

2008 SUMMARY OF FOREST HEALTH CONDITIONS IN BRITISH COLUMBIA



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Pest Management Report Number 15
Library and Archives Canada Cataloguing in Publication Data

Main entry under title:
Summary of forest health conditions in British Columbia. - -
2001 -

Annual.
Vols. for 2008- issued in Pest management report series.
Also issued on the Internet.
ISSN 1715-0167 = Summary of forest health conditions in British Columbia.

1. Forest health - British Columbia - Evaluation - Periodicals.
2. Trees - Diseases and pests - British Columbia - Periodicals.
3. Forest surveys - British Columbia - Periodicals. I. British Columbia. Forest Practices Branch. II. Series: Pest management report.

SB764.C3S95

634.9'6'09711

C2005-960057-8

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SUMMARY

The 2008 *Summary of Forest Health Conditions in British Columbia* (BC) is a compilation of current aerial overview forest health survey data in conjunction with insect population surveys, ground observations and special projects undertaken by the Ministry of Forests and Range (MFR) and their associates.

A total of 9,642,575 ha of BC forests were damaged by forest health agents in 2008. Mountain pine beetle continued to be the primary cause of mortality, though area affected is down to 7.8 million hectares after a peak of 10.1 million hectares last year. The Southern Interior Forest Region (SIFR) contained 4.8 million hectares of the attack. For the fourth consecutive year the Chilcotin Forest District sustained the highest amount of damage with 1.5 million hectares recorded. Infestations in the 100 Mile House Forest District remained steady with 742,077 ha of disturbances observed but attack levels dropped substantially in the Quesnel and Central Cariboo Forest Districts to 712,732 ha and 602,231 ha, respectively. The remaining 1 million hectares of damage was distributed throughout the other SIFR districts.

Mountain pine beetle infestations in the Northern Interior Forest Region (NIFR) decreased more than a third over 2007 to 2.9 million hectares. Damage peaked last year in the Nadina and Peace Forest Districts, with 859,748 ha and 620,730 ha recorded in 2008, respectively. The Mackenzie Forest District experienced an increase to 533,559 ha of attack, but this was because only a portion of the district was surveyed last year. Infestations fell in the Fort St. James Forest District to 520,969 ha affected and attack dropped dramatically in the Prince George and Vanderhoof Forest Districts to under 172,000 ha each. The only districts where mountain pine beetle mortality was still rising rapidly in the NIFR was in the Skeena Stikine (64,087 ha) and Kalum (4,057 ha) Forest Districts. Infestations in the Coast Forest Region (CFR) declined for the third consecutive year to 124,844 ha affected.

The area attacked by western balsam bark beetle mortality decreased to one-third that of last year with 532,064 ha recorded at primarily trace intensity. The majority of the infestations were observed in three NIFR districts (Skeena Stikine, Fort St. James and Mackenzie Forest Districts) and the Okanagan Shuswap Forest District in the SIFR. Douglas-fir beetle damage rose provincially for the sixth consecutive year to 97,053 ha affected. The Central Cariboo, Chilcotin, 100 Mile House and Quesnel Forest Districts of the SIFR contained most (89%) of the attack. Spruce beetle damage dropped for the fifth year in a row to 27,874 ha affected. Small scattered pockets of mortality were observed throughout the province, but the majority of the infestations occurred in the Central Cariboo, Peace, Okanagan Shuswap and Cascades Forest Districts.

Western spruce budworm continued to be the primary defoliator in 2008 though both area affected and intensity levels dropped over last year. Of the 766,224 ha defoliated provincially, most occurred in the Central Cariboo, 100 Mile House, Cascades, Okanagan Shuswap, Chilcotin and Chilliwack

Forest Districts. For the first time, damage was also recorded in the Quesnel Forest District. For priority areas, a record 61,966 ha were treated aerially with the biological control agent *Bacillus thuringiensis* var. *kurstaki* to reduce budworm populations. A new outbreak by Bruce spanworm defoliated 97,804 ha of aspen stands in the Peace Forest District in 2008. A variety of other insects damaged aspen throughout the province as well, including aspen leafminer, forest tent caterpillar and large aspen tortrix. Two-year-cycle budworm caused primarily light defoliation this year over 56,619 ha, mainly in the Headwaters Forest District.

The Douglas-fir tussock moth reached outbreak proportions this year, with 2,597 ha of damage recorded. Most of the defoliation occurred in the Kamloops Forest District, where 1,130 ha were aerially treated with nucleopolyhedrosis virus. Western hemlock looper defoliation impacted only 537 ha in the SIFR, but significant increases in moths caught in pheromone monitoring traps indicate an outbreak is developing in some areas. Traps placed to monitor the North American strain of European gypsy moth caught 45 moths in 2007, resulting in ground spray applications of *Btk* in the spring of 2008 on Saltspring Island and at Saltair near Ladysmith. Monitoring traps caught 33 moths in 2008 and treatment is planned around Harrison Hot Springs next year.

The majority of tree diseases are not easily discernable from the air, particularly at the height the overview surveys are conducted. However, some of the foliar diseases are visible. Dothistroma needle blight damage was observed over a record 53,505 ha in the NIFR this year. Pine needle cast defoliation was also recorded on 16,912 ha in the NIFR. Above average precipitation in 2007 contributed to the increases in these foliar diseases, and conditions for viewing the damage this year were very good. Larch needle blight defoliation in the southeast corner of BC dropped again this year to a total of 13,540 ha affected.

Yellow-cedar decline damage was the primary abiotic damage agent observed in 2008, with 47,130 ha mapped along the coast of BC. Wildfire damage was down for the second consecutive year with a total of 29,609 ha burnt, primarily in the NIFR. A total of 5,798 ha were damaged by windthrow across the province, with the majority of the disturbances located in the SIFR.

Other damaging agents such as slides, flooding, animals and diseases affected small scattered areas of forest throughout the province.

2008 SUMMARY OF FOREST HEALTH CONDITIONS IN BRITISH COLUMBIA

INTRODUCTION

British Columbia (BC) is Canada's most biologically diverse province. This rich diversity supports a wide variety of tree species, which in turn can be affected by many different damaging agents. Intensity and area of damage caused by insects, diseases, animals and abiotic factors in the forests can change dramatically from year to year. Therefore, monitoring and recording of damage to the forests of BC must be undertaken on an annual basis. One of the primary tools for gathering this information is the aerial overview survey. The BC Ministry of Forests and Range (MFR) has been responsible for conducting this survey for the past twelve years. Prior to 1997, this service was the responsibility of the Canadian Forest Service (CFS).

The intent of the aerial overview survey is to capture forest disturbance information in a quick and cost effective manner over large areas. Information is recorded for each forest health factor by size and severity of damage, which is then summarized by forest districts (Figure 1). Please note that the former Queen Charlotte Islands Forest District is now the Haida Gwaii Forest District. Each forest region is responsible for surveying their area, and then the data is collated by Forest Practices Branch for inclusion in the provincial Land and Resource Data Warehouse.

The gathered data is used for a variety of important purposes by a diverse group of organizations. Examples of use include monitoring changes in forest health conditions over time, providing input to Timber Supply Analysis, setting Government strategic objectives, providing support for research projects and contributing to national indicators for sustainable forest management.

This report summarizes the level of damage by various causal agents sustained by the forests of BC in 2008. Hectares affected by various agents were obtained directly from the aerial overview survey results. This data set includes all disturbances that are visible during the survey, such as tree mortality and obvious defoliation damage. Other forest health concerns, in particular diseases such as rusts, cankers and dwarf mistletoes are often not captured by this survey as they are not usually visible from the air. Information collected by other methods for these agents was included in this report if it arose as a concern and/or damage conditions changed since last year. To ensure consistency, this additional information was not added to the overview data. For some insects, population prediction surveys are undertaken and this information was also provided.

Forest health presentations, projects and publications undertaken by MFR staff and their associates were also included. The intent of this report is to summarize forest health conditions from a MFR perspective: this does not necessarily include research and management of forest health in BC by other agencies such as universities and other levels of government.

RSI · Southern Interior Forest Region (Kamloops)

DMH · 100 Mile House Forest District (100 Mile House)
 DAB · Arrow Boundary Forest District (Castlegar, Grand Forks, Nakusp)
 DCS · Cascades Forest District (Merritt, Lillooet, Princeton)
 DCC * Central Cariboo Forest District (Williams Lake, Horsefly, Likely)
 DCH · Chilcotin Forest District (Alexis Creek)
 DCO · Columbia Forest District (Revelstoke, Golden)
 DHW · Headwaters Forest District (Clearwater, McBride)
 DKA * Kamloops Forest District (Kamloops)
 DKL * Kootenay Lake Forest District (Nelson)
 DOS * Okanagan Shuswap Forest District (Vernon, Penticton, Salmon Arm)
 DQU · Quesnel Forest District (Quesnel)
 DRM · Rocky Mountain Forest District (Cranbrook, Invermere)

* Denotes BC Timber Sales Location

RNI · Northern Interior Forest Region (Prince George)

DFN · Fort Nelson Forest District (Fort Nelson)
 DJA · Fort St. James Forest District (Fort St. James)
 DKM * Kalum Forest District (Terrace)
 DMK · Mackenzie Forest District (Mackenzie)
 DND * Nadina Forest District (Burns Lake, Houston)
 DPC * Peace Forest District (Dawson Creek, Fort St. John)
 DPG * Prince George Forest District (Prince George)
 DSS · Skeena Stikine Forest District (Smithers, Dease Lake, Hazelton)
 DVA * Vanderhoof Forest District (Vanderhoof)

RCO · Coast Forest Region (Nanaimo)

DCR * Campbell River Forest District (Campbell River)
 DCK * Chilliwack Forest District (Chilliwack)
 DQC · Haida Gwaii Forest District (Queen Charlotte City)
 DNC · North Coast Forest District (Prince Rupert)
 DIC * North Island - Central Coast Forest District (Port McNeill, Hagensborg)
 DSI · South Island Forest District (Port Alberni, Duncan)
 DSQ · Squamish Forest District (Squamish)
 DSC · Sunshine Coast Forest District (Powell River, Sechart)



Figure 1. Map of British Columbia outlining regional and district forest boundaries as of April 1, 2003

METHODS

Aerial overview surveys are conducted in small fixed wing aircraft by two experienced observers sitting on opposite sides of the plane. Forest health disturbances are sketched on 1:100,000 scale maps. To assist with accurate delineation of damage, colour Landsat 5 satellite images with some digitally enhanced features are utilized for the sketch maps. After the flight, both sets of maps are collated onto mylars which are then digitized to obtain the final data. Details of survey methodology are available at <http://ilmbwww.gov.bc.ca/risc/pubs/teveg/foresthealth/index.htm> and details of digitizing standards can be found at <http://www.for.gov.bc.ca/hfp/health/overview/arcinfo.htm>.



Aerial observers preparing to record forest health damage

Flights are conducted, weather permitting, when damage from primary forest health factors are most visible. Timing varies by type of damage agent and location in the province. In 2008, flights started July 2nd and were completed by October 27th (Table 1). Surveys in the Southern Interior Forest Region (SIFR) were finished quickly, due to favourable weather conditions. As occurred last year, intermittent rain required some survey breaks but also resulted in better visibility when the weather was good. Weather was also reasonable in the Coast Forest Region (CFR), though higher rainfall than in the SIFR resulted in a longer period

required to complete the project. The Northern Interior Forest Region (NIFR) once again had the worst weather during surveys, resulting in numerous delays. Luckily, the weather remained mild and snow held off long enough to complete priority areas in the fall. Flights for the 2008 provincial program totalled 805.7 hours.

Global Positioning Satellite (GPS) receiver units were utilized to record all flight lines. Survey progress and coverage intensity were monitored using the digital GPS files (Figure 2). Flights were conducted between 450m to 1000m above ground in a grid pattern 7km to 9km apart where topography was relatively flat and by drainages in mountainous terrain. Flying height, plane speed and intensity of coverage depended on visibility and the extent and variety of damage.

The annual goal is to survey all forested land in the province, time and funding permitting. In addition to poor weather, the NIFR flights in general for the past two years have been flown at a higher intensity and slower speed than in the past, due to the increasing spread of mountain pine beetle disturbances. This has resulted in incomplete coverage of the landbase within the survey

Table 1. Flying hours and survey dates by region undertaken for the 2008 provincial aerial overview survey.

Region	Zone	Flight hours	Survey Dates
Southern Interior Forest Region	Cariboo	157.1	July 11 th – Aug 8 th
	Kamloops	57.5	July 21 st – Aug 12 th
	Nelson	111.0	July 8 th – Aug 17 th
Northern Interior Forest Region	Prince George	232.1	July 5 th – Oct 27 th
	Smithers	182.1	July 2 nd – Aug 26 th
Coast Forest Region		65.9	July 15 th – Sep 16 th
Total		805.7	July 2nd – Oct 27th

time window. Last year, the lower priority northwest portion of the NIFR was covered since it hadn't been surveyed for two years. This unfortunately left a gap in some priority areas. In 2008, priority areas were surveyed first and were completed, but most of the north portion with the exception of main drainages in Fort Nelson Forest District was not covered. A total of 76% of the province was flown this year (Figure 2).

For all disturbances, only new damage is recorded each year. The responsible agent is noted for each identified area and since 2007 the primary host tree species has also been recorded. If the causal agent cannot be determined from the air, ground checks are conducted if the area is accessible. Due to the large number of young pine stands dying from mountain pine beetle, it was also noted whether the stands under attack were immature or mature in 2007 and 2008.

Recently killed trees are identified by observing foliage colour. Generally, dying conifer tree foliage turns yellow to bright red, then over time colour intensity fades and foliage is shed. Small areas of up to 50 dead trees are recorded as spots. To include these spots in total hectares affected, 1 to 30 trees are given a size of 0.25ha and 31 to 50 trees 0.5ha at a severe intensity rating. Larger areas of mortality are mapped as polygons by five intensity classes (Table 2).

Trees with damaged foliage (caused by insect feeding, foliage diseases or abiotic

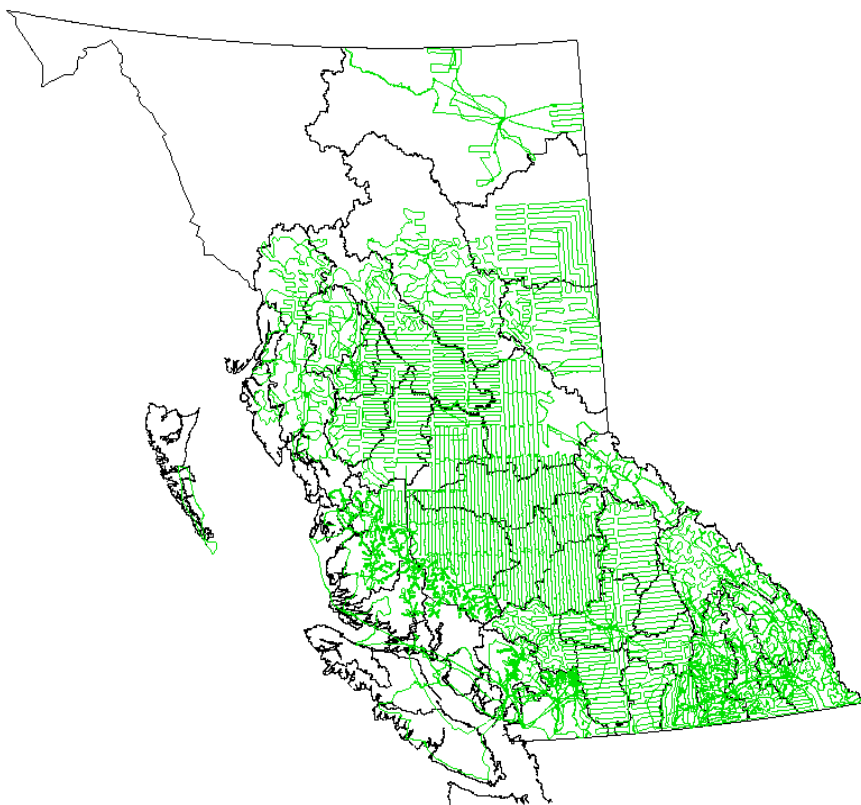


Figure 2. Flight paths flown while conducting the 2008 aerial overview surveys.

Table 2. Intensity classes used in aerial overview surveys for recording current forest health damage.

Disturbance	Intensity Class	Description
Mortality (bark beetle, abiotic, and animal damage)	Trace	<1% of the trees in the polygon recently killed.
	Light	1-10% of the trees in the polygon recently killed.
	Moderate	11-29% of the trees in the polygon recently killed.
	Severe	30-49% of the trees in the polygon recently killed.
	Very Severe	50%+ of the trees in the polygon recently killed.
Defoliation (defoliating insect and foliar disease damage)	Light	Some branch tip and upper crown defoliation, barely visible from the air.
	Moderate	Noticeably thin foliage, top third of many trees severely defoliated, some completely stripped.
	Severe	Bare branch tips and completely defoliated tops, most trees sustaining more than 50% total defoliation.



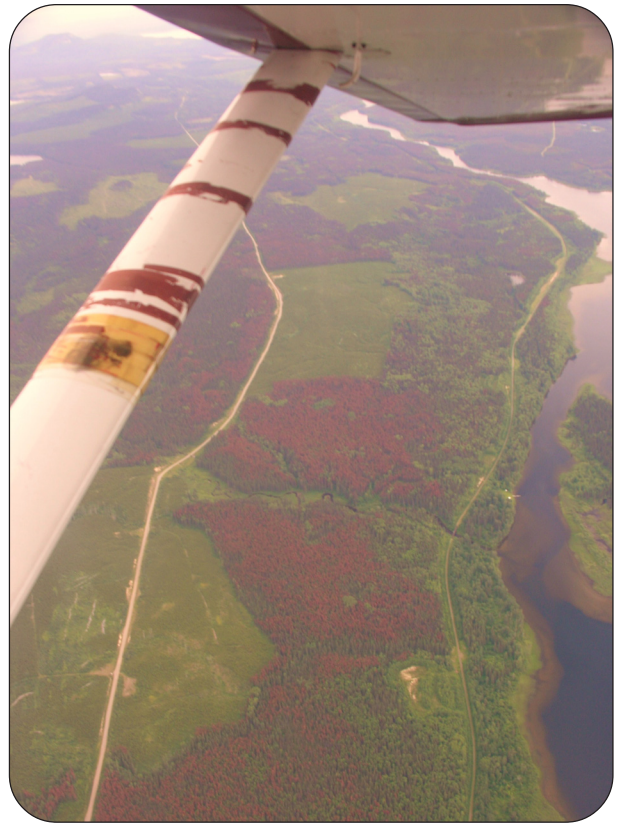
Satin moth, a deciduous defoliator

factors) are recorded differently as the defoliation tends to be fairly widespread throughout ages classes over larger areas. Only polygons are mapped under three intensity classes, and they are assessed as a percentage of foliage damaged over the entire polygon (Table 2). The window to accurately identify defoliation is shorter than that for tree mortality, as damaged foliage often drops off quickly or fades in colour and sometimes is masked with re-growth the same season.

The use of aerial overview survey data is limited for certain applications. Hectares of damage from past years by the same forest health agent cannot be added cumulatively, as new mortality or defoliation can appear in all or a portion of the same stands that were damaged previously. Also, fairly broad intensity classes and known errors of omission (i.e. missed trees) must be considered. For example, calculating accurate mortality volume estimations are not possible since the actual number of trees killed (and consequently, volume) is not precise.

GENERAL CONDITIONS

The forests of BC sustained a total of 9,642,575 ha of damage in 2008, as recorded during the aerial overview surveys (Table 3). Although mortality due to mountain pine beetle infestations continued to be the leading cause, it appears that the epidemic peaked last year at 10.1 million hectares affected as damage was down to 7.8 million hectares this year. The decline was anticipated, as the rate of hectares affected slowed substantially over the previous four years. This reflected significant decreases in areas where most of the host pine has been killed. Western balsam bark beetle damage also dropped by two-thirds, from 1.5 million hectares in 2007 to 0.5 million hectares in 2008. Severity levels remained primarily in the trace to light range. The only bark beetle mortality that increased at the provincial level this year was Douglas-fir beetle, which damaged 97,053 ha. Spruce beetle infestations have dropped for the fifth consecutive year to 27,874 ha.



Mountain pine beetle continued to be the leading cause of mortality in 2008

Defoliating insects caused 971,304 ha of damage across the province this year. Western spruce budworm continued to be the primary damaging agent in this group, with 782,240 ha of defoliation recorded in the southern half of BC. In the Peace Forest District, a new outbreak of Bruce spanworm affected 97,804 ha of aspen stands. Conversely, large aspen tortrix damage dropped for a third year in a row to only 1,546 ha this year. Since these and other aspen defoliators can occur together, particularly when one population is on the decrease while another is rising, it is sometimes difficult to determine the causal agent. Two-year-cycle budworm was in the second year of its life cycle in the SIFR and caused 56,619 ha of damage. Douglas-fir tussock moth reached outbreak proportions in the Kamloops Forest District this year, with 2,597 ha of defoliation reported.

Injuries caused by abiotic factors remained the third largest group of damaging agents, primarily due to a record 47,130 ha of yellow cedar decline delineated along the coast of BC. Observed damage due to disease increased substantially this year. Most of this increase was due to 53,505 ha of *Dothistroma* mapped in the Skeena Stikine and Kalum Forest Districts. Pine needle cast damage, which has only been mapped at endemic levels since 2003, affected 16,912 ha in the Nadina and Fort St. James Forest Districts. The large increase in mapped pine needle diseases in the NIFR was in part due to good infection conditions but also to good observational conditions. Larch needle blight damage continued to affect 12,285 ha in the south-eastern portion of the province. Locations, extent and intensity of damage by host tree species are documented in the next section of this report.

Table 3. Summary of hectares affected by forest damaging agents as detected in 2008 aerial overview surveys in British Columbia.

