management of the legacy MSMA-treated trees.

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Management of MSMA-treated Trees in British Columbia

POLICY INTENT

This policy has several purposes:

1. to provide guidance for the use of pesticides that are similar in action to Glowon® for the purpose of bark beetle control;
2. to provide clear direction that any MSMA-treated trees that are encountered shall be identified and marked but not be harvested;
3. to establish guidelines that will address legacy trees with the purpose of minimising the potential for exposure to those trees by forestry workers and by the public;
4. to establish policy priorities relating to legacy trees and sites;
5. to establish research priorities that will improve knowledge of the impact of legacy trees upon the environment and to initiate or promote funding for these research areas.

POLICY RATIONALE

1. *to provide guidance for the use of pesticides that are similar in action to Glowon® for the purpose of bark beetle control*
   - All applicable Federal and Provincial Legislation and the Regulations there under shall be followed with respect to the storage, transport, use and disposal of pesticides.
   - Any future considerations regarding the use of an active ingredient similar to that of MSMA must conform to the *Integrated Pest Management Act* and its Regulations.
   - Where replacement treatments are used, any advertising relating to that use and/or requesting comments from the public on pesticide use shall be clearly worded and not use ambiguous or excessively technical language.
   - In general, any pesticide that may be registered for single tree treatment shall be used only in areas that are considered to be inaccessible, where there is no expectation that harvesting will occur in the foreseeable future and in inoperable areas, where the potential for risk of exposure to private citizens and forestry workers is minimised. Treatment in inoperable areas should not normally occur near private property or in areas that are or could be frequented by people.
   - Where pesticides for single tree treatments may be used, detailed mapping utilising accurate GPSd locations will be mandatory and the resultant maps will be communicated to BC Timber Sales and to other agencies and licensees for their use in developing plans.

Management of MSMA-treated Trees in British Columbia

2. *to provide clear direction that any MSMA-treated trees that are encountered shall be indentified and marked but not be harvested*
   - Legacy trees that are encountered shall not be harvested, removed, milled and/or burned.
   - The Ministry of Forests and Range will work with BC Timber Sales and licensees to develop and implement controls that prevent the harvesting, removal and milling of legacy trees in areas where treatments are known to have occurred.
3. *to establish guidelines that will address legacy trees with the purpose of minimising the potential for exposure to those trees by forestry workers and the public*
   - A provincial database shall be developed and posted on the Ministry of Forests and Range website that summarises, by forest district:
     - location of legacy trees (GPS coordinates) including the following:
       - the approximate number and species of legacy trees,
       - the approximate area of the patch in hectares.
     - the date (season and year) that the legacy trees or legacy tree patches were established, if known.
   - The provincial database shall be available in a tabular and a map-based format for each forest district that will provide information on proximity to other resource values.
   - Human health risk assessment information relating to the risks from MSMA and from legacy trees shall be made available on the Ministry of Forests and Range website.
4. *to establish policy priorities relating to legacy trees and sites*
   - Where legacy trees are encountered, they shall be marked conspicuously, left on-site, and the site GPSd and reported to the data base custodian.
   - Where legacy trees are encountered they may be incorporated into leave areas. Where this approach is not practical, the trees should be marked conspicuously as MSMA-treated trees, and left on-site. It is recommended that these sites shall be mapped by BC Timber Sales and/or licensees and shall be recorded and reported to the data base custodian for entry into the provincial data base.

- Where legacy trees are incorporated into wildlife tree patches:
  - a previously-determined legacy threshold shall be complied with; and,
  - there shall be no net loss of habitat at the landscape level as a result of legacy trees being included in wildlife tree patches (e.g. non-salvageable stands). Heavily MSMA-treated stands should not be used as suitable wildlife tree patches and efforts should be made to compensate for habitat loss in these areas.