Damaging Agent	Hectares Affected
<i>Bark Beetles:</i>	
Mountain pine beetle ^a	7,841,993
Western balsam bark beetle	532,064
Douglas-fir beetle	97,053
Spruce beetle	27,874
Misc. beetle	8
<i>Total Bark Beetles:</i>	<i>8,498,992</i>
<i>Defoliators:</i>	
Western spruce budworm	782,240
Bruce spanworm	97,804
Two-year-cycle budworm	56,619
Aspen leafminer	16,641
Forest tent caterpillar	10,185
Douglas-fir tussock moth	2,597
Unknown defoliators	1,838
Large aspen tortrix	1,546
Birch leafminer	738
Western hemlock looper	537
Alder sawfly	427
Satin moth	127
Balsam woolly adelgid	6
<i>Total Defoliators:</i>	<i>971,304</i>
<i>Abiotics:</i>	
Yellow cedar decline	47,130
Fire	29,609
Windthrow	5,798
Slide	2,450
Flooding	1,959
Drought	237
Aspen decline	105
<i>Total Abiotics:</i>	<i>87,288</i>
<i>Diseases:</i>	
Dothistroma	53,505
Pine needle cast	16,912
Larch needle blight	12,285
Aspen/poplar leaf/twig blight	1,189
Laminated root disease	626
Douglas-fir needle cast	471
White pine blister rust	167
Unknown root disease	111
<i>Total Diseases:</i>	<i>85,266</i>
<i>Animals:</i>	
Bear	22
<i>Total Animals:</i>	<i>22</i>
Provincial Total	9,642,872

^a Includes infestations in parks totalling 700,223 ha.



Douglas-fir tussock moth larvae



Lodgepole pine needles infected with Phaeoseptoria contorta

DAMAGING AGENTS OF PINES

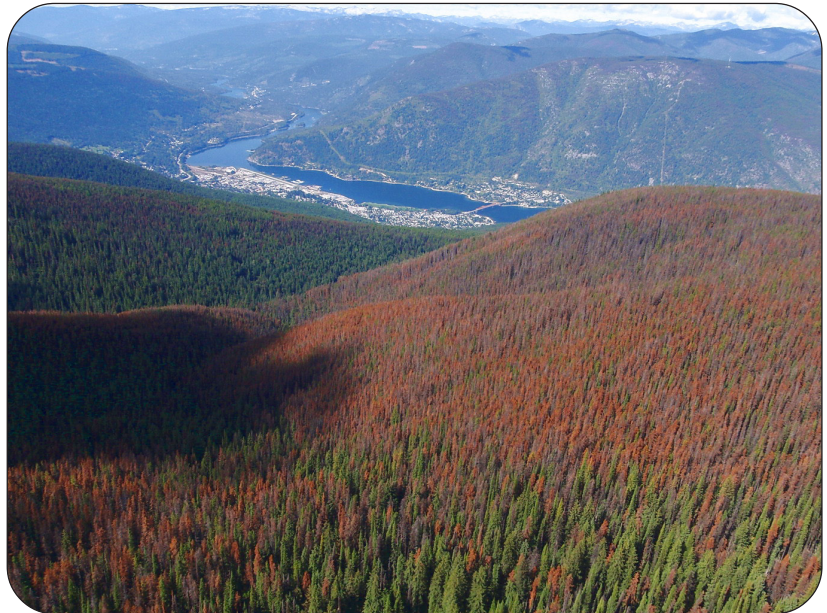
Mountain pine beetle, *Dendroctonus ponderosae*

Provincial Situation

Area affected by mountain pine beetle mortality peaked at 10,051,919 ha in 2007. Infestations continue to cause extensive damage throughout the range of pine in BC (Figure 3) but disturbances were down by 22% this year to 7,841,993 ha. Of this attack, 700,223 ha were located in provincial parks and protected areas.

Mountain pine beetle damage rose sharply from 284,041 ha in 2000 to 7,021,886 ha in 2004 (Figure 4). At that time, total affected hectares started to level off with progressively smaller increases through to the peak in 2007. The *Provincial-Level Projection of the Current MPB Outbreak* model predicts that the volume of pine killed will now stabilize until 2011, at which point it should begin to rapidly subside and the outbreak will essentially be over by 2019. It is noted that there is substantial variability in the timing of the infestation peak in different areas of the province.

Severity levels as assessed this year were 2,857,363 ha (37%) trace, 3,239,173 ha (41%) light, 1,287,539 ha (16%) moderate, 380,740 ha (5%) severe and 77,178 (1%) very severe. Higher intensity attack (moderate to very severe) dropped by half from last year's levels and the light to trace categories both rose correspondingly.



Mountain pine beetle mortality around the west arm of Kootenay Lake in 2008

Most of the infestations mapped at the trace level (with the exception of a few areas where the beetle is still advancing) represented scattered red attack that occurred within stands predominantly composed of old grey attack. Trees dying in these stands were suppressed understory that would not have even been visible aerially when the original estimates of percent stand attacked were made. Since very few of these stands have been visited on the ground, it is difficult to be certain of the causal agent. It could be remnants of the mountain pine beetle population, pine engraver bark beetle (which historically have increased in population near the end of a mountain pine beetle outbreak) or a combination of both. It is hypothesized that pine engraver bark beetle populations have not increased to anticipated levels due to the relatively cool summers experienced over most of the province the past two years. Pine engraver bark beetles are capable of more than one generation per year during warm summers, which can cause populations to build quickly.

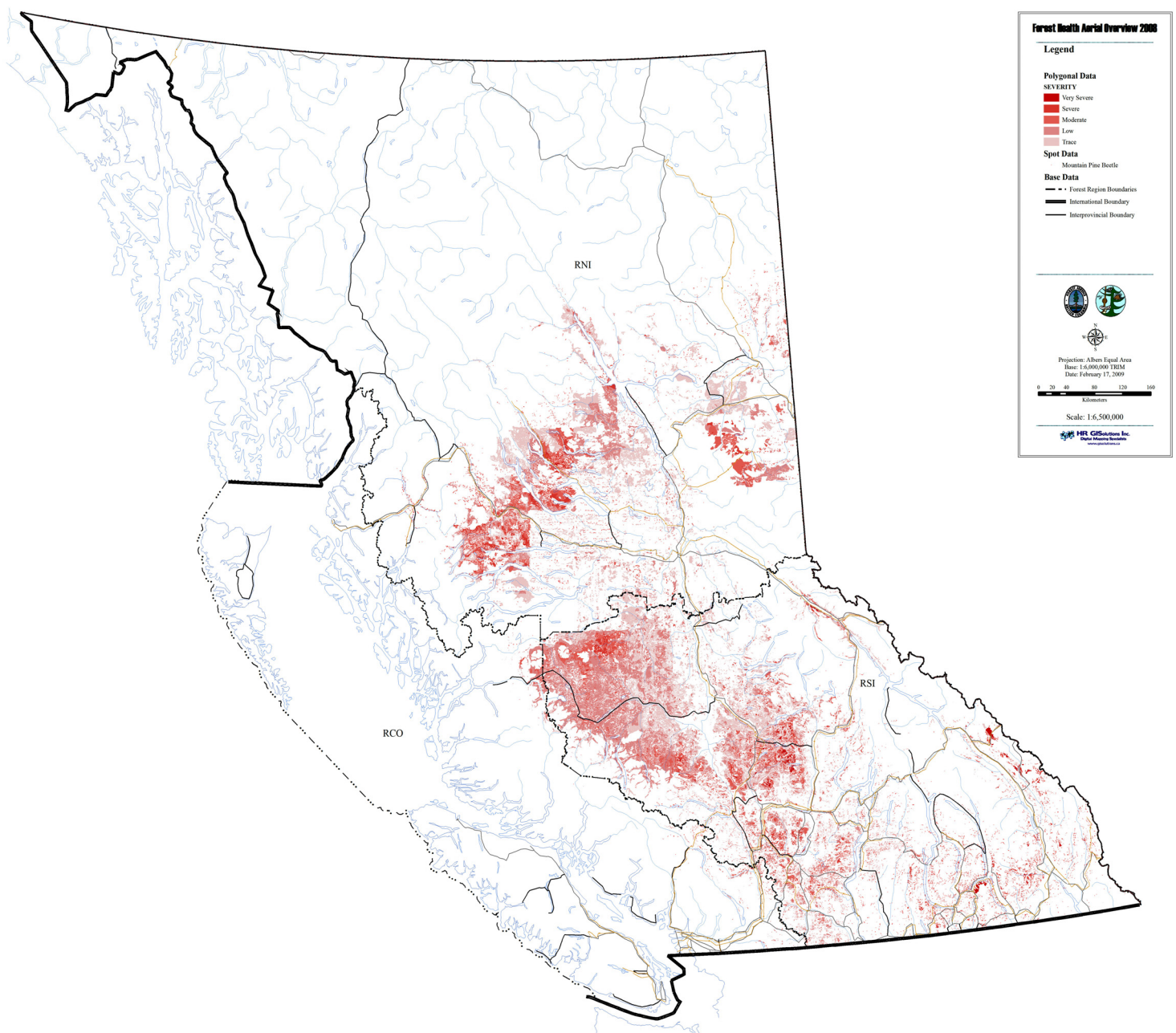


Figure 3. Mountain pine beetle infestations recorded in British Columbia in 2008.

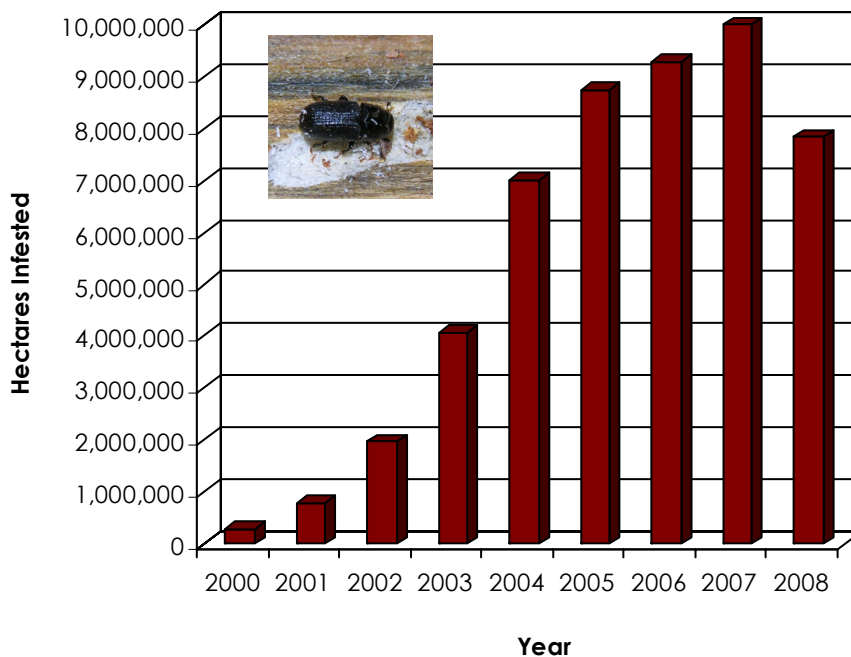


Figure 4. Hectares infested by mountain pine beetle from 2000 – 2008 in British Columbia.

During previous outbreaks, the primary host for mountain pine beetle has been mature lodgepole pine. Over the past few years of the current outbreak, ponderosa, whitebark and western white pine have also been killed in unprecedented numbers. Also unique to this outbreak is the high number of immature stands that have been attacked.

Southern Interior Forest Region Damage

Mountain pine beetle infestations were recorded on 4,812,915 ha across districts in the SIFR, which represents 61% of the provincial total. Of this, three quarters of the infestations were located in the Cariboo area of the region (Figure 5).

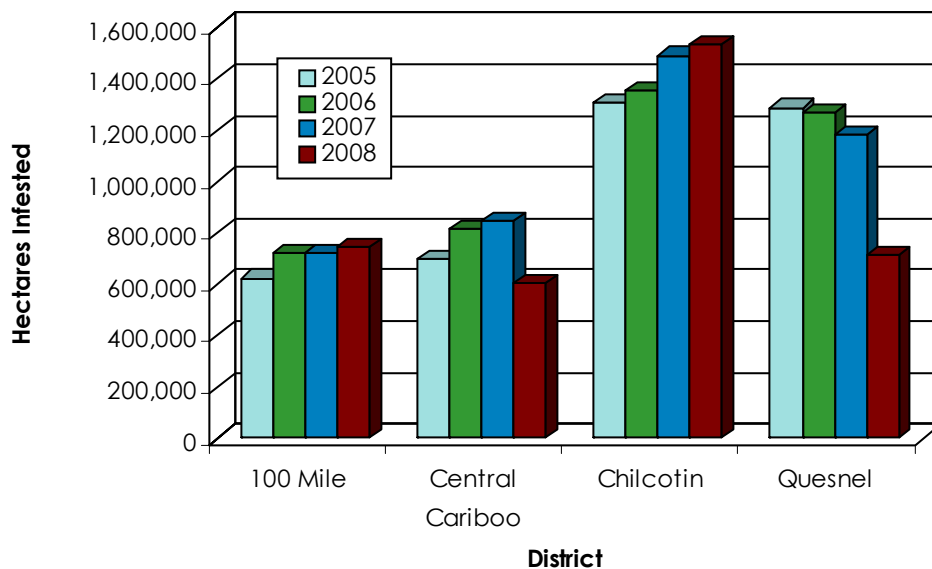


Figure 5. Hectares infested by mountain pine beetle from 2005 – 2008 in the Southern Interior Forest Region (districts with more than 500,000 ha affected in 2008).

For the fourth consecutive year, the highest infestation level occurred in the Chilcotin Forest District, with 1,532,556 ha affected. Increases in area of attack are slowing, with a 9% increase last year over 2006 and only 3% this year. Most of the new infestations were observed in the southern portion of the district around Chilko Lake and in drainages near Siva and Whitesaddle Mountains. Intensity of attack has declined dramatically in this district however, with only 10% in the moderate to severe range compared to 74% last year.

Area affected in the 100 Mile House Forest District has been fairly steady over the past three years with 742,077 ha recorded, up only 3% from 2007. New infestations are primarily located along the southern district boundary near Kelly Lake and along the Fraser River, in young stands and ponderosa pine. Intensity of mortality within affected stands dropped for the second year in a row, with trace to light severity recorded for three-quarters of the disturbances.

Mountain pine beetle attack reached outbreak proportions in the Quesnel Forest District earlier than most areas in the Cariboo and this is reflected in the large drop in area affected this year, from 1,183,307 ha in 2007 to 712,732 ha. Intensity levels continued to drop for the third year in a row, with both the moderate and severe categories recorded at half of last year, and trace to light categories up to 49% and 32%, respectively. Figure 6 illustrates the intensity changes over time as the infestations declined in this district. This is typical in most of the areas where the mountain pine beetle outbreak is waning.

Central Cariboo Forest District damage levels dropped substantially from 843,691 ha last year to 602,231 ha. Infestations in mixed stands in the northeast portion of the district experienced the largest declines. Trace severity has remained relatively constant compared to last year at just under half the recorded area, but the light category has tripled to 32%, with a corresponding drop in the higher severity levels.

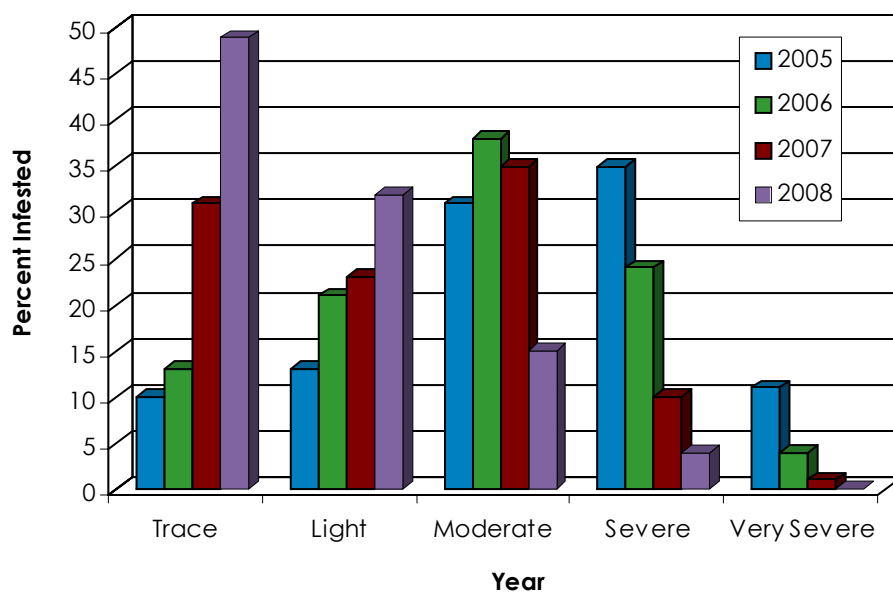


Figure 6. Change in severity of hectares infested by mountain pine beetle in the Quesnel Forest District from 2005 – 2008.

Infestations in the southern-most districts of the SIFR are newer and hence more active than in the north districts, and this was reflected in 370,935 ha of damage delineated in the Cascades Forest District, up 14% over last year. This is however much less than the 40% increase sustained from 2006 to 2007. The majority of the mortality continued to occur in the light to moderate intensity range, at 52% and 28%, respectively. A substantial amount of the new attack was observed mid district in low elevation ponderosa pine stands.

Mountain pine beetle mortality appears to have peaked in the Kamloops Forest District in 2006 at 320,759 ha. This year 232,286 ha of damage was recorded. Intensity levels began to drop this year as well, with moderate and higher severities decreasing by half. Almost three quarters of the disturbances are now assessed at the trace to light level. Infestations occurred in the same general areas as observed previously (particularly south of Kamloops Lake and along the 100 Mile House District border), but have decreased in size.

Attack levels in the Okanagan Shuswap Forest District increased by 10% since 2007 to 171,208 ha affected. Infestations increased to the largest extent between the Cascades Forest District boundary and Okanagan Lake, from Peachland and Summerland. After area affected doubled in the Headwaters Forest District from 2006 to 2007, recorded infestations were down this year by 30% to 164,489 ha. As in Kamloops Forest District, mortality occurred in the same general areas but delineated polygons were smaller.

Infestations in the south-eastern districts of the SIFR generally doubled over last year. Arrow Boundary and Rocky Mountain Forest Districts sustained similar levels of attack at 88,418 ha and 99,601 ha, respectively. Area affected grew to 41,118 ha in the Columbia Forest District and 55,265 ha in the Kootenay Lake Forest District. Generally, small scattered infestations grew in size. It was observed that mortality peaked around the west arm of Kootenay Lake this year, as pine types are now primarily depleted in that area.

Northern Interior Forest Region Damage

In the NIFR, recorded infestations dropped by more than a third since last year to 2,904,234 ha affected. Area damaged has decreased in most of the districts, particularly where the majority of the mature pine type has been depleted (Figure 7).

Although the Nadina Forest District sustained the highest level of attack for the fourth consecutive year in the NIFR, area of damage has been decreasing. Infestations are down by a quarter

over last year to 859,748 ha affected. Of this, 91,344 ha were located in the Tweedsmuir Provincial Park and Entiako Protected Area. The majority of the attack (88%) is at the trace to light level, reflecting scattered mortality within primarily old, grey attacked stands. District wide severity levels remained relatively constant at 34% trace, 27% light, 24% moderate, and 15% severe. These intensities were fairly high compared to other districts because beetle infestations were still moving westward across the Morice Lake portion of the district.

After a dramatic increase to 736,499 ha affected in the Peace Forest District last year, attack dropped slightly to 620,730 ha. This drop was at least partially due to a small portion of the southern part of the district not being surveyed this year. The north portion of the district also wasn't surveyed, but the mountain pine beetle attack was not reported as extending past the northern survey flight



Extensive old mountain pine beetle mortality in the Central Cariboo Forest District.

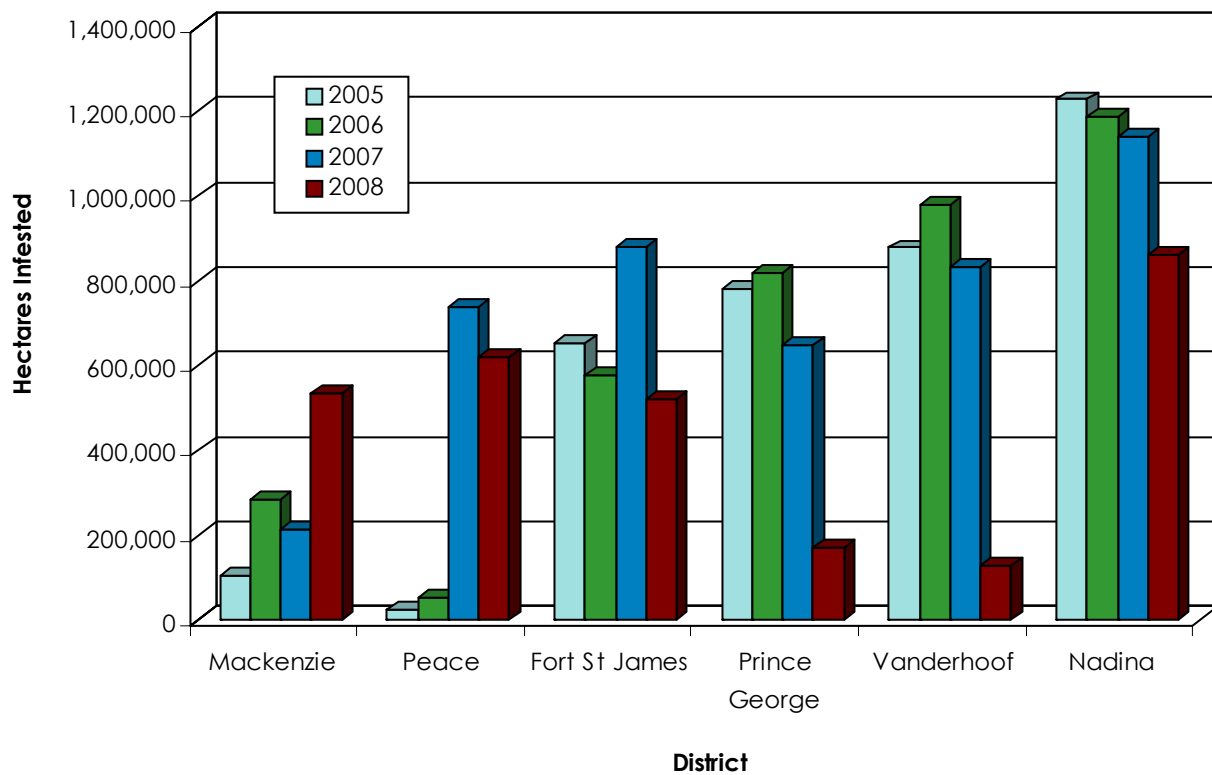


Figure 7. Hectares infested by mountain pine beetle from 2005 – 2008 in the Northern Interior Forest Region (districts with more than 200,000 ha affected in 2007). Note that the mapping of Mackenzie Forest District in 2007 was not completed and the actual total should have been higher.

line. The leading edge of new mortality reached as far as Wonowan, and was most extensive along the east and west district boundaries.