5. *to establish research priorities that will improve knowledge of the impact of legacy trees upon the environment and human health and to initiate or promote funding for these priorities*

- Identify knowledge gaps around longevity of arsenic risk in legacy trees and their surroundings (soil and botanicals):
  - measure total arsenic in samples from legacy and reference trees and surroundings.
  - organic arsenic speciation of legacy trees if required.
- Determine presence of arsenic in secondary insects:
  - determine presence of secondary insects and other invertebrates in legacy trees.
  - determine presence and extent of arsenic in those invertebrates that are found in legacy trees, relative to background levels in the same species that are found in non-treated trees.
- Identify woodpecker usage of legacy trees:
- Determine potential threats to other wildlife from legacy trees:

DEFINITIONS

Inaccessible/isolated means out-of-the way, secluded, where there is no chance of harvesting in the foreseeable future, where there is no private property of any kind in close proximity and where there are no areas (such as remote recreation sites) that are or could be frequented by people.

Inoperable means that terrain, slope, water, soil or environmentally sensitive site barriers would preclude harvesting.

Management of MSMA-treated Trees in British Columbia

Legacy tree means a tree that has been treated previously with MSMA and is still on-site, either standing or felled.

Legacy threshold means the maximum proportion of legacy trees to non-treated standing trees of merchantable size and species that is permitted within a wildlife tree patch.

Jim Snetsinger, R. P. F.
Chief Forester

July 25/07
Date

Tim Sheldan
Assistant Deputy Minister
Operations Division

07.07.25
Date

Dave Peterson
ADM - BC Timber Sales

July 25/07
Date

Appendix 13: Legacy Trees Brochure

Legacy Trees and Forest Management Operations

What is a Legacy Tree?

A Legacy Tree is a tree (usually lodgepole pine) that has been treated previously with the pesticide MSMA (trade name Glowon®) and is still on-site, either standing or felled. The purpose of the treatment was to kill the developing broods of mountain pine beetles in small and isolated infestations.

Why the Concern about Legacy Trees?

MSMA is an arsenical compound and recently there have been concerns that residual arsenic in legacy trees may be a risk to human health and to the well-being of the environment. Scientific investigations will be directed towards determining the extent and validity of these concerns. Legacy Trees are not to be removed from the forest or burned until the results of these investigations are complete.

How Will Legacy Trees Affect Operations?

Legacy Trees are to remain in place in the forest. They are not to be felled, removed or burned. They are to be conspicuously marked by whomever finds them, their extent and location recorded and that information reported to the district manager. Legacy trees can, in many cases, be incorporated into Wildlife Tree Patches, thereby minimising their impact upon harvesting operations.

How Are Legacy Trees Identified?

Legacy Trees were conspicously marked at the time of their establishment.

MSMA-treated tree at time of establishment

Over time, however, flagging tape and tags may fall off, paint may fade and brush may cover the axe frill.

Legacy tree seven years after establishment

Sometimes all that will identify a standing dead lodgepole pine Legacy Tree may be the axe frill very low on the bole.

Axe frill at base of Legacy Tree

Spruce trees have, from time to time, been treated with MSMA to create lethal trap trees. The trees were felled two weeks after injection with MSMA so that they would be attractive to spruce beetles. These trees may be difficult to quickly identify as MSMA-treated trees due to decomposition. However, when groups of felled spruce trees are discovered in remote locations one should examine them carefully for axe frills and treatment tags.

What Do I Do when I Find Legacy Trees?

Agreement has been reached that, when Legacy Trees are discovered in the field, the person finding them will:

- record an approximate central point of the area, using a GPS
- record the extent and approximate boundary of the area covered by Legacy Trees
- determine and record the approximate date of treatment
- record the approximate number of Legacy Trees
- record the species of the Legacy Trees
- report this information to the district manager

Where are Known Legacy Trees Listed?

Information on known Legacy Trees is available from the district manager and it will be available through the website noted below.

For More Information:

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

Or contact your district manager.

Legacy Tree Reporting Form

GPS location (degrees & decimal minutes)

_____N _____W

Approximate Area (hectares) (attach map)

_____ Ha

Approximate Date of Treatment

_____

Approximate Number of Trees Treated

_____

Other Pertinent Information

_____

_____

_____

_____

_____

Submitted By: **Date Submitted:**

_____ _____