In the Mackenzie Forest District, mountain pine beetle attack more than doubled since that recorded in 2007 to 533,559 ha. This is misleading however as a portion of the southern part of the district was not surveyed last year, and mortality was known to be substantial in that area. The leading edge of attack was pushing northward along drainages in this district, with infestations along the Finlay Reach of Williston Lake and in the Ospika River drainage expanding. Intensity levels declined however, with just 1% rated severe as opposed to 27% at the severe to very severe level last year. Detailed flight information was used to fill in a gap in the northern survey area last year, and detailed survey methodology often results in smaller, more intense areas of attack being recorded.

After a peak of 879,859 ha of attack in 2007, infestations in the Fort St. James Forest District declined to 520,969 ha. The majority of the attack in the southern half of the district was now grey, and the leading edge was slowly moving northward. Primarily, new infestations were located at the top end of the Nations Lakes. Intensity levels have decreased somewhat, particularly in the very severe category (from 9% to <1%).

Mountain pine beetle damage in both the Prince George and Vanderhoof Forest Districts decreased dramatically to 171,502 ha and 129,584 ha, respectively. Infestations were located in similar locations

to last year, but were greatly reduced in size. This reflects the declining beetle population, due to the lack of remaining host material. Decreases are also partially due to portions of each district not being surveyed in 2008. Intensity of mortality within disturbances also continued to drop substantially in both districts. The largest category was trace at 75% in the Vanderhoof and 69% in the Prince George Forest Districts. Stands with moderate attack totalled 5% and most of the remaining damage was light.

Infestations from the Nadina Forest District continued to move northwest into the Skeena Stikine Forest District, with area affected more than triple that of last year at 64,087 ha. Large disturbances were mapped west of Babine and Nilkitkwa Lakes, along the Bulkley River around Moricetown and the McDonnell Lake area. Intensity levels were primarily recorded as trace (47%) and light (44%) with the remaining 6% moderate and 3% severe. Unlike many other NIFR districts, scattered trace mortality was occurring in live rather than dead stands. The Bulkley TSA is one of the few remaining NIFR TSAs where aggressive mountain pine beetle treatments occurred in 2008.

After the large influx of beetles last year from the Nadina Forest District, observed attack grew from 772 ha to 4,057 ha in the Kalum Forest District. Correspondingly, mortality intensified from all trace last year to 10% trace, 66% light, 18% moderate and 6% severe. Infestations were located mid district radiating out from Terrace along most drainages as far north as Sand Lake, in particular along Cedar, Skeena, Zymoetz and Kitimat Rivers.

Coast Forest Region Damage

Attack in the CFR declined for the third year in a row to 124,844 ha affected. The majority of the infestations continued to occur in the North Island – Central Coast Forest District. Damage was down to almost half that of last year, with 88,448 ha of mortality delineated. Almost all (87,095 ha) of this attack was located in Tweedsmuir Provincial Park. The majority of the decline was situated at the north edge of the damage south of Sigutlat Creek. Intensity in the higher categories dropped substantially, to 14% moderate and no severe. Light severity was assessed for 77% of the stands, and trace for 9%.

After an increase in damage last year, attack in the Chilliwack Forest District fell 11% to 28,600 ha. Infestations decreased slightly in most areas. Increases were primarily observed at the northern district boundary east of the Fraser River, along the Nahatlatch drainage and at the north end of Harrison Lake. Attack decreased 45% in Manning Park to 4,321 ha affected. Stands delineated at severe or higher intensity remained low (7%) but moderate levels dropped by half to 17%, with light intensity rising correspondingly.

Recorded attack dropped by half in the Squamish Forest District, with 7,778 ha of damage observed. Mortality continued in the same general areas as last year, but polygon sizes were reduced. Changes in severity levels were very similar to those experienced in the Chilliwack Forest District. Two small areas at the north end of the Homathko River totaling 18 ha were the only mountain pine beetle attack recorded in the Sunshine Coast Forest District this year. One spot of mortality less than 1 ha in size was also observed on Sonora Island in the Campbell River Forest District, though a ground check was not conducted to confirm causal agent.

Beetle Flights / Larval Development

In most areas of the province, weather was cool and wet in the spring, which resulted in a slightly delayed start to the beetle flight. In the south-eastern portion of the NIFR, flights started about 10 days later than usual in mid July and were primarily over by mid to late August. Weather overall was quite dry and favourable for beetle flights in the Peace Forest District, with the main flights starting at the beginning of August and continuing through September.

In the western districts of the NIFR flights were observed to have a late start (variable) and they did not appear to be concentrated. Beetle flights in the Nadina Forest District occurred as late as the third week of September, since the weather was cool and wet until that time. This dispersed flight pattern resulted in very mixed beetle progeny development throughout most areas, particularly in the Kalum Forest District.

For the SIFR in general, cooler than normal temperatures with intermittent rain events resulted in dispersed small flights that extended later into the fall than usual. This in turn resulted in differential progeny development, which was exacerbated by a similar trend last year. The variable stages of beetle development were particularly prevalent in the south-eastern districts, with some populations reported to be in a two-year life cycle in the Arrow Boundary Forest District. Poor flight patterns have also resulted in some weak attacks, where pine engraver bark beetles were found mixed with mountain pine beetles throughout attacked trees. The best flights (early and concentrated) were observed in the south Okanagan portion of the Okanagan Shuswap Forest District and around the Coquihalla connector route on the border of the Cascades and Okanagan Shuswap Forest Districts.

Tree Response to Attack

Throughout the province, trees attacked in 2007 were generally reported to be turning colour later than usual. This probably resulted in some attack being missed during the 2008 aerial overview surveys. Some trees did not change colour until the end of August. These late faders were probably the result of late flights last year. This phenomenon was particularly prevalent in the Kootenay Lake Forest District, where some trees did not turn colour until September. In this case, it was suspected that the hot dry weather in the summer of 2007 may have allowed for two generations of beetles in a single year, with the second flight producing the late turning trees in 2008.

Relatively moist weather conditions across most of the province during the growing season in 2007 and 2008 allowed for vigorous tree response to beetle attack. This resulted in normal pitch tube production on most trees.



Pitch tubes produced in response to mountain pine beetle attack

Population Fluctuations

In early spring of 2008, samples were collected from attacked trees to estimate mortality and vigour of progeny. Data collected included percent mortality of beetles (all life stages included) which was used to calculate the “r” value that indicates whether a population is decreasing (<2.6), static (2.6 – 4.0) or increasing (>4.0).

Most of the sample sites were located in various districts in the SIFR. Where attack was present in young stands, both mature and immature stands were sampled. A total of 1,349 attacked trees were examined across 142 sites in 2008 (Table 4). The average r-value predicted increasing populations only in the Robson timber supply area (TSA) of the Headwaters Forest District. All other r-values indicated decreasing populations, with the exception of Arrow Boundary, Chilcotin, Kootenay Lake and Rocky Mountain Forest Districts, where populations are expected to remain static. These population predictions are significantly lower than last year, when all districts were expected to have increasing beetle in mature stands. Survival in young pine stands also declined over last year, with an average SIFR r-value of 0.6 *vs.* 2.4 in 2007. Only the Merritt TSA in the Cascades Forest District had static populations predicted, while the remaining districts had substantially decreasing populations (Table 5). Results from both the mature and immature sampling concur with other indications that in most areas, the peak of the mountain pine beetle outbreak has occurred and populations are now on the decline.

Table 4. 2007/2008 mountain pine beetle overwinter mortality estimates in mature pine for the Southern Interior Forest Region.

District (TSA)	# of Sites Sampled	# of Trees Sampled	Average % Mortality	Average r -Value
Arrow Boundary	18	166	57.5	3.5
Cascades (Lillooet)	11	110	99.7	0.1
Cascades (Merritt)	13	126	86.3	0.9
Central Cariboo	5	50	97.4	0.01
Chilcotin	1	10	37.0	2.9
Columbia (Golden)	13	113	69.2	2.0
Headwaters (Robson)	10	100	39.1	10.6
Headwaters (Clearwater)	9	88	82.4	1.2
Headwaters (Mt. Robson Park)	17	161	92.2	1.2
Kamloops	6	55	89.9	0.3
Kootenay Lake	12	115	68.2	2.7
Okanagan Shuswap	11	97	71.0	2.0
Rocky Mountain	16	158	58.2	3.8
Totals/Averages	142	1,349	72.9	2.4

Table 5. 2007/2008 mountain pine beetle overwinter mortality estimates in immature pine for the Southern Interior Forest Region.

District (TSA)	# of Sites Sampled	# of Trees Sampled	Average % Mortality	Average r- Value
100 Mile House	1	10	98.1	0.1
Cascades (Lillooet)	4	40	98.5	0.2
Cascades (Merritt)	3	24	62.7	2.6
Central Cariboo	5	50	99.8	0.01
Chilcotin	4	40	83.8	2.2
Headwaters (Clearwater)	2	19	100.0	0.0
Kamloops	6	51	96.3	0.2
Okanagan Shuswap	6	50	100.0	0.03
Quesnel	5	50	99.9	0.0
Totals/Averages	36	334	93.2	0.59

Overwinter mortality sampling was also conducted in the suppression zones of the Peace Forest District. In the northern portion of the district, eighteen out of twenty-one sites sampled strongly indicated decreasing populations. Only three sites in the Wonowan, South Miligan and Inga Lake areas had static populations predicted. In the southern portion of the district, five of six areas sampled predicted population reductions. Only one site just south of Dawson Creek had increases predicted, with an r-value of 9.3.

In forest districts where mountain pine beetle suppression efforts are still underway, ground surveys were conducted. One detail from data collected during these surveys was green attack to red attack (G:R) ratio information. This statistic is another tool that assists in predicting mountain pine beetle population changes. A >1 G:R ratio indicates rising populations, while <1 G:R generally means declining populations. Ratios higher than 5:1 however tend to indicate that the sample area was inundated by beetles from other sources as opposed to true local population information.

Table 6. Green to red mountain pine beetle attack ratios observed in 2008.

Region / District	High	Average	Low
NIFR – Kalum	22:1	1.7:1	0:1
Peace	47:1	8.2:1	0.3:1
Skeena Stikine	15:1	3:1	2:1
SIFR – Arrow Boundary	5:1	1.5:1	0.3:1
Columbia	20:1	2.1:1	0:1
Headwaters (Mt. Robson Park)	0.9:1	0.5:1	0.4:1
Headwaters (Holmes)	4:1	3.2:1	1:1
Kootenay Lake	10:1		1.3:1
Okanagan Shuswap	6:1	2:1	1:1
Rocky Mountain	7:1	2.8:1	0.3:1

Ground surveys are ongoing throughout the winter, so G:R data reported in table 6 is still preliminary. Average G:R ratios indicate growth in beetle populations, except for Mt. Robson Park area in the Headwaters Forest District. This is contradictory to other indications that the mountain pine beetle population in general is on the decline. It must be remembered however that G:R data is primarily collected in suppression areas, where beetle infestations are still relatively new.

Ponderosa, Whitebark and Western White Pine Mortality

Ponderosa pine continued to be significantly impacted by mountain pine beetle attack with a total of 132,929 ha damaged in BC. Severity levels were assessed at 21% trace, 47% light, 26% moderate, 5% severe and 1% very severe. Intensity overall was down from last year. Mortality in ponderosa pine stands rose from 83,420 ha affected last year and only 46,775 ha in 2006, when host species were first recorded in the aerial overview data.

Most of the attack was located in the SIFR throughout the range of ponderosa pine down to the US border and up to Chasm. Infestations increased substantially in the Cascades Forest District, where 71,639 ha of attack were observed. Mortality due to mountain pine beetle in the Kamloops and 100 Mile Forest District declined to 34,168 ha and 15,754 ha respectively. The majority of the mature ponderosa pine in these two districts has been killed. Recorded attack climbed in the Okanagan Shuswap Forest District to 11,110 ha. The remaining 26 ha were noted in the Kootenay Lake Forest District. Western pine beetle (*Dendroctonus brevicomis*) contributed to some of the ponderosa pine mortality in lower elevations, but was not observed to the same extent it was the previous three years.

In small patches at high elevations, attack of whitebark pine decreased slightly from a peak of 14,238 ha last year to 13,910 ha. Stand mortality decreased as well, with severity classified as 25% trace, 49% light, 22% moderate, 2% severe and 2% very severe.

A minor amount of the whitebark pine attack (233 ha) was located in the Chilliwack and Sunshine Coast Forest Districts of the CFR. The rest of the damage occurred in the SIFR, with the Rocky Mountain and Cascades Forest Districts most affected at 5,029 ha and 4,668 ha mapped, respectively. Arrow Boundary, Columbia, Central Cariboo, Kootenay Lake and Okanagan Shuswap Forest Districts contained the remaining whitebark pine mortality.



Ponderosa pine killed by mountain pine beetle near Clinton

Attack was also observed in white pine this year, with 3,777 ha affected. Intensity levels were very low, with 84% trace, 14% light and 2% severe. All the infestations were reported in the SIFR, with most of the damage (3,607 ha) located in the Headwaters Forest District. Minor mortality also occurred in the Cascades and Okanagan Shuswap Forest Districts.

Young Pine Mortality

As the current mountain pine beetle outbreak progressed and mature stands were denuded, progressively smaller and younger trees began to be attacked. By 2004, reports of young pine mortality were being made in various areas throughout the NIFR and in the northern SIFR districts where the beetle had been active for a few years. This phenomenon became more prevalent, and last year young pine mortality began to be recorded during the overview surveys separately from mature pine mortality.

Initially, young pine mortality was reported primarily in spaced, pure pine regeneration that tended to be fairly large diameter. As the outbreak progressed, smaller stems in denser stands and mixed species types were attacked. This year in some areas (particularly the 100 Mile House, Central Cariboo, Prince George, Quesnel, and Vanderhoof Forest Districts) surveyors were recording young pine mortality understory in some old grey attacked stands. An



Young lodgepole pine mortality

effort will be made next year to further delineate this type of attack from young pine in harvested areas. Without ground confirmation, it is uncertain if these were truly “young” trees or just very short suppressed trees (larger suppressed trees were recorded as mature), and whether secondary beetles were partially responsible. Various types of secondary beetles have been observed during ground surveys to be killing a portion of trees in immature stands along with the mountain pine beetle.

During the aerial overview surveys in 2008, a total of 357,017 ha of attack were recorded in immature pine in BC. Severity was assessed at 164,714 ha (46%) trace, 105,688 ha (29%) light, 56,100 ha (16%) moderate, 23,969 ha (7%) severe and 6,545 ha (2%) very severe. This is more than double the 157,360 ha observed last year, but severity levels overall were higher in 2007. The greater area affected at a lower intensity in 2008 is primarily due to the addition of the affected naturally regenerated understory scattered throughout old attack. Previously, most of the attack was recorded in cutblocks.

The SIFR continued to sustain the majority of the attack, with 279,986 ha affected. Most of the infestations were scattered throughout three districts: 113,447 ha in Central Cariboo, 81,064 ha in 100 Mile House and 45,235 ha in Quesnel Forest Districts. Attack in young pine stands was also significant in the Kamloops Forest District with 18,271 ha affected, particularly west of the Fraser River and around LacLeJeune and Dardanelles Lake. All infestations totalling 10,813 ha in the Chilcotin Forest District were located along the boundary with the Central Cariboo Forest District. In the Headwaters Forest District, 6,020 ha were damaged in the southern portion of the district, and 3,246 ha were attacked in the north section of the Okanagan Shuswap Forest District. Stands were also impacted in the Rocky Mountain Forest District (35 ha) and in the Kootenay Lake Forest District (7 ha).



Ips pini galleries on young pine
as exposed by woodpecker

Seven forest districts in the NIFR had a total of 76,939 ha of immature pine affected. Prince George continued to have the majority of the attack with 61,138 ha delineated, primarily in the western half of the district. Vanderhoof Forest District sustained 13,622 ha of damage, mainly around Nulki Lake and west of Naltesby Lake. A fertilization project is being considered for the remaining young pine stands in these districts, but experts want to be reasonably certain that attack by the mountain pine beetle and other secondary beetles is finished before proceeding. In Prince George and Vanderhoof Forest Districts, approximately 1.2 million trees were planted this year in stands that have significantly been affected by beetle mortality under the *Forests for Tomorrow* program.

Most of the mortality in the Nadina Forest District was around Binta Lake and north of Ootsa Lake, with 1,389 ha affected. The remaining attack (790 ha) was located in the Fort St. James, Peace, Mackenzie and Kalum Forest Districts. Infestations in the Skeena Stikine Forest District are starting to move into intermediate age class pine, but no attack has been observed in young pine to date.

In the CFR, minor areas of immature pine were attacked in three districts: 58 ha in Chilliwack, 17 ha in Sunshine Coast and 16 ha in North Island – Central Coast Forest Districts.

Dothistroma needle blight, *Dothistroma septospora*

In 2008, 53,505 ha of *Dothistroma* needle blight damage was observed during the aerial overview survey in the NIFR (Figure 8). This is the highest amount ever recorded by this survey it but does not necessarily reflect a large increase in infection levels. Damage was more visible than usual this year due to the survey commencing slightly earlier, the cool spring weather retarding new growth, and the above average summer precipitation of 2007. Disturbance severity was recorded at 31,996 ha (60%) light, 18,506 ha (34%) moderate and 3,003 ha (6%) severe.

Damage was greatest in the Skeena Stikine Forest District, where 38,827 ha were affected. Disturbances were concentrated near the Bulkley, Kispiox and Skeena Rivers. The Kalum Forest District sustained the remaining damage, with 14,678 ha denoted primarily mid district along the Nass River. Damage northwest of Smithers has been documented to be caused by *Dothistroma* needle blight, but east of the Bulkley Valley other needle diseases are likely part of a disease complex at work in stands.

Dothistroma needle blight was detected in 32% of a randomly selected population of 78 lodgepole pine leading plantations in the Morice TSA. In all but one of these instances, the needle blight was confined to low lying depressions and drainage courses. One of the surveyed stands close to Morrison Logging Camp near Babine Lake was severely impacted with >30% of trees having less than 50% live crown and only two years worth of healthy needles. This population of lodgepole pine plantations will serve as a baseline to monitor foliar disease behaviour in the west central interior and will be reassessed.

The *Dothistroma* Needle Blight Strategic Plan was adopted in 2006 to guide management and investment in stands impacted by *Dothistroma*. As part of the strategic plan, bi-annual helicopter monitoring flights initiated in 2006 were conducted again this year. The data collected included not only damage assessments but management recommendations for affected stands with

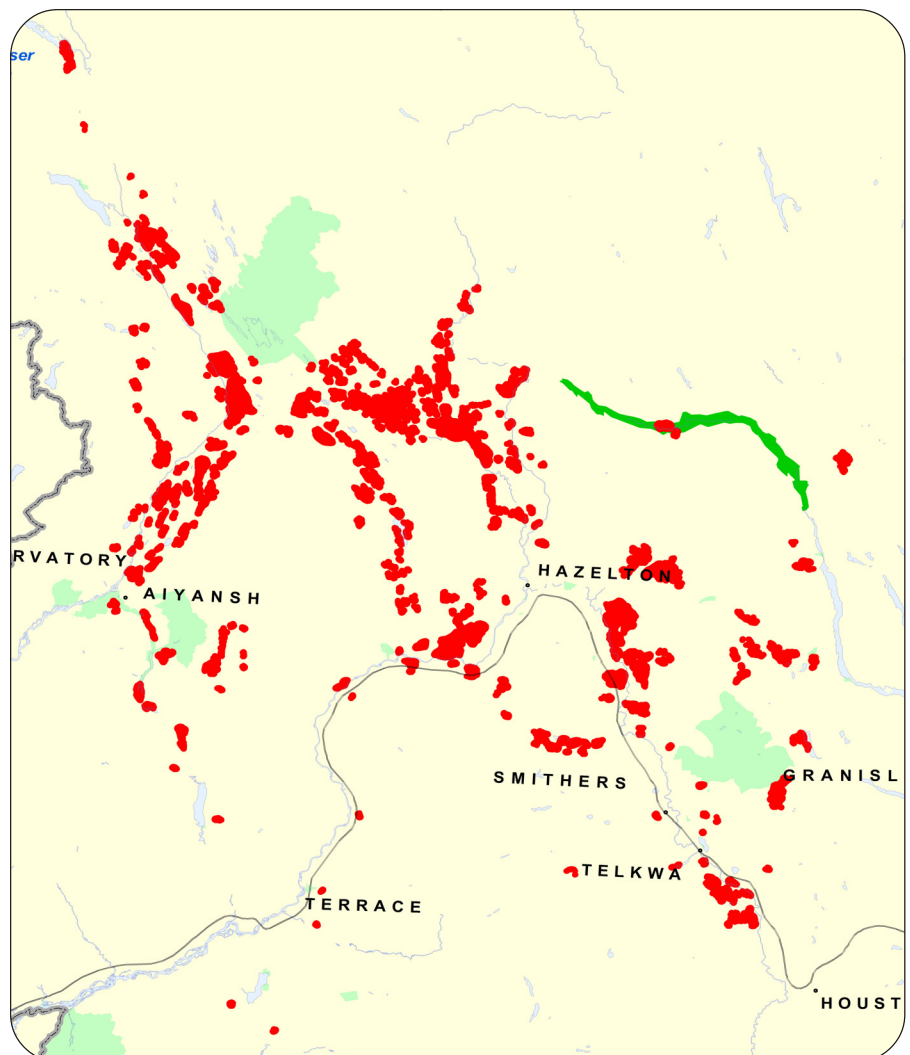


Figure 8. *Dothistroma* needle blight damage recorded in BC in 2008.

stratification down to 2 ha. The 2008 survey identified 844 ha where stocking is low enough that treatments are most likely required.

This year approximately 267 ha of severely damaged young lodgepole pine stands were planted. Fortunately, snowshoe hare surveys conducted around the Smithers area have shown that populations are down so damage to the newly planted trees should be minimal.



Damage to young lodgepole pine stand caused by
Dothistroma needle blight

Pine needle cast, *Lophodermella concolor*

Since 2003, damage caused by pine needle cast infections have only been mapped at endemic levels (under 320 ha) in small areas across the SIFR. Last year, no defoliation at all was noted during the aerial overview surveys. Damage has still been observed on the ground during this period throughout various sites where lodgepole pine grows in the province, but infections were not heavy enough for the damage to be noted from the air.

During the 2008 aerial overview surveys, a total of 16,912 ha of damage were recorded, all in the NIFR. Intensity of damage was rated as 2,956 ha (18%) light, 13,103 ha (77%) moderate and 853 ha (5%) severe.

Nadina Forest District sustained the majority of the damage, with 14,645 ha affected. Most of the defoliation was noted in immature lodgepole pine stands scattered throughout the Morrice TSA. Damage in the Fort St. James Forest District was mapped on 2,266 ha, primarily along Takla and Stuart Lakes.

Although pine needle cast is the primary damaging agent affecting lodgepole pine overall in the delineated areas, other needle diseases are also present, particularly in the Nadina Forest District. *Leptomelanconium pinicola* is likely causing the most damage to higher elevation stands, *Phaeoseptoria contortae* may be present with pine needle cast in the other areas, and *Dothistroma* needle blight may be affecting stands primarily in low lying topographic positions.

In a 78 stand random sample of lodgepole pine plantations in the Morice TSA, 47% exhibited evidence of foliar disease that was evident from a low level aerial survey. *Lophodermella* was detected in 32% of these stands; *Dothistroma* was also detected in 32% of sampled stands and close to 20% of the stands contained both of these foliar pathogens.

White pine blister rust, *Cronartium ribicola*

As with most of the pine rusts, white pine blister rust is an important damaging agent that is rarely discernable during the aerial overview surveys. Last year 448 ha were delineated in the CFR in the Sunshine Coast, Campbell River and South Island Forest Districts. Recorded damage was down to 167 ha in 2008, in part due to the reduced intensity of flight lines in the CFR this year. Three trace polygons and single trees totalled 88 ha of damage primarily south of Duncan and in the Gulf Islands of the South Island Forest District. In the Chilliwack Forest District, one trace disturbance of 76 ha was noted along Dewdney Creek. Minor single tree occurrences were mapped in other coastal districts.

Projects are presently underway to study blister rust canker dynamics and to conduct disease resistance screening on whitebark pine (Projects 1 - 3, Pages 50 - 52).



Topkill caused by white pine
blister rust infection

DAMAGING AGENTS OF DOUGLAS-FIR

Western spruce budworm, *Choristoneura occidentalis*

Recorded Defoliation

Western spruce budworm defoliation decreased by 22% since 2007 to 782,240 ha recorded in the southern half of BC (Figure 9). Severity of infestations also dropped, with 742,297 ha (95%) light, 37,291 ha (5%) moderate and 2,652 ha (<1%) severe.

The SIFR continued to be the most affected, with 766,224 (98%) of the total damage in the province. This is slightly down (5%) over last year, but is still the second highest level of western spruce budworm disturbance recorded over the past twenty-one years.

Defoliation dropped for the 2nd year in a row in the Central Cariboo Forest District to 211,982 ha, but this was still the highest amount of damage in the province. Intensity levels continued to drop as well, down to 93% light from 89% light in 2007 and 63% light in 2006 (Figure 10). Infestations occurred throughout Douglas-fir stands to the north, south and west district boundaries, and to Dugan Lake in the east.

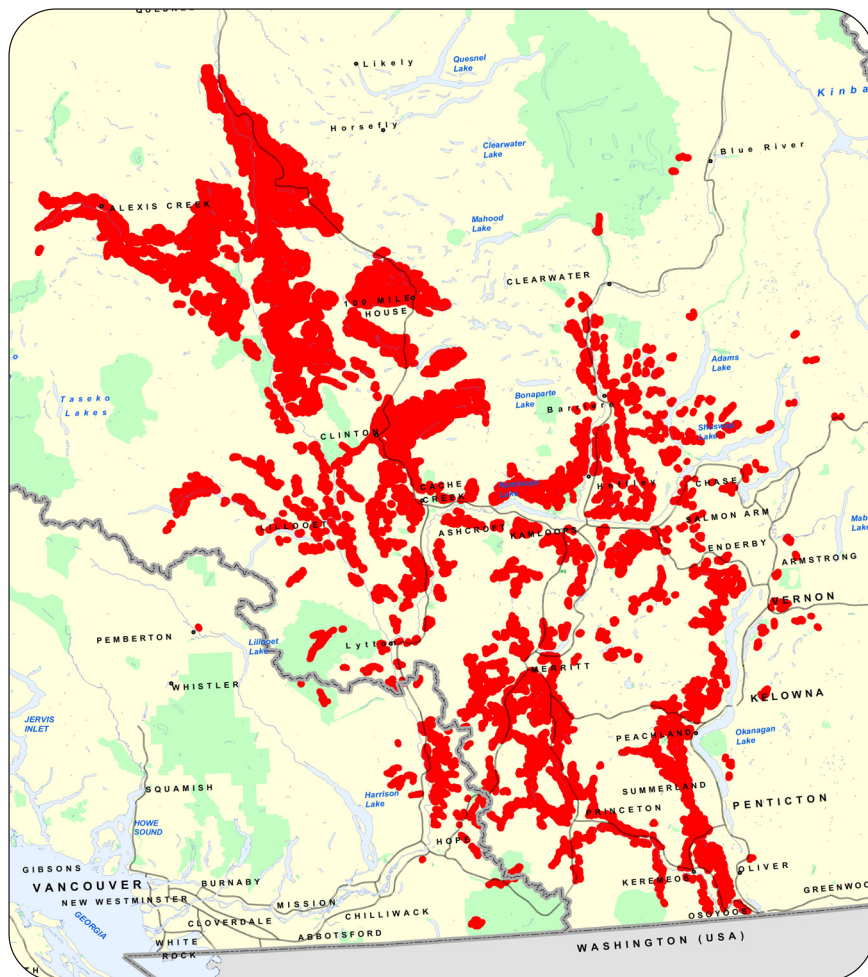


Figure 9. Areas defoliated by western spruce budworm in BC in 2008.

Merritt TSA, damage was mainly observed from Nicola Lake south through the Tulameen and Coldwater Creek drainages. In the Lillooet TSA, defoliation occurred predominantly along the Fraser River, Carpenter Lake and Yalakam River.

Defoliation in the Kamloops Forest District was similar to last year, with 124,616 ha of primarily light (99%) damage recorded. Main disturbance areas were up the North Thompson River, around Campbell Lake, north and south of Kamloops Lake, and around Bonaparte River/Hat Creek in the west.

The largest increase in defoliation occurred in the Okanagan Shuswap Forest District, from 29,630 ha in 2007 to 74,412 ha in 2008. Infestations were concentrated along the west side of the district, particularly down the west side of Okanagan Lake down through Keremeos Creek to the Oliver area. Damage levels continued to be predominantly light.

In the Chilcotin Forest District, infestations dropped by a third since last year to 40,947 ha affected. Intensity of the disturbances was the 2nd highest provincially however, with 12% moderate and 3% severe defoliation. Observed damage stretched from the eastern district boundary along the Chilko River almost to Redstone, which is not as far west as last year.

Infestations in the 100 Mile House Forest District steadily increased for the fourth year in a row to 174,604 ha, though this was still well below the peak of 234,656 ha recorded in 2004. The bulk of the defoliation was observed northwest of 100 Mile House, around 83 Mile House, north of Loon Lake and west of Meadow Lake.

Damage in the Cascades Forest District dropped for the 2nd year in a row to 127,938 ha. Assessed severity also was significantly reduced, from 23% moderate to severe in 2007 to 98% light intensity this year. Infestations were scattered throughout the primary host Douglas-fir stands but also continued to move up in elevation into subalpine fir and spruce stands in several areas. In the

For the first time, infestations spread north into the Quesnel Forest District, with 9,434 ha of light intensity defoliation recorded. All the damage occurred along the Fraser River from the south district boundary as far north as Alexandria. The remaining 2,291 ha of light defoliation was recorded in the Headwaters Forest District near Murtle Lake, Hemp Creek and Mann Creek.

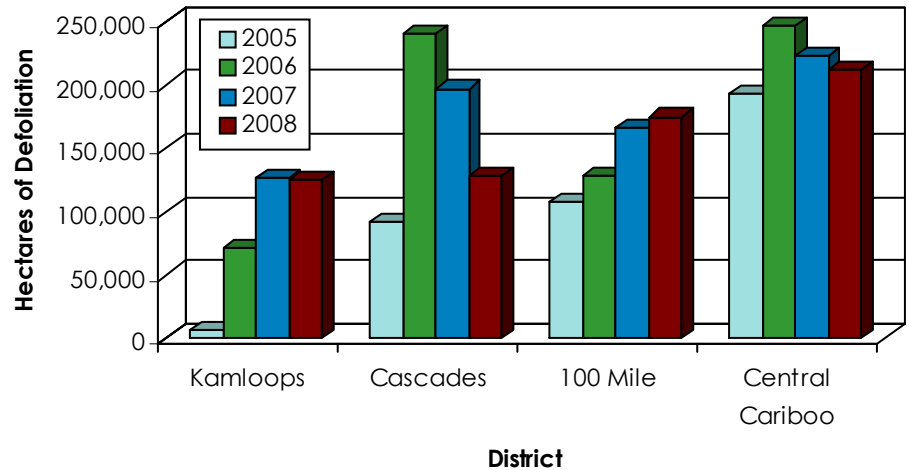


Figure 10. Hectares of western spruce budworm defoliation from 2005 – 2008, for districts with over 100,000 ha damaged in 2008.

After a two year increase, infestations in the CFR dropped substantially. Western spruce budworm defoliation was absent in most of the areas mapped in 2007. In the Chilliwack Forest District, damage dropped by a third to 15,966 ha affected. Recorded intensity was highest of all the districts in BC however, at 64% light, 30% moderate and 6% severe. Disturbances were most prevalent from Yale east to the Coquihalla toll booth and south to the Skagit River. As in the Cascades forest district, some infestations extended into subalpine fir and spruce stands. Damage in the Squamish Forest District was drastically reduced from 18,702 ha last year to only 50 ha of light defoliation between Darcy and Pemberton. Although not visible during the overview flight, light defoliation was observed over a much larger area on the ground in the Squamish Forest District.

Treatment Program

Priority ratings were given to stands based on several criteria including: previous and predicted defoliation; ability of stands to recover from damage (e.g. moister biogeoclimatic zones have better recovery potential); value of stands (e.g. investments in spacing, pruning, fertilizing); stand structure (e.g. multi-layered stands with understory at high risk of mortality); Douglas-fir types at risk in the area; wildlife habitat at risk and recreational /aesthetic value. In high priority areas, treatment



Btk loading operations of an AT 802 Air Tractor



Lama AS315B Helicopter applying Btk in Chilliwack Forest District

programs to reduce western spruce budworm populations were conducted utilizing the biological control agent *Bacillus thuringiensis* var. *kurstaki* (*Btk*). One aerial application of the *Btk* product Foray 48B® was applied to stands at a rate of 2.4 l/ha. Treatment of 61,966 ha occurred from June 23rd to July 5th over five SIFR districts and one CFR district. This was the largest *Btk* program ever undertaken in BC.

The Cariboo portion of the program was completed with two fixed wing AT 802 Air Tractors operating from the Williams Lake and 100 Mile House airports. A total of twenty-two blocks ranging from 117 ha to

5,443 ha in size were sprayed, consisting of fourteen areas in the 100 Mile House Forest District (18,239 ha), six in the Central Cariboo Forest District (8,561 ha) and two in the Chilcotin Forest District (1,382 ha).

In the southern part of the SIFR, treatment was conducted with one AS315B Lama and one UH12ET Hiller helicopter. Twenty-two blocks ranging in size from 125 ha to 6,693 ha were treated. A total of fifteen blocks covering 27,309 ha in the Kamloops Forest District and seven areas over 5,592 ha in the Cascades Forest District were sprayed.

For the first time, treatment was conducted in the Chilliwack Forest District of the CFR. A total of 833 ha were treated over four areas in the Anderson River drainage. The same helicopters were employed as those used for the SIFR project.

Pre and post treatment egg mass sampling was conducted in several of the treatment areas. Although this sampling methodology is not a direct indicator of treatment success, significant population reductions were achieved in the surveyed areas.

Egg Mass Results

Egg mass surveys were conducted at 759 sites in eight forest districts in the fall of 2008 (Table 7). The results were used to predict 2008 defoliation levels in specific areas and to assist with prioritizing areas for spring 2009 treatment. Sites with moderate to severe defoliation predicted were considered for treatment, depending on various criteria such as ecosystem (stand recovery capability), values at risk and previous defoliation.

Sites with severe defoliation predicted have decreased in all forest districts, with only four sites in total delineated, as compared to 28 last year. Kamloops Forest District continued to have the

Table 7. Summary of 2008 western spruce budworm egg mass survey results.

Forest District	Number of Sites by Defoliation Category				Total Sites
	Nil	Light	Moderate	Severe	
100 Mile House	5	85	20	0	110
Cascades	4	132	55	2	193
Central Cariboo	1	54	20	0	75
Chilcotin	4	8	7	1	20
Chilliwack	0	12	8	0	20
Kamloops	19	178	72	1	270
Headwaters	1	1	0	0	2
Okanagan Shuswap	4	43	22	0	69



Western spruce
budworm egg mass

highest number of sites (72) with moderate damage (and one with severe) predicted for next year. General areas of concern include Ashcroft, Barnhartvale, Hat Creek, Heffley, Logan Lake and Monte Lake. Areas expecting significant defoliation in the Cascades Forest District are similar to last year with 55 moderate and two severe sites. More sites were sampled than last year resulting in sites with light predicted to more than double. Areas of interest are around Tulameen, Merritt, Princeton, Coldwater Creek, Lillooet and Fountain Lake. In the Okanagan Shuswap Forest District, moderate defoliation is predicted in 22 sampling areas, particularly near the southern district boundary around Summerland and Peachland. No sites in the Headwaters Forest District are expected to have significant defoliation.

Sites with moderate damage expected in the 100 Mile House Forest District have dropped by half to twenty from last year. The primary areas of concern are north of Loon Lake, Mt. Grant, Kelly Lake, China Lake and Canoe Creek. Areas with moderate predictions in the Central Cariboo Forest District are up slightly since last year to twenty, mainly around Sting Lake and north/south of Williams Lake. In the Chilcotin Forest District, one severe and seven moderate sites were identified around Alexis Creek, Hanceville and Kloh Lake.

In the CFR, eight sites in the Chilliwack Forest District around Anderson River are predicted to sustain moderate defoliation next year.

Since various areas across the southern half of BC are expected to experience moderate to severe defoliation next year, an aerial treatment program is planned for the spring of 2009.



Douglas-fir defoliated by western spruce budworm

Douglas-fir beetle, *Dendroctonus pseudotsugae*

Stands affected by Douglas-fir beetle attack rose in BC for the sixth consecutive year to 97,053 ha, up 17% over last year (Figure 11). Intensity of mortality increased slightly to 58,859 ha (61%) trace, 26,541 ha (27%) light, 8,640 ha (9%) moderate, 2,779 ha (3%) severe and 234 ha (<1%) very severe. Douglas-fir beetle attack usually results in small scattered spots of mortality, usually mapped as larger polygons of trace to light intensity or as spots. Almost all of the area recorded as severe intensity hectares were mapped as spot infestations.

Most of the infestations (89%) continued to be observed in the Cariboo area of the SIFR, where many new patches have been noted outside of chronic areas of concern (Figure 12). Central Cariboo Forest District continued to sustain the majority of this attack, where area affected rose for the seventh consecutive year to 53,643 ha. Primary areas of concern are Gaspard Creek, Big Lake and along the Fraser River. Infestations in the Chilcotin Forest District rose thirty percent over last year to 15,244 ha of attack. Damage continued to expand along the Chilko and Chilcotin River drainages and

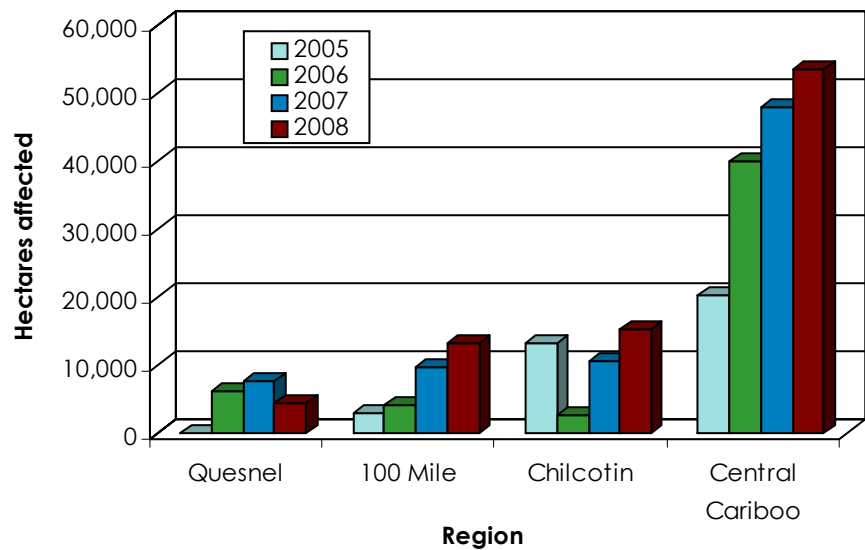


Figure 11. Hectares of Douglas-fir beetle damage from 2005 – 2008, for districts with over 4,000 ha damaged in 2008.

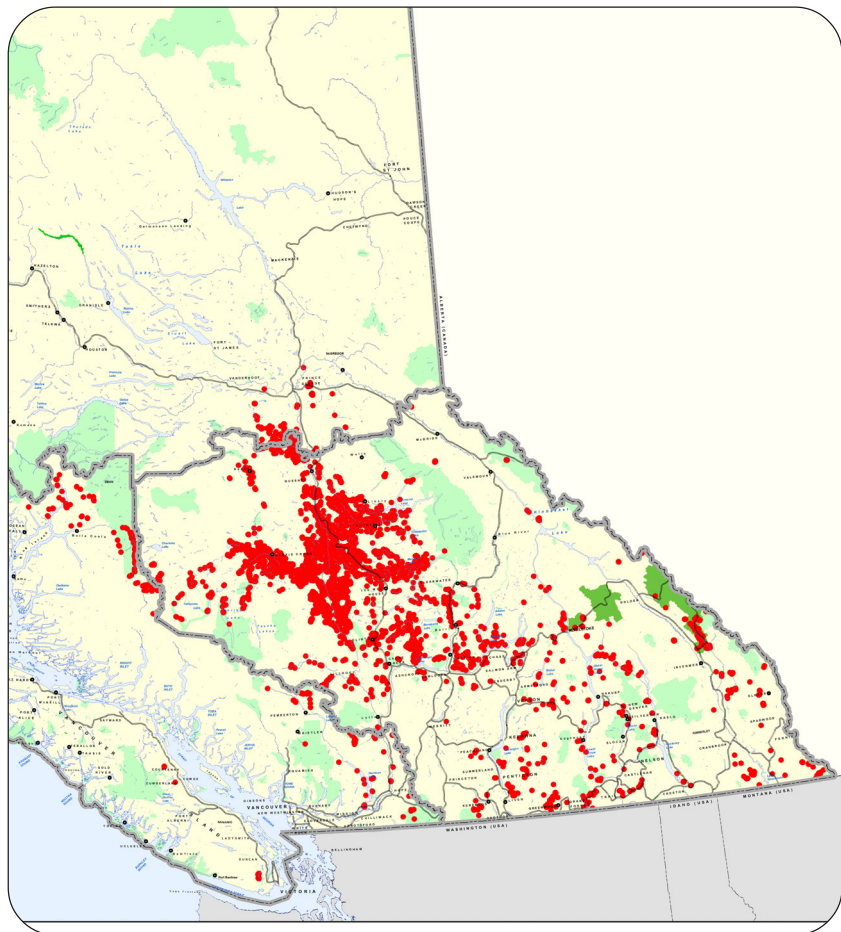


Figure 12. Douglas-fir beetle mortality recorded in BC in 2008.

disturbances were also noted on Colwell Ck, near Mt. McClinchy and south of Mt. Skinner. Douglas-fir beetle mortality in the 100 Mile House Forest District has been steadily increasing for three years, with 13,255 ha of attack recorded in 2008. Infestations were scattered throughout the district, notably around Jesmond, Canoe Creek, Bonaparte River and Loon, Young, Canim, Eagle and Timothy Lakes.

Overwinter brood assessments were conducted in the spring for these three Cariboo forest districts (Table 8). An r-value number was produced from the results, which indicated if the population was decreasing (<0.7), static (0.7 to 1.3) or increasing (>1.3). The results show a continued increasing population, which concurs with the larger areas mapped as infected in 2008. However, trap trees situated throughout the 100 Mile House District had very little overflow attack as compared to the last two years. This may be a sign the population is slowing down (as is indicated by a reduction in the r-values for this district as well).

Table 8. Douglas-fir beetle overwinter mortality results for three Cariboo districts 2006 to 2008.

Forest District	r Value		
	2006	2007	2008
100 Mile House	3.3	2.5	2.1
Central Cariboo	4.6	3.4	3.9
Chilcotin	4.5	2.3	3.1

Although attack in the Quesnel Forest District was still substantial at 4,495 ha, this was the only SIFR district to experience a drop in disturbances over last year, which was recorded at 7,586 ha. Most of the damage occurred along the Fraser River corridor at the north edge of the district.

For the rest of the SIFR, Rocky Mountain Forest District continued to sustain the highest levels of attack with a slight increase to 2,037 ha of mortality. Infestations were most prevalent along the Kootenay and White Rivers in the north and Koocanusa Lake and Kishinena Creek in the south. A dispersed windthrow event this summer in the Palliser Drainage may contribute to increased Douglas-fir beetle populations in the future. This situation will be closely watched. Attack rose substantially in the Columbia Forest District to 1,897 ha affected from only 132 ha last year. Some of the mortality was recorded as scattered spots, but the largest increase was from an infestation along the Kootenay River at the south boundary of the district, that moved in from the Rocky Mountain Forest District.

Douglas-fir beetle attack more than tripled to 1,473 ha in the Arrow Boundary Forest District in 2008. Spot of mortality were scattered throughout the range of Douglas-fir, and one larger infestation was observed near Copper Mountain. Attack also more than tripled in the Kamloops Forest District with 943 ha affected. Areas of concern were around the Deadman River, the North Thompson River and the Paul Lake area, but spots of mortality were noted throughout the district. Attack levels were similar in the Cascades and Okanagan Shuswap Forest Districts, with 490 ha

and 389 ha affected, respectively. Small infestations were scattered around the Kootenay Lake Forest District, totalling 265 ha. In 2007, wildfires around the Argenta area scorched significant numbers of Douglas-fir trees, which may result in a population upswing for this area.

Only 171 ha of primarily spot infestations were identified in the Headwaters Forest District, but Douglas-fir beetle populations are increasing following a significant windthrow event

in 2007 in the Jackman – Tete Jeune area. Surveys indicate that out of approximately 1,000 trees that blew down, 800 have Douglas-fir beetle attack. Overflow attack into live trees in 2008 occurred on twenty-five trees at one site and efforts are underway to control this problem.



Mortality caused by Douglas-fir bark beetle

Of the 1,706 ha of damage located in the CFR, most (1,019 ha) were recorded in the North Island – Central Coast Forest District. Spots were scattered around the Dean Channel and the boundary with the Chilcotin Forest District, but the largest infestation increases were in the Atnarko and Klinklini drainages. Attack delineated in the Chilliwack Forest District was 277 ha, which was almost a third of the damage recorded last year. Infestations were primarily mapped along Mehati Creek and near Mount Hewitt Bostock. Operational trials with the anti-aggregation pheromone MCH were conducted in this district in 2008 (Project 5, Page 52).

In the Prince George Forest District of the NIFR, recorded Douglas-fir beetle attack rose to 888 ha from 677 ha last year. Infestations moved north out of the Blackwater River area up to Naltesby Lake this year, and a few disturbances were noted around the Mt Tabor area. A funnel trap program was utilized to provide some measure of control this year (Project 6, Page 53), as interest is down in salvage sales due to the poor market and Douglas-fir are very expensive to pile and burn (this scenario was the case in many districts).

Only one spot infestation was observed during the overview surveys in the Vanderhoof Forest District, but a detailed aerial helicopter survey in the fall recorded 243 red attacked trees adjacent to the Prince George District in the southeast. No attack was noted during the overview flight in the Fort St. James Forest District, though some Douglas-fir bark beetle mortality is occurring. Detailed aerial and ground surveys have reported infestations in the southern half of the district around Stuart, Trembleur and Pinchie Lakes. The highest concentrations are on TFL 42 and the UNBC research forest.

Douglas-fir tussock moth, *Orgyia pseudotsugata*

Historically, Douglas-fir tussock moth populations have reached outbreak proportions in southern BC every decade except the 1950's since 1916. Therefore, these moths are monitored annually with pheromone traps at specific sites within known high hazard areas in Cascades, Kamloops, Okanagan Shuswap and 100 Mile House Forest Districts. This system was developed to provide early warning of rising populations so treatment can be initiated before significant defoliation occurs, as outbreaks develop very quickly.

From 2002 to 2005, the average number of moths caught per trap in each district fluctuated considerably, but during the last three years catches overall have consistently risen (Table 9). The threshold where an outbreak is likely was reached in some areas of the Kamloops Forest District last year and in all six-trap cluster areas this year with the exception of Spences Bridge. In the Okanagan Shuswap and Cascades Forest District specific sites are exhibiting high trap catches. 100 Mile House Forest District catches are still low, but rising overall.

Since the MFR began conducting the aerial overview surveys, visible defoliation has been negligible with the highest area of damage totalling 88 ha last year. As indicated by the trapping system, an outbreak began this year with 2,597 ha of defoliation mapped in the SFR. Intensity levels were assessed at 957 ha (37%) light, 717 ha (28%) moderate and 922 ha (35%) severe.

The majority (2,249 ha) of the damage occurred in the Kamloops Forest District with infestations located south of Kamloops Lake, around Heffley Lake, along the South Thompson River from Kamloops to Monte Creek and a small area near Stump Lake (Figure 13). The Okanagan Shuswap Forest District sustained 220 ha of defoliation in two primary locations near Osoyoos and Okanagan Falls. A total of 117 ha of defoliation were observed in the Cascades Forest District along the Similkameen River on the border with Okanagan Shuswap Forest District. In the Arrow Boundary Forest District,

Table 9. Average number of Douglas-fir tussock male moths caught per trap, 2002 – 2008.

Year	District			
	Kamloops (90 traps)	Okanagan Shuswap (135 traps)	Cascades (57 traps)	100 Mile House (144 traps)
2002	11.5	6.5	8.2	1.2
2003	31.5	9.5	6.8	2.3
2004	13.6	7.2	2.8	1.3
2005	8.5	8.5	3.8	0.6
2006	12.7	2.2	1.4	0.5
2007	23.6	1.2 ^a	5.0	0.6
2008	46.7	25.0 ^a	11.8	2.2

^a 26 traps in 2007, 96 traps in 2008



Douglas-fir tussock moth defoliation near Kamloops

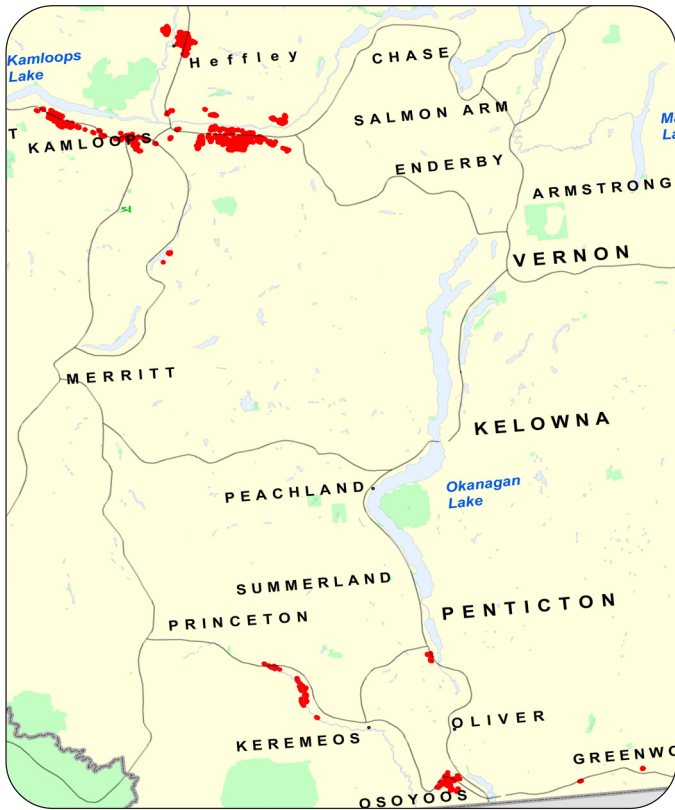


Figure 13. Douglas-fir tussock moth defoliation recorded in 2008.

trap catches and the outbreak is expected to continue in 2009. Generally, populations are highest in various lower elevation Douglas-fir stands in the Kamloops Forest District. Populations also seem to be building in the southern part of the Okanagan Shuswap Forest District from Keremeos to the Arrow Boundary Forest District border. In the Arrow Boundary Forest District, populations are also highest in the south, particularly around Rock Creek and Bridesville. Another NPV treatment program is planned for the spring of 2009 in high value stands where damage is anticipated to be worst. Most of the treatments are expected to be conducted in the Kamloops Forest District.

one area of 11 ha of damage was mapped near Rock Creek. Other scattered, individual trees were noted near Grand Forks, Midway and Bridesville.

Based on 2007 trap catches and fall egg mass surveys, a treatment of nucleopolyhedrosis virus (NPV) was conducted in early June with a UH12ET Hiller helicopter. Areas with moderate to severe defoliation predicted south of Kamloops Lake, around Heffley Creek, Campbell Creek and Barnhartvale in the Kamloops Forest District were treated. A total of 1,130 ha equivalent was sprayed (consisted of full coverage and alternate swathing methods). Results were promising, with very few egg masses found within the treatment areas.

Egg mass surveys were conducted again this fall in all historical budworm outbreak areas. Egg masses at varying levels of intensity were found at most sites. Results are still being compiled, but the surveys are confirming increasing



Female Douglas-fir tussock moth laying eggs

Laminated root disease, *Phellinus weirii*

Root diseases in general are difficult to identify during the aerial overview survey and are usually not mapped unless surveyors have some local knowledge of the area. Last year small infection centers of laminated root disease totalling 404 ha were identified in the CFR. This year 626 ha of primarily light damage were mapped in three CFR forest districts. In Squamish Forest District, 243 ha were delineated northwest of Pemberton. Small scattered sites throughout the Chilliwack Forest District totalled 195 ha and sites on Cortes Island in the Sunshine Coast Forest District accounted for the remaining 187 ha.

Douglas-fir Needle Cast, *Rhabdocline pseudotsugae*

Douglas-fir needle cast can affect trees throughout the range of Douglas-fir in BC, but damage is not usually significant enough to be seen during the aerial overview surveys. Since the MFR has been conducting the survey, Douglas-fir needle cast damage has not been recorded until this year when 471 ha were delineated in the Kootenay Lake Forest District.

All the damage was located in drainages along the Kootenay River, scattered in small polygons from Skookumchuck south to Gold Creek. Intensity of defoliation was assessed at 379 ha (80%) moderate and 92 ha (20%) light.



Needles infected with Douglas-fir needle cast

DAMAGING AGENTS OF SPRUCE

Spruce beetle, *Dendroctonus rufipennis*

Provincially, spruce beetle damaged 27,874 ha in 2008. This is the fifth consecutive year that mortality from spruce beetle has dropped from a peak of 315,953 ha affected in 2003. Attack intensity also continued to drop, with 13,975 ha (50%) trace, 6,946 ha (25%) light, 5,027 ha (18%) moderate and 1,927 ha (7%) severe.

Current spruce beetle attack is one of the most difficult to record from the air due to the subtle, but quick colour change to foliage of infested trees that occurs within a year after attack. In stands where current mountain pine beetle attack is still prevalent, it is even harder to identify. Regardless, ground observations generally concur that infestations of spruce beetle are not widespread across the province at this time.

The majority of the damage (20,539 ha) continued to be recorded in the SIFR. Infestations observed in the Central Cariboo Forest District were less than half that of last year but still were the highest in the province with 6,008 ha affected. Most of the damage occurred in the eastern portion of the district, which contains the majority of the spruce stands. Mortality was concentrated on Niagara Creek and south of Quesnel Lake. Ground reconnaissance noted that attacked spruce trees were unusually vigorous in pitch tube production this year.

Spruce beetle populations continue to be quite active in the Okanagan Shuswap Forest District, with 3,898 ha delineated. This is a drop from 5,874 ha last year when infestations rose sharply, but the decrease may be attributed to the two-year life cycle of the spruce beetle, as current green attack was prevalent in 2008 ground surveys. Most of the infestations continue to be located in the south around Cathedral Provincial Park and the Snowy protected area. It is suspected that trees scorched by the fire in Cathedral Provincial Park in 2006 were highly susceptible to attack and contributed to this outbreak. An infestation in the Young Creek area is scheduled for harvesting this winter.

Attack in the Cascades Forest District more than doubled over last year from 1,656 ha to 3,384 ha. Most of this occurred in the Lillooet TSA, in particular around Mt. McGillivray and southeast of Anderson Lake. Infestations decreased substantially in the 100 Mile House Forest District, from 8,643 ha last year to 2,000 ha in 2008. Damage continued to occur in the same general areas (in the northeast corner of the district).

Infestations in the Headwaters Forest District tripled in 2008 to 1,631 ha. The largest affected area was in the Dawson Creek drainage in a hanging valley that fortunately does not have other susceptible timber types nearby. The remaining attack recorded in the SIFR occurred in the Quesnel, Kamloops, Rocky Mountain and Columbia Forest Districts. Some drainages with spruce stands in the southeast portion of the province have been affected by windthrow and fire events over the past two years, and are being closely watched for possible spruce beetle outbreaks.

A total of 7,023 ha were damaged by spruce beetle in the NIFR in 2008. Most of this attack was situated in the Peace Forest District with 6,749 ha affected, particularly around Halfway River. The attack was primarily assessed to be trace in severity however (94%) and detailed aerial surveys flown later in the year only noted small spots of mortality in over-mature spruce stands. Small widely scattered infestations accounted for 267 ha of attack in the Prince George Forest District. In the rest of the NIFR, small spots of mortality were less than 5 ha per district. To date, the widespread tree breakage that occurred across the NIFR in 2006 due to a heavy snowfall event has not resulted in an upswing in spruce beetle.

Spruce beetle populations in general were endemic in the CFR in 2008. The North Island – Central Coast, Squamish and Chilliwack Forest Districts sustained 195 ha, 105 ha and 12 ha of attack, respectively.

Green spruce aphid, *Elatobium abietinum*

A small outbreak by the green spruce aphid began in the Haida Gwaii Forest District in 2006. The infestation spread to 604 ha last year, and increased from light to severe intensity. This year populations declined abruptly, possibly due to the cold winter weather. No defoliation was visible aurally in 2008.



Damage to Sitka spruce caused by green spruce aphid

DAMAGING AGENTS OF TRUE FIR

Western balsam bark beetle, *Dryocoetes confusus*

Mortality caused by western balsam bark beetle affected 532,064 ha provincially in 2008. This was one-third the area mapped last year. Intensity levels dropped slightly as well, with 495,238 ha (93%) trace, 35,016 ha (7%) light, and 1,840 ha (<1%) moderate to very severe.

This damaging agent tends to affect the same stands year after year with chronic, low level, scattered attack. Since 2004 base flight maps have included the previous year's disturbance polygons to save time and to improve incidence estimates. Surveyors verify existing boundaries and make changes where required. The large drop in area this year therefore indicates a true drop, as overall polygon size had to be adjusted downward and very few new infestations were noted. Where mortality continues to be chronic however, cumulative attack can result in severely damaged stands over time. A project to try and determine non-recoverable losses due to western balsam bark beetle mortality is in progress in the NIFR (Project 7, Page 53).

The majority of the attack continued to occur in the NIFR where subalpine fir (primary host species) is most abundant. Of the northern forest districts, Skeena Stikine Forest District continued to be the most affected with 100,116 ha of mortality recorded (Figure 14). This was half the level mapped last year, but similar to incidence observed the year before. The primary reason was the northwest portion of the district (in the Cassiar TSA), where mortality was particularly extensive and intensive, was surveyed for the first time in several years in 2007, and was not flown again in 2008.

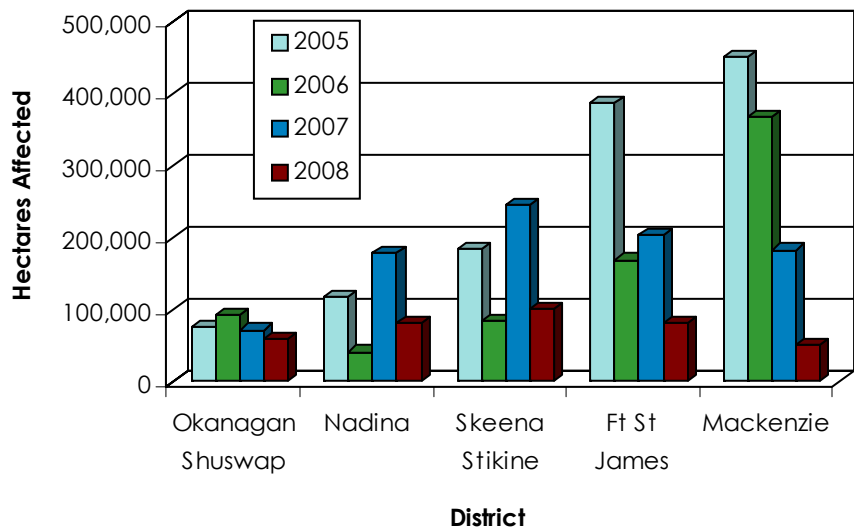
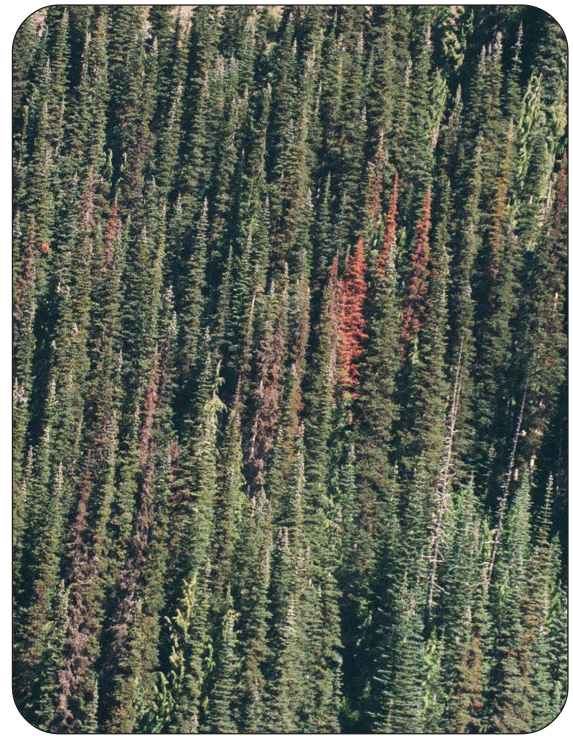


Figure 14. Hectares affected by western balsam bark beetle in BC from 2005 – 2008, for districts with over 50,000 ha of damage in 2008.

Infestations in the Fort St. James Forest District affected 82,640 ha, primarily in large polygons mid district. Despite having the second highest level of attack in the province again this year, damage mapped is down sixty percent from last year. Nadina Forest District sustained 80,738 ha of western balsam bark beetle damage throughout the district, down from a peak of 178,155 ha in 2007. The other NIFR district to have significant attack in 2008 was the Mackenzie Forest District with 51,843 ha. The majority of the disturbances were mapped mid district. Infestations in Mackenzie Forest District have been steadily declining since a peak of 539,429 ha in 2004. Disturbances in the Peace

Forest District declined drastically to 6,126 ha from 101,713 ha last year, and are all located in the northwest tip of the district. The reduction follows the provincial trend, but also may in part be due to less coverage of this district than last year. Small, scattered polygons of attack occurred in the other NIFR districts, with no district sustaining a total of more than 1,200 ha of damage.

In the SIFR, the highest level of attack at 59,029 ha was observed in the Okanagan Shuswap Forest District. Area affected is down 18% since last year, but this is relatively static compared to the large drops in the NIFR (Figure 14). Detected infestations in the Headwaters Forest District totalled 24,027 ha, down to a quarter of the mortality noted last year. Area affected in the Central Cariboo Forest District was 20,976 ha, down from 68,891 ha.



Subalpine fir mortality due to western balsam bark beetle attack

The only two districts in the SIFR to experience increases in western balsam bark beetle infestations were the Chilcotin and Kamloops Forest Districts with 19,685 ha and 9,742 ha affected, respectively. Area of damage recorded was similar in 100 Mile House Forest District with 10,639 ha and Arrow Boundary Forest District with 10,545 ha. Attack levels in the Cascades and Rocky Mountain Forest Districts were also alike, at 8,581 ha and 8,004 ha, respectively. The largest decrease in western balsam bark beetle attack in the SIFR occurred in the Quesnel Forest District, where only 5,977 ha were mapped, compared to 104,481 ha last year. The remainder of the SIFR mortality was recorded in the Columbia and Kootenay Lake Forest Districts, with 5,086 ha and 2,555 ha affected, respectively.

In the CFR, damage remained highest in the North Island – Central Coast Forest District, where infestations rose by 13% to 13,424 ha. Infestations noted in the Chilliwack Forest District rose by 12% to 7,776 ha, but dropped by more than half in the Squamish Forest District to 2,187 ha affected. Generally, attack in the CFR was contained within the subarctic and warm subzones of the region at higher elevations. In addition to the primary host subalpine fir, *Amabilis* fir was attacked to a minor extent in the maritime subzones.

Two-year-cycle budworm, *Choristoneura biennis*

Defoliation by the two-year-cycle budworm affected 56,619 ha provincially in 2008, with almost all (99%) recorded at light intensity. Since this budworm is on the even year cycle in the SIFR, 54,136 ha (96%) of the damage occurred in this region in 2008.

Infestations were most prevalent in the Headwaters Forest District, with 50,716 ha delineated. This was the only district where any defoliation over light intensity was recorded, with 304 ha of moderate and 19 ha of severe mapped. Damage was scattered throughout the district, with a

concentration of disturbances between Murtle Lake and the North Thompson River. Two infestations totalling 1,813 ha were observed in the Quesnel Forest District, north of Keithley Creek and on Isaac Lake. The Keithley Creek disturbance extended into the Central Cariboo Forest District where one other infestation west of Quesnel Lake was also recorded for a total of 956 ha affected. In Central Cariboo Forest District, 328 ha of defoliation were mapped east of Canim Lake. In subalpine fir/spruce forests areas of these districts, extensive defoliation was observed from the ground but it was generally too light to be seen from the air.

The only defoliation in the NIFR was mapped west of Lodi Lake in the Prince George Forest District, adjacent to the boundary of Quesnel Forest District. It is suspected that the 2,483 ha of defoliation recorded was caused by two-year-cycle budworm on the even year cycle, as it is close to the SIFR and no defoliation was recorded here last year. In Fort St. James Forest District where the budworm is on an odd year cycle, light defoliation was observed from the ground throughout susceptible stands. It is suspected that damage will be high next year in this district.

Woolly adelgid, *Adelges* spp.

Balsam woolly adelgid (*Adelges piceae*) infestations are known to exist in the Campbell River, Chilliwack, South Island, Squamish and Sunshine Coast Forest Districts of the CFR, though they are not usually seen during the overview survey. Observed damage was down substantially over the 860 ha last year to only 6 ha in 2008. This was partially due to reduced intensity of the CFR flight lines this year. Two small infestations were recorded, both on Cortes Island in the Sunshine Coast Forest District.

In the Rossland area of the Arrow Boundary Forest District, subalpine fir trees were identified to be dying from damage by a type of woolly adelgid, though the species was not determined. The affected trees were located on a golf course, and the owner removed the trees before sufficient samples could be gathered for species confirmation. This area will be closely watched for any other affected trees, as *Adelges piceae* has not been detected here previously.



Subalpine fir damaged by woolly adelgid near Rossland



Woolly adelgid on felled bole of subalpine fir

DAMAGING AGENTS OF HEMLOCK

Western hemlock looper, *Lambdina fiscellaria lugubrosa*

Light defoliation attributed to western hemlock looper impacted 537 ha in the SIFR in 2008. In the Headwaters Forest District, 469 ha of damage were located east of Hobson Lake. Two small polygons totalling 68 ha were mapped in the Okanagan Shuswap Forest District south of Sicamous and east of Three Valley Gap.

An infestation of western hemlock looper was confirmed on the ground in the Skeena Stikine Forest District, though it wasn't observed during the aerial survey. The defoliation was estimated to be affecting approximately 10 ha of subalpine fir and spruce at the top of the Telegraph Creek drainage, at the upper end of a coastal valley. This area will be surveyed next year, to ascertain if the infestation is moving into the more traditionally affected hemlock stands further down the valley.



Severe western hemlock looper defoliation in
Telegraph Creek drainage

Since western hemlock looper outbreaks are cyclical in nature, populations have been monitored in the SIFR for several years in chronic areas (Table 10). After a peak in 2003, the number of male moths caught in pheromone traps indicated an endemic population for the next four years. In 2008 however, average trap catches jumped dramatically. Areas with the highest trap catches (over 500 average caught per trap) were at Finn Creek, Murtle Lake Road and Thunder River in the Headwaters Forest District. Two other high catch areas at Noisy/Kingfisher Creek and Adams River were located in the Okanagan Shuswap Forest District. Pheromone trap catches in the wet belt area of the Quesnel and Central Cariboo Forest Districts were very low.

Table 10. Average number of western hemlock looper male moths caught per trap at various MFR sites (6-trap clusters per site), 2003 - 2008.

Forest District (# sites)	Year					
	2003	2004	2005	2006	2007	2008
Headwaters (5)	79.2	7.5	9.2	5.0	19.9	552.7
Okanagan Shuswap (11)	878.9	45.3	8.0	3.7	7.7	202.9
Columbia (11)	No traps	4.8	1.2	4.1	1.9	25.0

This trapping program began during the last outbreak, and hence the number of moths that indicate defoliation is eminent the next year is not known at this point. The high rise in moths caught in some areas this year suggests an outbreak is developing and when defoliation does occur trap calibration will be refined.

DAMAGING AGENTS OF LARCH

Larch needle blight, *Hypodermella laricis*

Larch needle blight damage in the southeast corner of BC peaked in 2006 with 68,228 ha affected. Last year damaged dropped to 13,540 ha and intensity decreased substantially as well, with only 11% recorded as severe. In 2008, area defoliated remained relatively constant at 12,285 ha, but severity levels increased to 59% severe, 27% moderate and only 14% light. All the damage was reported to be in western larch stands this year. Alpine larch stands that were severely defoliated in 2006 and did not look like they would live appeared to be recovering in 2008.



Larch needle blight damage in Kootenay Lake Forest District

Defoliation continued to be highest in the Rocky Mountain Forest District, with 9,859 ha affected. Damage was scattered around the district but the largest concentrations were noted southwest of Columbia Lake, which is slightly further north than the majority of the disturbances recorded last year.

Larch needle blight affected 1,944 ha in the Kootenay Lake Forest District, primarily south of Kootenay Lake and further west than most of last year's areas. Infestations were also observed at higher elevations this year with older stands on or near the top of ridges primarily affected, as opposed to stands in valley bottoms which were defoliated in 2007. Defoliation also appeared to be patchy rather than uniform throughout a stand, which is unusual. The remaining 482 ha of damage were recorded over one polygon along McKinney Creek in the Arrow Boundary Forest District.



Trees severely defoliated by larch needle blight

DAMAGING AGENTS OF CEDAR

Yellow-cedar decline

In-depth investigation of damage due to yellow-cedar decline in BC began with detailed aerial surveys in 2004. Last year, 24,282 ha of this disturbance were mapped at the aerial overview level along the coast of BC. In 2008, damage continued to be observed during the overview with 47,130 ha delineated. Severity was assessed at similar levels to last year, with 11,766 ha (25%) trace, 17,741 ha (38%) light, 2,552 ha (5%) moderate and 15,071 ha (32%) severe.

In the CFR 41,972 ha of yellow-cedar decline was delineated. North Island – Central Coast Forest District observed damage doubled over last year to 32,305 ha. Decline damage was located throughout coastal inlets, primarily from King Island south to Kingcome Inlet, where some of the largest disturbance polygons were noted. In the North Coast Forest District, damage also increased from 1,982 ha last year to 4,898 ha. Small polygons were scattered along coastal inlets, with the greatest concentrations along Observatory Inlet. Damage in the Haida Gwaii Forest District remained static with 4,769 ha affected.



Yellow-cedar decline damage on Owikeno Lake

Yellow-cedar decline damage in the NIFR all occurred in the Kalum Forest District, with 5,158 ha mapped. This is up substantially over last year, when only 353 ha were delineated. Small scattered polygons were mapped along the coast, with the main areas affected around Kitimat Arm.

Several projects are presently underway to study various aspects of the yellow-cedar decline phenomenon (Project 8, Page 54).

DAMAGING AGENTS OF DECIDUOUS TREES

Bruce spanworm, *Operophtera bruceata*

Since the aerial overview surveys have been conducted by the MFR, damage by Bruce spanworm has not been recorded. This moth is a native defoliator that is found throughout the Boreal forests of Canada. A variety of deciduous trees can be attacked, though the infestations observed this year were in aspen stands. Outbreaks usually last two to three years and result in reduced radial growth. Tree mortality will only result if defoliation is severe for several consecutive years.

Recorded damage was concentrated north and south of the Peace River in the Peace Forest District in 2008. A total of 97,804 ha were affected, at 63,691 ha (65%) light, 33,359 ha (34%) moderate and 753 ha (1%) severe intensity. Over the past few years, large aspen tortrix has been defoliating some of these same stands and was still present with the Bruce spanworm to a minor degree this year.



Defoliation caused by
Bruce spanworm

Large aspen tortrix, *Choristoneura conflictana*

Large aspen tortrix defoliation has been prevalent in trembling aspen and balsam poplar stands in the NIFR for several years, with peak damage occurring in 2004. Infestations have steadily declined since the peak to only 1,546 ha recorded this year, down substantially from 61,910 ha in 2007. Declining populations are also indicated in the decreasing intensity levels, assessed at 1,391 ha (90%) light, 43 ha (3%) moderate and 112 ha (7%) severe this year.

The majority of the drop in damage occurred in the Peace Forest District, where 59,458 ha were recorded as defoliated last year and none was in 2008. Several deciduous defoliators have historically damaged stands in the NIFR, and when one is on the decline and another is on the rise, it is sometimes difficult to determine the primary damaging insect. That was the case in the Peace Forest District where Bruce spanworm was identified this year as the main defoliator. Large aspen tortrix could also be found in stands, but at a much lower level than the Bruce spanworm. Hence, the decision was made to identify the damage by the primary agent. It is likely that last year Bruce spanworm was present with the large aspen tortrix, but was not yet identified.

Damage by the large aspen tortrix in the Skeena Stikine Forest District returned this year with several small infestations totalling 1,414 ha near Bulkley Canyon and the Kispiox River. Again, a portion of this defoliation may be caused by another insect, the western winter moth (*Erannis tiliaria vancouverensis*). This moth was identified as the primary defoliator of a few trees in the Hazelton town area. Minor disturbances attributed to the large aspen tortrix were also noted in the Fort St. James, Fort Nelson and Nadina Forest Districts at 60 ha, 51 ha and 20 ha, respectively.

Gypsy moth, *Lymantria dispar*

Although the North American strain of the European gypsy moth has been periodically discovered in BC, aggressive detection and prompt eradication programs over the past twenty years have been successful in preventing establishment.

In response to 45 male moths caught in monitoring pheromone traps in 2007, a treatment program was conducted in 2008. On Saltspring Island and at Saltair near Ladysmith, three ground spray applications of the organic *Btk* formulation Foray 48B® were conducted between May 21st and June 12th. These treatments were followed up with mass pheromone trapping in the summer. Mass trapping was also conducted near Lake Cowichan. Treatments in these areas were highly successful, with no moths caught in the traps.

General monitoring pheromone traps deployed by the Canadian Food Inspection Agency in 2008 caught a total of 33 male moths (Figure 15). Trapping results indicate that despite high populations in Eastern Canada, the rate of new finds in BC is relatively low. The majority of the moths were found in the Lower Mainland/Fraser Valley, with sixteen at Harrison Hot Springs, three around South Surrey/White Rock, one in Burnaby, two in Richmond, two in Vancouver, two in Langley, three in Delta and one in Chilliwack.

An additional two moths were caught near Victoria and one in the interior near Creston.

The current primary area of concern is Harrison Hot Springs. An aerial spray of up to four applications with Foray 48B® is planned for the spring of 2009. Other locations where moths were trapped in 2008 will be monitored next summer with sampling grids using various trap densities. Further information regarding the current gypsy moth program and historical records can be accessed at the MFR's gypsy moth website at <http://www.for.gov.bc.ca/hfp/gypsymoth/index.htm>.



Figure 15. Gypsy moth trap locations with positive catches in 2008.

Forest tent caterpillar, *Malacosoma disstria*

Forest tent caterpillar defoliation of aspen rose substantially to 10,185 ha affected provincially from only 2,829 ha last year. Severity was assessed at 1,284 ha (13%) light, 4,088 ha (49%) moderate and 4,813 ha (47%) severe.

Unlike last year when most of the damage occurred in the NIFR, this year the SIFR sustained the bulk of the defoliation. Most of disturbances (8,345 ha) were mapped in the Quesnel Forest District east of Quesnel in the Cottonwood River area. An additional 919 ha were located in the Headwaters Forest District along the Fraser River near Mt. Robson. In the Columbia Forest District, 241 ha were mapped east of Upper Arrow Lake. Rocky Mountain and Arrow Boundary Forest Districts sustained the remaining defoliation with 130 ha and 11 ha damaged, respectively.

In the NIFR, 340 ha of forest tent caterpillar defoliation occurred near Dunkley in the Prince George Forest District. One infestation east of Kitsumkalum Lake in the Kalum Forest District covered 164 ha, and the remaining 36 ha were mapped in the Peace Forest District.

Serpentine leaf miner, *Phyllocristis populiella*

After a dramatic drop in recorded damage last year to 1,185 ha, serpentine leaf miner defoliation of aspen stands increased to 16,641 ha in 2008. In the SIFR, 10,927 ha of defoliation was mapped, 99% of which was rated light in intensity. The Headwaters Forest District sustained 8,751 ha of damage south of Clearwater Lake and east of Adams River. Infestations totalling 1,585 ha were observed north of Shuswap Lake and near the Perry River in the Okanagan – Shuswap Forest District. In the Kamloops Forest District, 469 ha were damaged near Taweel Lake and the remaining 23 ha were located in the Arrow Boundary Forest District.

No damage by the serpentine leaf miner was mapped in the southern portion of the province last year though defoliation continued to be widespread in the Quesnel, Central Cariboo and 100 Mile House Forest District. This continued to be the case this year. In the areas where serpentine leaf miner occurs in these districts, the aspen is very widespread but occurs as a minor component with other tree species in stands, and mapping of infestations is not usually practical. This is particularly the case for the past few years, when extensive bark beetle infestations have also been present.

In the NIFR, the Skeena Stikine Forest District contained 5,259 ha of moderate defoliation, all in one large infestation along the Babine River. Fort Nelson Forest District was the only other northern district to have significant serpentine leaf miner damage, with 552 ha of small, scattered light infestations recorded. This was half the amount that was observed in this district last year.



*Serpentine leaf miner damage to aspen stand in
100 Mile House Forest District*

Aspen and poplar leaf and twig blight, *Venturia* spp.

Damage caused by aspen and poplar leaf and twig blight infections across the NIFR peaked at 82,376 ha in 2002. Disturbances caused by this blight decreased to levels that were not detected at all in the aerial overview surveys in 2005 and 2006.

In 2007, damage was recorded on 1,313 ha in four NIFR forest districts. This year, affected area observed was similar at 1,189 ha but the damage was not as widespread. The majority of the defoliation was mapped in the Skeena Stikine Forest District, with 912 ha delineated in three large polygons. Two of the areas were on the Babine River south of Gunanoot Lake, and the other disturbance was near the Skeena River south of Hazelton. The remaining 276 ha were located in small, scattered polygons in the Fort Nelson Forest District. Intensity of the damage was rated at 16% light, 55% moderate and 29% severe.

In the fall, cottonwood trees in the Kalum Forest District, east of Prince George in the Prince George Forest District and in the Robson Valley of the Headwaters Forest District were observed to be turning black instead of yellow. Trees of all ages were affected by this late season damage, primarily in wet, valley bottom areas. The damage appeared to be caused by aspen and poplar leaf and twig blight though it was unusual that nearby aspen were not affected as well. A possible reason for this may be that cottonwood tends to flush about a week earlier in the spring than aspen, and conditions may have been best for infections at this time.

Satin moth, *Leucoma salicis*

For the fourth consecutive year, satin moth populations remained low. Aspen defoliation totalling 127 ha was observed in the Chilcotin Forest District in six small areas near Tatlayoko Lake and on the east side of Chilko Lake. Severity was assessed at 80% light and 20% moderate. A small number of moths were observed on the ground in some coastal valleys, but damage was not visible from the air.

Satin moth is an introduced insect that has spread throughout the southern interior and is now being found further north. Last year satin moth was confirmed defoliating aspen around the Terrace area. This year two Lombardy poplars in a residential area of Prince George were heavily defoliated. In both cases, satin moth had never been documented that far north before.



*Satin moth defoliation in
Prince George in 2008*



Birch leafminer damage

Birch leafminer, *Fenusa pusilla*

Birch leaf miner defoliation was prevalent in the southeast portion of the SIFR over the past several years, until last year when only 14 ha of defoliation were detected in the Columbia Forest District. This year, 738 ha of light defoliation were observed in the Okanagan Shuswap Forest District near Sugar Lake and north of Shuswap Lake. Previous birch leaf miner damage is thought to be a contributing factor to the birch decline phenomenon.

Birch Deline

Birch decline has become more prominent throughout much of BC, particularly in the southern interior. The syndrome appears to be a result of several factors working in concert that prevent normal tree growth, limit defensive processes and hasten top-kill and tree death. An insect-pathogen complex of bronze birch borer, several birch leaf miner species, and pathogens are involved; however, climate change may well be the underlying cause. Summer drought stress, temperature variability and freeze-thaw events likely reduce tree vigour and growth and influence the incidence of pests. Several studies suggest that region-wide birch dieback is caused by extreme freezing and/or moisture fluctuations which permanently damages functional living tree tissues. The frequency of such climate events is expected to increase in the future. This may push paper birch beyond its adaptive limit leading to large-scale dieback throughout its current range.



Topkill due to birch decline

DAMAGING AGENTS OF MULTIPLE HOST SPECIES

Abiotic injury and associated forest health factors

The primary forest health factors that the aerial overview surveys are designed to capture are biotic and occur or are most visible during the survey period. In contrast, abiotic disturbances often occur outside the survey window and are recorded in the first year they are observed.

Wildfire damage was down for the second year in a row due to the cool wet spring and moderate summer weather conditions experienced across most of the province. A total of 29,609 ha of primarily severe intensity fires were delineated in 2008.

Unlike last year when the SIFR had the highest wildfire activity, the majority (87%) of the fires occurred in the NIFR this year. The Peace Forest District sustained 15,792 ha of damage, with two main fires near Blueberry and Murray Rivers. Two fires north and south of Steamboat Mountain and one near Mount Winston accounted for the majority of the 7,136 ha burnt in Fort Nelson Forest District. Fire disturbances totalling 1,540 ha were recorded in the Mackenzie Forest District. For the rest of the province, small scattered areas were burnt with fewer than 800 ha affected per district.

Windthrow as recorded during the overview survey refers to uprooting or breaking of trees by wind, snow or ice. In addition to direct tree damage from windthrow, some bark beetle populations such as spruce and Douglas-fir beetles thrive on downed or damaged trees. Hence, tree species are recorded when possible.

A total of 5,798 ha of windthrow damage was recorded in 2008 across BC, down slightly from 6,803 ha last year. Severity of the damage was 13% light, 18% moderate, 49% severe and 20% very severe. Low levels of windthrow scattered throughout a stand are difficult to observe from the height of the overview survey and are therefore not well represented.

The majority (3,625 ha) of the damage occurred in the SIFR. The Okanagan Shuswap Forest District

had 1,744 ha of windthrow in primarily lodgepole pine stands. Most of the damage occurred north of Little White Mountain. 100 Mile House Forest District sustained 777 ha of damage, chiefly in lodgepole pine and spruce stands south of Big Bar Lake. In December 2008 a heavy snowfall followed by two days of freezing rain resulted in significant windthrow damage for trees up to 40 cm DBH in the northern portion of the 100 Mile House Forest District. Most of the remaining damage in the SIFR was recorded in the Quesnel and Cascades Forest Districts, with scattered windthrow incidences of 437 ha and 359 ha, respectively.



Windthrow damage on the BC coast

In the NIFR, windthrow damage occurred in small scattered disturbances covering 1,158 ha. In the Kalum Forest District, 389 ha of mostly hemlock were affected and in the Fort Nelson Forest District 237 ha of spruce and aspen were damaged. Prince George and Skeena Stikine Forest Districts sustained 195 ha and 160 ha of damage, respectively.

Most of the 1,015 ha of windthrow mapped in the CFR occurred in South Island Forest District (649 ha) and Campbell River Forest District (201 ha). The majority of this windthrow was associated with exposed cutblock edges and was small and localized.

Slide damage recorded across the province tripled over last year to 2,450 ha affected. As is common with this disturbance, affected areas were small and scattered. Most of the slides were classified as moderate to severe in intensity.

Most (81%) of the slides occurred in the NIFR. Fort Nelson Forest District sustained 1,337 ha of damage along river banks, particularly the Liard River in spruce or aspen stands. The majority of the remaining slides in the NIFR occurred on 400 ha in the Kalum Forest District. Many of these slides were also along rivers, in particular the Kitnayakwa River, and affected hemlock and subalpine fir trees.

A total of 386 ha were damaged by slides in the CFR, with North – Island Central Coast, North Coast and Chilliwack Forest Districts most affected. One slide on Chehalis Lake in the Chilliwack Forest District created vigorous wave action due to the large amount of material that slid into the lake, which scoured the shore down to bedrock. Slides are most common in the hypermaritime on steep slopes in the CFR. Damage to the SIFR due to slides was minimal, with only 73 ha mapped.

Flooding damage occurred on 1,959 ha in 2008, up one-third from last year. Most of the flooding resulted in small, scattered, moderate to severe disturbances. The NIFR sustained the bulk of the damage with 1,692 ha affected. Chiefly aspen and spruce stands were flooded along rivers in the Fort Nelson Forest District, where 1,293 ha of damage were delineated. Minor flooding under 130 ha per district was reported for the rest of the NIFR. Damage remained at low levels across the CFR and SIFR with 182 ha and 85 ha affected, respectively.



*Windthrow damage from heavy snowfall in
100 Mile House Forest District*



Slide damage on Chehalis Lake in Chilliwack Forest District

Drought was the only other abiotic factor recorded that affected multiple host species in 2008. A total of 237 ha were delineated provincially, with spruce, subalpine fir, hemlock and aspen tree species damaged. Most of this occurred in the NIFR, where 135 ha in the Peace Forest District and 65 ha in the Kalum Forest District were mapped at primarily moderate to severe levels. The majority of the damage occurred on edges of fields, highway road cuts and rock outcroppings. Only 37 ha of primarily light drought damage was observed in the CFR and this was mainly situated in the North Coast Forest District.

Extremely cold weather in mid April in parts of the Kalum Forest District adversely affected some deciduous tree stands. Aspen clones that were the furthest advanced in breaking dormancy near Terrace suffered the greatest damage. Also observed was a stand of red alder in Douglas Channel that was severely affected.

Animal damage

Impact from animal damage is usually underestimated in the aerial overview surveys. Most damage is not conspicuous enough to be visible at the height flown for the survey and/or because it is masked by the current mountain pine beetle outbreak.

Black bear (*Ursus americanus*) and **porcupine** (*Erethizon dorsatum*) feeding can cause dead tops or mortality, primarily to intermediate aged conifer trees. In 2008, the only animal damage observed during the overview surveys was bear with a total of 22 ha located in the CFR. An 18 ha polygon of trace intensity was mapped in Tofino Inlet of South Island Forest District. The remaining 4 ha of severe damage occurred near Upper Campbell Lake in the Campbell River Forest District.

Bear damage, although not observed during the overview survey, continued in the Sunshine Coast Forest District, particularly in Toba Inlet and on Elizabeth Island. Ground observations found that trees not directly killed by girdling from bark stripping were still dying of complications due



Bear damage in the Golden TSA

to open wounds. These wounds become entrance courts for decay which result in breakage during snow or wind events. Bear damage was also noted on young red-cedar trees on Gilford Island in the North Island Central Coast Forest District during ground surveys. In study areas that have been under observation for many years in the Golden TSA, bear damage incidence seemed to be much higher this year than in previous times. Intermediate age Douglas-fir and pine were the most affected. Porcupine damage continued to be unobserved during the aerial surveys, but ground reports are that damage is continuing, particularly in northern coastal areas.

Snowshoe hare (*Lepus americanus*) populations were monitored last year in the NIFR with pellet surveys and live trapping. In the east around the Prince George Forest District, populations continued to be high and consequently feeding damage to seedlings was still prevalent. High hazard areas are in the moister ecosystems, where brush provides protection from predators. Mountain pine beetle killed overstory trees also provide cover. All planted conifer species have been significantly browsed in these situations, with up to 96% of the trees impacted in some blocks. To combat this problem, site preparation to remove dead trees is being conducted in high hazard areas, either through pile and burn or fibre sales, though with the present depressed market only two sales were successful. Larger two year old stock is also being tried, as indications are they are sturdy enough to survive moderate browsing. To decrease the nitrogen content that attracts the hares, trials are also being conducted with stock that is grown in the nursery for one year then out-planted in a field for one year, before being planted in the woods. In the west near Smithers, hare surveys indicated the populations were down, which is fortunate for *Dothistroma* damaged site rehabilitation. Snowshoe hare populations in southern BC also appeared to be low, though no formal surveys were conducted.

The **red squirrel** (*Tamiasciurus hudsonicus*) appeared to generally be causing more damage in lodgepole pine stands than normal this past year. Bark stripping and tissue feeding, particularly on disease infection sites, was the prevalent damage. Of particular interest was an area of lodgepole pine covering approximately 200 ha in the Hawkins Creek drainage of the Kootenay Lake Forest District. During an aerial helicopter survey, forest health staff noticed patchy groups of trees with dead branches, some with up to one-third of the branches affected. Further ground reconnaissance showed that the damage was caused by squirrel feeding on lodgepole pine mistletoe infections. It is possible that squirrel populations are up, but also increased damage levels may in part be due to the preponderance of lodgepole pine killed by mountain pine beetle, which may be forcing the squirrels to concentrate in the remaining live forests.



Red squirrel damage in
Kootenay Lake Forest District

Vole (*Microtus* spp.) damage to most plantations was minor in 2008, which corresponds to vole surveys that found populations were very low. One notable exception was found during the assessment of a Comandra resistance trial south of Fraser Lake. Lodgepole pine seedlings planted in 2004 sustained attack on 23% of the stems in the spring of 2008, with no damage previous to this date. Damage ranged from 10 to 100% stem girdling, with 8% of 7,440 trees being 100% girdled. It is suspected that the unusually late snow melt may have contributed to the unexpected damage of these relatively large seedlings. With the cyclical nature of vole populations, it is anticipated that numbers will creep up next year, with a high expected in 2010.

MISCELLANEOUS DAMAGING AGENTS

Striped alder sawfly (*Hemichroa crosea*) feeding resulted in 337 ha of primarily (92%) moderate intensity defoliation in the CFR in 2008. Small pockets of damage totalling 296 ha were scattered around Gambier Island in the Sunshine Coast Forest District and 40 ha were located on Bowen Island in the Squamish Forest District. The outbreak began last year in the same general areas with a total of 466 ha affected at moderate to severe intensity levels.

Willow leafminer (*Micurapteryx salicifoliella*) damage was observed along rivers and in bogs in the Fort Nelson Forest District during the aerial surveys and ground reconnaissance this year. The noted defoliation occurred in willow clumps and was primarily severe. Alberta had extensive areas damaged by willow leafminer in the northeast in 2006.



Willow leafminer damage
Fort Nelson Forest District



Willow leaf miner damage

This insect mines directly into the leaves and passes through five instars. The fourth and fifth instar larvae create necrotic, reddish-brown blotches on both leaf surfaces and cause the leaves to roll. The damage renders trees unsightly and can cause some mortality after consecutive years of heavy defoliation. However, most heavily impacted willow stands are usually able to re-sprout.

Unknown defoliation was observed in small, scattered polygons province wide over 1,838 ha. The assessed severity levels were 1,175 ha (64%) light, 622 ha (35%) moderate and 42 ha (2%) severe. Extent and intensity of damage was similar to that mapped last year. Confirmation of damaging agents could not be undertaken, due to inaccessibility for ground checks. In all cases, the tree species affected could be damaged by more than one agent, hence the cause could not be identified past tree species and defoliating insect (none of this damage was caused by disease).

In the NIFR Fort Nelson and Peace Forest Districts, 671 ha and 98 ha were damaged, respectively. Defoliation occurred in scattered aspen stands. A total of 697 ha were affected in the SIFR, with the defoliation occurring on Douglas-fir in the north tips of the Arrow Boundary and Kootenay Lake Forest Districts. In the CFR, 371 ha of infested stands were mapped. Conifer stands around Dean Channel totalling 185 ha were affected in the North Island – Central Coast Forest District. In the North Coast Forest District, 180 ha of Hemlock east of Port Edward were defoliated. The remaining 6 ha were located in the Chilliwack Forest District.

One area of defoliator damage was identified in the Kalum Forest District on the ground that was not observed during the aerial overview survey. Approximately 800 ha of moderate defoliation were noted in hemlock in the mid Copper River drainage south of Red Canyon Creek. Damaging

agent was not confirmed, but the area will be checked next year. Another small area of defoliation on Douglas-fir was observed on the ground in Cottonwood Creek just south of Nelson in the Kootenay Lake Forest District. False hemlock looper was the suspected forest health agent, though this was not positively confirmed.

Conifer sawfly defoliation caused 20 ha of mortality to amabilis fir at Alpha Bluff in Butte Inlet this year. Also in the Sunshine Coast Forest District, light defoliation was observed during lower level flights on Cortez and Marina Island in primarily Amabilis fir. Ground access was not possible for confirmation, but it is suspected that this damage was also caused by conifer sawfly.

White pine butterfly (*Neophasia menapia*) defoliation was observed from the ground around the Princeton area this year in ponderosa pine stands. This defoliation was not noted during the aerial overview survey.



Douglas-fir defoliation south of Nelson

FOREST HEALTH PROJECTS

1. Blister rust canker dynamics on whitebark pine

Michael Murray, Forest Pathologist, SIFR

In most instances of tree infection, white pine blister rust manifests itself as one or more cankers. This injury can cause branches to die, or when located on the stem, can girdle and eventually kill the tree. Cankers are the most visible and dramatic symptom of blister rust, yet there’s much to be learned regarding their dynamics of growth and activity. There have been several studies associated with young (<44 years old) western white pine. However, no published works on mature trees or whitebark pine exist.

Yearly observations of individual cankers on whitebark pine are virtually absent. The most relevant data is now available from the Cascades of Oregon and is being analyzed by MFR. Preliminary results reveal some interesting patterns. During five years of monitoring, 43% of cankers changed status (active vs. inactive). Active cankers were more numerous than inactive cankers in every year except one (Table 11). Branch cankers appear to be significantly more active than stem cankers. This is a

Table 11. Status of individual blister rust cankers on whitebark pine.

	2003	2004	2005	2006	2007	AVG
Not Active	5	23	17	15	17	
Active	25	19	25	30	25	
%Active	83.3	45.2	59.5	66.7	59.5	62.9
%Inactive	16.7	54.8	40.5	33.3	40.5	37.1

notable departure from earlier findings with western white pine. Questions arise from these early findings. What may cause drops in yearly activity? What are the implications of less stem activity?

Monitoring of canker dynamics may be incorporated into established Provincial plots. However, annual measurements are challenging due to cost constraints and the remote character of monitoring sites. By learning more, we may improve our responses and predictions toward better coping with this non-native pathogen.

2. Disease resistance screening

Michael Murray, Forest Pathologist, SIFR

In order to retain whitebark pine for the values it provides, we must actively pursue protection, conservation and restoration. We estimate that only about 0-5% of wild trees are naturally resistant to blister rust. These rare individuals are the life-link to the tree's future. Through formal rust screening efforts, several trees have been found in the US which are showing resistance. To date, only a few pines from BC have begun the screening process, and no resistance has been detected yet. Once trees are discovered, they can be protected and bred for outplanting progeny, thus restoring denuded stands. Most of whitebark pine's geographic range lies in Canada and we can ensure success of outplantings by using Canadian parent trees. Thus, we wish to formalize and accelerate a Province-wide screening program. Experts from BC and Alberta convene in February (2009) to discuss opportunities and challenges.



Whitebark pine seedlings surviving blister rust resistant screening in US.

3. Saving whitebark pine

Michael Murray, Forest Pathologist, SIFR

Up to 90% of whitebark pine may have perished over the past several decades in certain places like the Selkirk Mountains. This important tree for wildlife is succumbing to the non-native scourge, white pine blister rust. The pine's steady decline has been accelerated with the recent mountain pine beetle epidemic. In fact, the insects have outpaced the disease as the leading cause of death, at least for the short-term. As a response to these factors, in 2008, the Province of BC placed whitebark pine on the 'blue-list' of species. It is the only tree species listed that is declining throughout most of its natural range.



An active canker on whitebark pine as indicated by rust-coloured fruiting bodies plus seeping sap.

4. Review of the western spruce budworm spray program in the Cariboo-Chilcotin

Leo Rankin, Forest Entomologist, SIFR

Matthew Klingenberg, Forest Health Technician, SIFR

Western spruce budworm has been a significant defoliator of Douglas-fir forests in the Cariboo-Chilcotin (CC) portion of the SIFR over the last 12 years. Areas were prioritized annually for defoliation severity and those with the highest levels of predicted defoliation and other considerations were treated with *Btk*. Between 1997 and 2008 the average treatment area in CC has been 21,207 ha. The largest area was sprayed in 2007, totalling 36,274 ha and the smallest area treated was in 2000 totalling 7,091 ha.

It has been observed that areas treated generally do not require a *Btk* spray in following years to control budworm. Data was analyzed on the treatment blocks sprayed and re-sprayed within CC from the start of the program in 1997. Areas of spray overlap were determined for each of the three forest districts within the CC.

Over the course of the CC budworm program a total of 254,479 ha were treated. Of the total area treated approximately 87,600 ha were in the Central Cariboo, 131,332 ha in the 100 Mile House and 34,946 ha in the Chilcotin Forest Districts. During the 12 years period approximately 206,963 ha were only treated once, 30,951 ha were treated twice, 7,360 ha were treated three times and a total of 2,212 ha were treated four or more times.

Of the total area treated, approximately 16% (40,523ha) was re-treated at some point (Figure 16). More specifically, of the total area sprayed in the Cariboo-Chilcotin 13% of the area was only re-sprayed once, 3% was re-sprayed twice and 1 % was re-sprayed four or more times. The greatest percent area re-sprayed (+/- 18%) was found within the 100 Mile House Forest District, which has had some *Btk* treatment every year between 1997 and 2008. In contrast, the least amount of area re-sprayed was found within the Chilcotin Forest District (14%), which has only had an active control program since 2005.

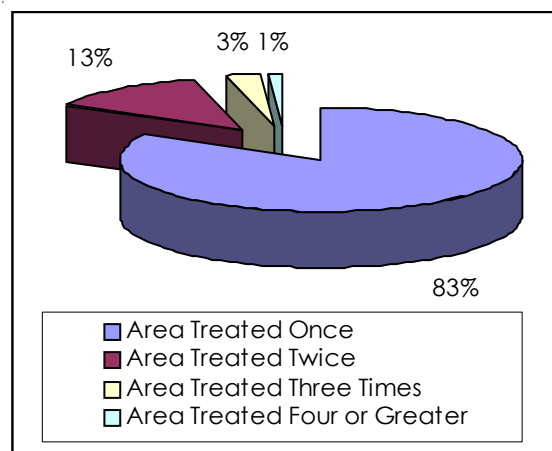


Figure 16. Percentages of area sprayed one or more times from 1997 to 2008.

5. Chilliwack Forest District MCH operational trials

Don Heppner, Forest Entomologist, CFR

Lucy Stad, Stewardship Forester, Chilliwack Forest District

A number of operational trials are underway within the Chilliwack Forest District to test the effectiveness of MCH in controlling Douglas-fir beetle (DfB) in coastal forests. We are attempting to control DfB within a partially cut stand of Douglas-fir (one trial) and are also trying to prevent beetles within windthrown timber from spreading into adjacent standing Douglas-fir trees (5 trials). MCH bubble caps were placed in 10m by 10m grids over the treatment areas.

So far the results are inconclusive. Beetle attack within the partial cut area has declined, but it appears that the Douglas-fir beetle population over the region has declined at the same time. The MCH placed within blowdown areas did not appear to prevent Douglas-fir beetle from attacking standing green Douglas-fir. Further assessments will be conducted in the spring of 2009.

6. Douglas-fir beetle cluster funnel trap trial

Robert Hodgkinson, Forest Entomologist, NIFR

Ten ground-accessible Douglas-fir beetle infested sites were chosen in southwestern Prince George Forest District in 2008 for control action. In early spring, openings within or directly adjacent to each site were baited with 3 Lindgren funnel traps 5 meters apart in a triangular pattern. Traps were serviced every 7-10 days and all collections were preserved for eventual counting. At the conclusion of the Douglas-fir beetle flight, all sites were ground surveyed along with 3 un-trapped adjacent control areas. A report on the success of the project with recommendations will be prepared by spring 2009. Plans are underway to at least double the number of trapping sites in the Prince George Forest District in 2009.



Lindgren funnel traps placed in a 3 trap cluster

7. Western balsam bark beetle non-recoverable losses plot re-measurements

Ken White, Forest Entomologist, NIFR

Forty-nine three plot clusters of cruise plots were initially established in the Kispiox and Morice TSAs in 2001 to try and determine non-recoverable losses due to the western balsam bark beetle (IBB) in these TSAs. These plots were chosen by using the same methodology as VRI, in order to ensure randomness and comparability. The results of the initial analysis of this data showed that while losses to IBB were variable across the landscape, Variable Density Yield Predictions (VDYP) calculations covered the losses in these two TSAs. As these plots only captured a “moment in time”, part of the Chief Forester’s recommendations from the two timber supply reviews for these TSAs was to re-measure these plots to see if mortality was continuing.

This fiscal year, the plots in the Kispiox have been completely re-measured. The main reason for the long gap between establishment and re-measurement was that the majority of the plots are in the ESSF, and this limits access to a large extent. Analysis of the new data will start early in fiscal 2009, and will enable us to see if mortality has continued in these plots, and whether that mortality is accurately captured by VDYP estimates.

8. Yellow cedar decline projects

Stefan Zeglen, Forest Pathologist, CFR

Yellow-cedar forests of coastal British Columbia are experiencing death and decline in a manner similar to that observed in southeastern Alaska. As reported last year, an exploratory study using dendrochronological techniques was piloted in the North Coast Forest District. An executive summary by report lead author Amanda Stan, of UBC Geography Department, is provided below. The finalized report will be available in mid-2009.

“We assessed asymptomatic and standing dead yellow-cedar trees within concentrated patches of dying and dead yellow-cedar at four sites near Prince Rupert on the North Coast of British Columbia. Our goal was to gather baseline information on the growth patterns of asymptomatic trees, test the climatic conditions associated with these patterns, and assess time since death and partial cambial mortality of standing dead trees in different decay classes. We developed four site-specific ring-width chronologies for yellow-cedar. All chronologies were significantly ($p < 0.01$) correlated and characterized by low interannual variability and periods of growth suppression lasting three to eight years from the 1810s to the 1980s. Significant negative correlations to El Niño Southern Oscillation and significant positive correlations to the Pacific Decadal Oscillation indicate that growth of yellow-cedar at these sites is sensitive to low temperatures in the fall and spring. We determined the year of death of 70 of 79 (89%) standing dead yellow-cedar. For 68 of the 70 trees, time since death in 2007 ranged from 1 to 58 years and increased significantly with advanced stages of decay. We found evidence of partial cambial mortality in 43 of 51 (84%) standing dead yellow-cedar. Specifically, the outer ring dates of crossdated ring-width series from the same standing dead tree differed between 0 and 13 years. Quantifying this degree of error is important for estimating year of death using only a single core from a standing dead tree or log. Overall, results from this study provide quantitative, baseline information useful for more in-depth studies of yellow-cedar decline in coastal British Columbia.”

To better quantify the extent of the decline our collaborator, Dr. Brian Klinkenberg of the UBC Geography Department, has recruited graduate student Claire Wooten to conduct a remote sensing evaluation of yellow-cedar decline. The major aims of Claire’s MSc research project are to quantify the distribution and density of the yellow-cedar decline in British Columbia, and to evaluate the role of various biophysical factors (e.g., elevation, slope, aspect, snow pack) implicated in the hypothesis. The project will use a combination of remote sensing and GIS analysis. Forest inventory and forest health datasets, containing known areas of yellow cedar decline, and air photos taken during 2006 and 2007 of the Mid- and North-Coast Forest Districts, have been collected from the Integrated Land Management Bureau. This data will be used to delineate areas of healthy and declining yellow-cedar stands and the biophysical factors will be derived from a Digital Elevation Model. A predictive model will then be developed on the basis of these results to attempt to forecast sites susceptible to decline in the long term. Cross-validation will be performed to evaluate model fitness.

On the ecological side, we plan to follow-up on the dendrochronology pilot. To that end our research partner, Dr Lori Daniels of the UBC Dendrochronology Lab, has recruited PhD student Tom Maertens to investigate the causes and effects of this forest decline. Tom’s work plan isn’t finalized yet but he plans to characterize stand dynamics at 12 declining sites along the north and central coasts of British Columbia. Dendroecological (tree-ring) stand reconstructions will quantify patterns of growth and decline over the last several centuries. In each stand, 100 yellow-cedars,

including live trees, snags, and logs, will be cored and described. He will measure and crossdate the tree-rings using well-established dendroecological techniques and transform the measurements into annual basal area increments. Intervention analyses will identify the onset of decline in yellow-cedar trees; describing patterns of growth suppression and mortality will point to causal mechanisms. Growth and mortality rates will be assessed in relation to intra-annual to decadal-scale variations in climate using correlation and principal components analyses. He will determine age, growth, and size structures of all tree species at six of these sites and quantify the recruitment of coarse woody debris. Tree- and stand-level responses to yellow-cedar mortality will be explored, including growth releases of associated tree species and the reorganization of the canopy. In regeneration subplots, he will intensively sample all seedlings and saplings in order to determine establishment and survival rates in relation to yellow-cedar decline and climatic variability.

9. Are free-growing stands meeting timber productivity expectations in the Lakes Timber Supply Area?

Alex Woods, Forest Pathologist, NIFR

Wendy Bergerud, Senior Biometrician, Research Branch, Victoria

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 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 m³/ha, respectively. Using 2005 stand attributes, projected volume for the early and late groups were 324 and 314 m³/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.

In our 2005 assessment 18% of stands no longer contained the minimum of 700 free growing stems/ha based on the lower confidence decision rule, due mainly to the high incidence of hard pine rusts. Over 27% of all declared free-growing, pine-leading stands had greater than 20% hard pine rust incidence. Pine-leading stands represent 90% of the sampled managed stands in the Lakes

TSA. The majority (84%) of pest-affected trees in stands that no longer pass the minimum stocking level were in the 4 m+ height class.

In 2005, only one of our sample stands had been attacked by mountain pine beetle with 70 – 75% of the trees infested. As of November 2007, the insects had attacked 10 additional stands. The incidence of red attack in these stands ranged from approximately 1% to close to 20%. Our analyses do not reflect these recent insect attacks because our ground-based field work took place prior to the mountain pine beetle attacking many of the young stands in the TSA.

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 considered¹. 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



Young lodgepole pine stem severely impacted by western gall rust infections

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.

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.



*Canker caused by comandra blister rust
with squirrel feeding*

This report in full is available at:

http://www.for.gov.bc.ca/hfp/frep/site_files/reports/FREP_Report_13.pdf

10. Kootenay/Headwaters FREP post-free-growing forest health assessments

Alex Woods, Forest Pathologist, NIFR

Two intensive Forest and Range Evaluation Program (FREP) post-free-growing forest health assessments were conducted in 2008, a 30 stand sample in the Headwaters Forest District and a 60 stand sample in the Kootenay Lake TSA, both following the methods developed in the Lakes TSA study (http://www.for.gov.bc.ca/hfp/frep/site_files/reports/FREP_Report_13.pdf). The Headwaters District project was co-coordinated at the district level by Heather MacLennan while the Kootenay Lakes project was co-coordinated by Kristine Sacenieks. Both projects were overseen by Regional Pathologists Michelle Cleary and Alex Woods. In both the Headwaters and Kootenay Lake projects we were fortunate to have experienced dedicated surveyors collecting the field data (KDC Forestry Consulting Ltd in Headwaters and Darkstar Forestry Ltd in the Kootenays). We are still in the early stages of analyzing the data from both projects. Early indications from the Headwaters Forest District suggest that free-growing stands in the ICH portion of that area may not be fully meeting timber productivity expectations. This project involved an examination of 30 stands declared in the period 1995-2001. All of these stands were originally surveyed with a formal free-growing survey. Thirty-six percent of the surveyed stands failed the minimum of 700 free-growing stems per hectare (fgph), based on the mean decision rule, but four of the 11 stands that are now below 700 fgph were below 700 at declaration. The more recently declared stands are, in general, less well stocked. Armillaria root disease was the most prominent pathogen in the Headwaters Forest District. As of January 2009 we have not yet summarized the Kootenay TSA data. Progress is being made on a FREP RSM survey protocol for district led surveys of stands post free-growing for use throughout BC.

11. 2008 Mackenzie TSA rust hazard surveys

Richard Reich, Forest Pathologist, NIFR

This project involved sampling for pine stem rust hazard. Sampling occurred in the first two years based on a random sampling of stands. Elevation was the single most important variable, but the multivariate model didn't explain enough of the variation for reliable hazard rating. It was decided in the third year that the differences observed at the subzone and site series level warranted further sampling. Therefore the samples selected in the third year were to complete a BEC sampling selection matrix.

This added a layer of complexity to the site selection. The first step involved ecosystem classification of each silviculture opening in the field to determine if it matched the RESULTS record. Surveys were only initiated on the opening if it matched the classification. If not, the contractor travelled to the next opening on the list to repeat this step.

The second step involved establishing twenty 3.99 m radius sample plots per opening. The sampling involved an ecoclassification at each plot, in order to determine the BEC sites series and soil moisture and nutrient regime. All countable lodgepole pine were searched for pine stem rust infections.

12. Predicting risk of infection by comandra blister rust on lodgepole pine in the Sub-Boreal Spruce (SBS) dry cool biogeoclimatic subzone

Richard Reich, Forest Pathologist, NIFR

The objective of this project is to model the influence of multiple factors in predicting risk of infection on a comandra blister rust resistance trial. Factors include: site, climate, ecology, host resistance, and alternate host abundance and susceptibility. The trial was established by Dr. Sally John in 2004. The layout involves 50 trees of each of 130 families planted on a 1.5m square grid on each of three different sites in the SBSdk (dry cool Sub Boreal Spruce). Counts of the number of rust infections of comandra blister rust (CBR), stalactiform blister rust, and western gall rust were made in 2006, 2007 and also in 2008. Counts of the number of stems of the alternate hosts for the respective blister rusts were conducted on a 1.5 meter grid in 2007. Additional data collected included a decimetre accuracy differential GPS survey for terrain, and a standard ecoclassification for each site. A preliminary spatial analysis of the percent incidence and the intensity of CBR infection based on the distance from the alternate host *Geocaulon lividum* was conducted. The preliminary spatial analysis showed that risk of infection is very high when lodgepole pine seedlings are in close proximity to *Geocaulon*, drops dramatically over the first several meters and gradually decreases over the next 25 to 35 meters. Future work will focus on modelling the influence of major variables. A graduate student in statistics at Simon Fraser University will conduct spatial analyses in 2009.

The 2008 assessment showed that there was a third wave year in a row (2004, 2005, and 2006) in the two western sites (Nadina district), and for the 3rd year there was negligible infection at the eastern site (Vanderhoof district). This is strong evidence of local variation in climate resulting in dramatic differences in infection on otherwise similar sites.

13. Field testing for lodgepole pine clonal susceptibility ranking to important pine pathogens

Richard Reich, Forest Pathologist, NIFR

The susceptibility of clonal orchard stock to several pathogens has been evaluated at the Prince George Tree Improvement Station (PGTIS) for all three lodgepole pine seed orchards, but has not been field tested. Risk was inadequate for determining the susceptibility ranking for certain pathogens at some orchards, and for some of the pathogens at all orchards, resulting in an incomplete matrix of pathogen susceptibility rankings.

Risk to specific pathogens was highly variable for the different orchards, depending on orchard location. Risk to certain pathogens appeared to be less variable within a particular orchard than between orchards. Risk was clearly high enough at certain orchards to provide accurate susceptibility ranking for certain pathogens. Risk was clearly inadequate for determining susceptibility for other pathogens such as *Dothistroma septospora* and comandra blister rust at all three orchards.

As a result, the objective of this field testing trial will vary depending on the pathogen being screened for. For certain pathogens, field testing will be used to confirm/verify the relative susceptibility determined by the PGTIS assessment. For other pathogens, field testing will be used to determine the relative susceptibility on sites known to be high risk to untested pathogens.

Field testing will be conducted at sites that will be selected for known high risk to specific pathogens. One site will be selected for its high risk to comandra blister rust, a second site for its high risk to *Dothistroma septospora*,

and hopefully a third site for high risk to *Elytroderma deformans*. A fourth site could be at the PGTIS, near the Bulkley Seed Orchard #228, in order to serve as a control for the effect of time.

In April of 2008, 120 scion were collected from each of 25 clones at the Bulkley Orchard # 228 for a total of 3000 scion. The grafting was conducted at the Skimikin Nursery in Salmon Arm. The ramets will be planted in spring 2009.



Young lodgepole pine stand damaged by
Dothistroma septospora infection near Castle Creek

14. 2008 forest health assessment of lodgepole pine seed orchards at the Prince George Tree Improvement Station

Richard Reich, Forest Pathologist, NIFR

Three 1.5 generation lodgepole pine seed orchards at the PGTIS were assessed for foliar infection by *Elytroderma deformans* and *Lophodermella concolor*. Infection levels were very high in 2008, indicating successful infection in 2007 due to the wet summer. *Dothistroma septospora* was also found, but at very low to negligible levels.

The assessment of these installations has highlighted the high level of genetic variation in lodgepole pine to more than one pathogen. It has also underscored the value of assessing seed orchards that occur within similar ecosystems to where the seed is out-planted.

The data from 2008, plus the western gall rust data collected in 2007 will be used to determine susceptibility rankings. These rankings will be independently tested by Dr. Chris Wallis, a post doc at UNBC, through comparison with bark chemical analysis in 2009.

15. Armillaria map verification project

Richard Reich, Forest Pathologist, NIFR

This is the 3rd year of a project initially described in the 2006 Forest Health Annual Report. The purpose of this project is to assess the accuracy of the Armillaria map of the northern portion of the Headwaters Forest District (former Robson Valley Forest District). The map was assembled over a period of several years starting in 1991 using detection methods ranging from detailed aerial sketch mapping using rotary wing aircraft and limited ground surveys. In 2006 a verification project was initiated in collaboration with Michelle Cleary of the SIFR to ground survey a representative sample of the 1180 silviculture openings that were aerially sketch mapped.

Approximately 28 stands were surveyed in the fall of 2006, 23 in 2007, and 19 in 2008 for a cumulative total of 70 stands. A custom built ArcPad GPS program was designed and utilized in 2008. It creates a shape file and digital record of the transect survey and of the delineation of each root disease stratum.

We used 1:4,000 scale colour photography to independently validate the accuracy of the Armillaria centre delineation on several openings. Initial results indicate that the centre delineation is providing highly reliable results.

The delineated centres from 22 openings formed the basis for a population genetics study using DNA characterization of disease centers (into unique genets) by Simren Brar (UBC undergraduate thesis project). The purpose was to interpret operational survey results. This study is showing that the delineated centres are typically unique genets. This shows that the survey is identifying biologically based disease strata. As a result, the survey data can be used in studies to quantify ecological parameters, and potentially can be used to predict effects of climate change on disease dynamics.

16. How well is stump removal curtailing Armillaria root disease?

Michael Murray, Forest Pathologist, SIFR

Michelle Cleary, Forest Pathologist, SIFR

Root rot, especially *Armillaria ostoyae*, causes significant mortality of plantation trees, affecting most biogeoclimatic zones in the southern interior of BC. In undisturbed mature stands, the incidence of diseased trees can range from 10% to 80% depending on the climatic region. In the interior cedar-hemlock zone, Armillaria inoculum is universally present in all but the driest and wettest sites. Research to date suggests that below-ground incidence of diseased trees often reaches 30-35% by age 20, resulting in undesirable stocking in juvenile stands. It is also predicted that additional mortality and growth loss on trees that sustain non-lethal infections will occur throughout a rotation. Ultimately, these losses may lower the level of sustainable harvest.

Removal of stumps from the ground has been considered a viable treatment for reducing disease spread to planted trees. However, longer-term evaluations of post-harvest stump treatment trials are lacking. Most treated sites established as long-term trials to measure the effectiveness of stump removal have yet to be examined beyond the initial post-treatment assessments.

One such site is located in the Arrow Boundary District. This is called the Knappen Creek Unit and was created by former Forest Pathologist (MFR - SIFR), Don Norris (retired). This predominantly western larch – lodgepole pine stand underwent four treatments in 1989: 1) stump removal & root raking; 2) stump removal only; 3) planting 1m away from stump/major roots, and; 4) planting (no other treatments). An additional fifth treatment unit is provided by a patch of unharvested forest. These distinct treatments provide an excellent opportunity to study and compare the effects of stumping on *Armillaria* root disease as expressed in the regenerating cohort of trees. There are at least a dozen other sites treated similarly to Knappen Creek in the SIFR. Don Norris is expressing a strong interest in the MFR re-examining these sites. We are currently seeking funding, beginning with Knappen Creek, to investigate and describe the incidence of root disease some 18 years post-treatment.

17. Spruce needle cast permanent sample plot establishment

Alex Woods, Forest Pathologist, NIFR

Permanent sample plots (5.64m radius) were established in two young spruce plantations in the Morice TSA to monitor the behaviour of the foliar disease *Rhizosphaera kalkhoffii*. The plots were designed to capture a sample of 10 or more trees that would be photographed from a permanently established point. These young plantations have suffered considerable defoliation due to the foliar disease over the past five to six years. The wet summer of 2007 made the symptoms of this disease particularly prominent. We plan to establish more foliar disease monitoring plots in the western half of the Northern Interior Forest Region to follow what we believe could be a trend to increasing losses from foliar pathogens.



Young spruce needles infected with
spruce needle cast

18. *Septoria musiva* update

Harry Kope, Provincial Forest Pathologist, FPB

Stefan Zeglen, Forest Pathologist, CFR

Septoria musiva (anamorph; *Mycosphaerella populorum*) causes leaf spots and cankers on *Populus* species (aspen and poplar) across almost all of North America. All North American *Populus* species are at least somewhat susceptible to *S. musiva*. Hybrids and Eurasian species sustain the most damage.

The disease in British Columbia – The pathogen was isolated from cankered hybrid poplar stems in commercial stool beds in the Fraser Valley, in November 2006 and January 2007. Through to the end of 2007, a number of local surveys were made of hybrid poplars in commercial stool beds and plantations. The results indicated that multiple hybrid poplar clones were susceptible to and cankered by *S. musiva*. In conjunction with the commercial grower, the susceptible clones were removed and destroyed. Although all hybrid clones are susceptible the commercial grower has not removed all clones, but has chosen to spray (for the 2008 growing season) the remaining clones in the nursery with a suitable fungicide. Their long term goal is to replace all of the susceptible clones with clones that are more resistant to *S. musiva*.

A more comprehensive survey was conducted from September to November 2008, where leaf samples were collected from *P. trichocarpa* (and hybrids) and tested using genetic markers for the presence of *S. musiva*. The collection area covered both sides of, and within 5 kilometres of the Fraser River, from Dewdney and Chilliwack to Hope (see Figure 17). Leaves were collected from a suspected tree and assayed for the presence of *S. musiva*. The results found that none of the collected material was positive for *S. musiva*.

A risk analysis is to be completed in early 2009 using the findings and data collected to date. Three primary questions need to be answered; 1) what is the distribution of *S. musiva* in the Fraser Valley, 2) has *S. musiva* infected *P. trichocarpa*?, and 3) can *S. musiva* be eradicated from the Fraser Valley? The result of the risk analysis will help determine the future direction taken in managing this invasive fungus.



Septoria musiva canker

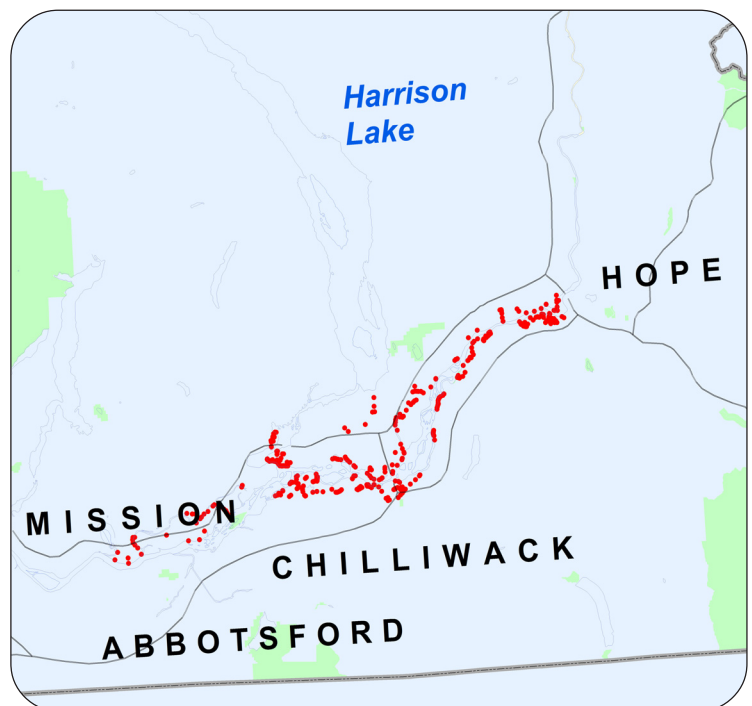


Figure 17. The sampling area in the Fraser Valley for putative *Septoria musiva* infections of *Populus trichocarpa*.

19. Lodgepole pine dwarf mistletoe yield loss simulation

Stefan Zeglen, Forest Pathologist, CFR

Michelle Cleary, Forest Pathologist, SIFR

Michael Murray, Forest Pathologist, SIFR

Harry Kope, Forest Pathologist, FPB

One of the difficulties with estimating losses due to dwarf mistletoes is that death does not happen rapidly, or often at all, but tree growth declines over a long period which makes quantification tricky. Another difficulty is to estimate the volume loss impact on stands rather than individual trees. Mistletoe dynamics do not easily scale up from an individual tree to the stand and into adjacent stands. As such, growth and yield models, like TASS or FVS, are rarely able to account for mistletoe impact following stand altering events like natural disturbance or harvesting using retention systems. To remedy this gap, we have initiated a study that attempts to model future stand condition based on current mistletoe incidence and intensity data collected using a relatively simple survey.

In conjunction with Dr Fred Baker (Utah State University), we are adapting a model he has developed for use with dwarf mistletoe of Jack pine. We are currently calibrating the model for lodgepole pine stands by selecting infested stands in the southern interior from Valemount to Penticton. To collect incidence and intensity data, each stand is surveyed for the distribution of infested tree crowns and plots of visually infested and uninfested pine are inspected for stem and crown infections. This creates a picture of mistletoe in the current stand and allows for reconstruction of mistletoe behaviour to date. Once this is done, predictions on the future behaviour of both mistletoe and host, based on stand structure, species and future tree growth, can be made.

We hope to derive two useful predictive tools from this project. The first would be a model of how mistletoe develops and behaves in various stand types. In addition, by combining this model with a stand-level growth and yield model, we can make predictions on the outcomes of stand manipulations, like partial cuts, that alter stand structure but not necessarily mistletoe incidence. This could prove useful in quantifying the risk/reward in leaving infested trees behind after a natural disturbance or harvesting.



Lodgepole pine dwarf mistletoe infections on a young tree

20. Monitoring hemlock dwarf mistletoe in coastal forests

John Muir, Forest Pathologist, FPB (retired)

Warren Warttig, Planning Biologist, International Forest Products

Innovative Project No. SC 6738004 funded by the Forest Investment Account was undertaken to monitor the spread and infection by western hemlock dwarf mistletoe (*Arceuthobium tsugense* (Rosendahl) G.N. Jones subspecies *tsugense*) of young western hemlock (*Tsuga heterophylla* [Raf.] Sarg.) in coastal British Columbia retention-harvested forests.

To ensure sustainable management of western hemlock forests, one of the major challenges is to manage forests infested with hemlock dwarf mistletoe, particularly in retention-harvested areas (Beese et al. 2003, Coast Region Implementation Team 2006, Forest Practices Board 2008, Muir and Hennon 2007). Data on hemlock dwarf mistletoe effects on tree growth and timber quality are essential for determining timber supply projections and silviculture strategies. However, data for hemlock dwarf mistletoe-infested western hemlock forests, particularly for retention-harvested forests, are very limited and have not been objectively applied to timber projections. Muir and Hennon (2007) and Muir et al. (2007) synthesized available information on hemlock dwarf mistletoe related to forest management, particularly for retention harvesting and uneven-aged management of infested forests, and identified knowledge gaps. They concluded that a wide variation and lack of data on hemlock dwarf mistletoe, particularly its spread and impacts in second-growth forests, resulted in considerable uncertainty (and at times controversy) about its potential impacts in retention-harvested forests. The goal of the monitoring project is to develop methods and provide baseline data that facilitates sustainable management of retention-harvested, mistletoe-infested coastal forests.

In 2008 (year four of the monitoring project), the HDM monitoring project was expanded to include monitoring plots in the Sunshine Coast TSA, CWHdm dry maritime subzone. A low level helicopter flight, a maritime boat trip and roadside vehicle surveys were used to search for prospective monitoring areas. Hemlock dwarf mistletoe infestations of young trees in recently logged cut blocks (>5 years) in low-elevation sites were limited by a scarcity of western hemlock regenerating trees, presumably because of generally mesic to dry moisture regimes and widespread plantings of Douglas-fir and western red cedar. However, older-immature, mixed species stands, particularly in or near riparian zones or shorelines, often had substantial numbers of western hemlock trees that frequently were infested by hemlock dwarf mistletoe. Three monitoring plots were established: one near Sechelt and two north of Powell River, at West Redonda Island and Ramsay Arm, with 1 to 10 per cent of young trees infested. Monitoring plots established in 2005 at block UC5C near Ucluelet were re-inspected and very little new infestation was found, despite the plots being placed around or adjacent to severely infected hemlock trees.



Aerial shoots of hemlock dwarf mistletoe

In the Sunshine Coast TSA, hemlock dwarf mistletoe shoots and berries appeared more abundant on residual and regenerating trees than previously observed in the CWHvh, vm and xm subzones. Observations on the monitoring plots and of seed dispersal in the Ucluelet area suggested that hemlock dwarf mistletoe seed production on, and seed dispersal from, most residual infested trees could be relatively low in these subzones. When young trees are infested, hemlock dwarf mistletoe shoot and seed production usually appears more prolific on young trees than on nearby residual trees. This suggests that most of the hemlock dwarf mistletoe infestation of young trees will develop from young infested trees and some infested advanced regeneration trees that were established and infected before harvesting.

Although in cooler and wetter subzones we have observed relatively low incidence and rate of spread of hemlock dwarf mistletoe in young stands, we do not suggest that this necessarily means low future spread and infection by hemlock dwarf mistletoe in older second-growth hemlock forests. In older, second growth hemlock stands in the CWHvh, vm and xm subzones we observed several high incidences of hemlock dwarf mistletoe with apparently severe effects. So far, we have found that the rate of spread and infection of hemlock dwarf mistletoe are extremely variable in young coastal forests. Further observations and data from the monitoring plots and likely other experimental studies are required to substantiate these possibilities.

A year-end (March 31, 2009) report is being prepared and will be available from the authors upon request (johnmuir@consultant.com or warren.warttig@interfor.com) or from the MFR library website. Included are summary background information on hemlock dwarf mistletoe biology, objectives of the monitoring project, description of methods and results, appendices containing plot establishment and re-measurement data for 2008, and a summary of accomplishments from 2005 to March 2008.

21. Mountain pine beetle in spruce – blue stain fungi analysis

Robert Hodgkinson, *Forest Entomologist, NIFR*

In cooperation with staff from the University of Northern British Columbia, Forestry Canada and the Ministry of Forests in Prince George, samples from interior spruce successfully attacked by mountain pine beetle in 2008 will be sent to the Pacific Forestry Center in late spring for an analysis of the blue stain complex. These samples will be compared to mountain pine beetle attacked lodgepole pine samples from the same area. Dr. Katherine Bleiker of Forestry Canada in Victoria and Dr. Colette Breuil of the University of British Columbia in Vancouver will be determining if there are any differences in the blue stain fungal complex between the two conifer species.

22. 2008 Verbenone flake application in young lodgepole pine stands at risk from mountain pine beetle attack

Lorraine Maclauchlan, Forest Entomologist, SIFR

Verbenone trials were conducted in 2007 and 2008 to evaluate the potential of protecting high-risk young lodgepole pine stands. Disrupt Micro-Flake® VBN (Verbenone flakes), was applied to approximately 177 ha in the Helmer Road area of Cascades Forest District (Figure 18) using a Hiller 12E helicopter equipped with a spreader at 6.5-6.7 kg/ha (15% *a.i.* by weight, 1,000 gm *a.i.* per ha) on July 23, 2008. The selected stands were between 25 and 35 years old, with less than 15% in-stand 2007 MPB attack. Seven treatment blocks and 7 control blocks, each approximately 20 ha, were selected in areas of moderate to high adjacent MPB pressure. Each of the 14 blocks had 3 baited Lindgren funnel traps located within the blocks. Beetles were collected twice a week during peak flight and then weekly until cessation of flight in late September 2008.

Efficacy assessments were conducted in all treatment and control blocks in October 2008. Assessments consisted of the following:

1. 10 strip plots per block (each strip plot was 3m x 100m)
2. 5 variable radius plots per block to assess attack status and tree statistics (dbh) – each plot had an average of 5-8 trees
3. Star-probe at each trap: 3m width in each of the cardinal directions to determine trap influence. MPB attack was recorded

All trees >10cm were assessed, and all MPB or other bark beetle (e.g. *Ips*) attack was recorded (regardless of tree size).

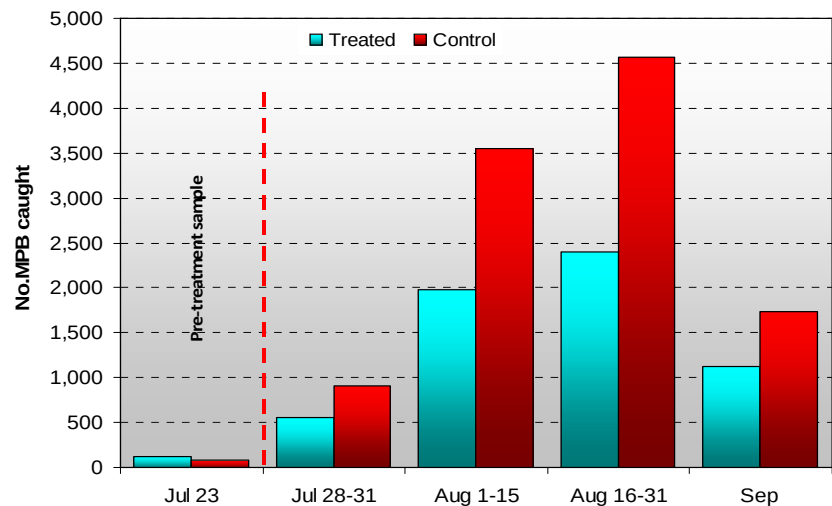


Figure 18. Total number of mountain pine beetles caught in semiochemical-baited Lindgren funnel traps located within verbenone-treated and untreated (control) blocks. Trap catches from the seven treated and control blocks were combined. The July 23rd collection date represents the "pre-treatment" sample.



Good verbenone flake deposit

2008 Results

The highest mountain pine beetle catches in baited Lindgren funnel traps occurred in mid-August (Figure 18) with the peak flight occurring between August 14 and August 22, 2008. Higher trap catches were noticed in the control blocks throughout the summer except on the first sampling date.

Strip survey results showed very low levels of MPB attack in all stands, treated or control (Table 12). There was no significant difference in attack levels (t-test, $P < 0.05$) between treated and control areas, with average mass attack of 27 attacks per/ha and 22 attacks per ha, respectively (Table 12). 2008 attack levels generally remained static or decreased in the control blocks when compared with the 2007 results. The treated blocks also saw a decrease in attack levels in 2008 (Table 12). The 2008 attack was a result of both beetles emerging from within the stand, as well as from the surrounding area.

Table 12. Average number of old (2007) and new (2008) mountain pine beetle mass attacks per hectare in verbenone flake-treated blocks and control blocks.

Block	Ave. MPB atk/ha in Controls		Ave. MPB atk/ha in Treated	
	2007	2008	2007	2008
1	16.7 ± 52.7	3.33 ± 10.5	210 ± 197.5	36.7 ± 45.7
2	30 ± 63.7	40 ± 69.9	203.3 ± 184.2	23.3 ± 35.3
3	100 ± 93	96.7 ± 249.7	180 ± 84.9	90 ± 205.5
4	140 ± 161.6	36.7 ± 61.8	240 ± 122.5	6.7 ± 21.1
5	0.0	0	0.0	0
6	0.0	0	0.0	0
7	0.0	13.3 ± 28.1	10 ± 31.6	0
Ave	41.0 ± 90.5	27.1 ± 102.2	120.5 ± 152.5	22.4 ± 83.4

23. Evaluation of MPB outbreak on young pine – year four

Lorraine Maclauchlan, Forest Entomologist, SIFR

The overall objectives of this project were to quantify mortality due to mountain pine beetle in young lodgepole pine stands and to estimate the duration and severity of future attack. In 2008, approximately 47,321 ha of young pine, aged 20 to 55 years, was assessed from the air for mortality (Table 13). Over 1,778 polygons in 9 forest Districts were surveyed for a total exceeding 7,634 polygons assessed since 2005. Many polygons were surveyed in more than one year to monitor the progression of attack and influence of the outbreak on young pine mortality. The average percent red attack (2007 attack) decreased in all 7 districts surveyed in both 2007 and 2008, with the exception of the Headwaters District (DHW) that saw a three-fold increase in red attack (Table 13). This trend directly reflects the trends of the general MPB outbreak in 2007 and 2008 in mature stands throughout BC. There is significantly lesser red attack in the central Districts and the most active areas are now located in the south and on the periphery of the outbreak area. The decline of MPB attack in young stands is more rapid in young stands as the risk in adjacent stands declines. Although, as noticed in stands used in the verbenone trial, there is ongoing, low levels of MPB attack from beetles generated within these young stands. However, additional, significant mortality is unlikely once the outbreak diminishes in surrounding mature forests (about two year post-peak).

Table 13. Summary of hectares, mapsheets and polygons aerially surveyed in 2008, by District, showing average percent red attack, percent total attack (red + grey attack) and percent stands affected (showing some level of MPB attack). The average percent red attack mapped in 2007 is also shown as a comparison. Districts are denoted by: DCC=Central Cariboo; DCS=Cascades; DHW=Headwaters; DKA=Kamloops; DMH=100 Mile House; DND=Nadina; DOS=Okanagan Shuswap; DPG=Prince George; and, DQU=Quesnel.

	DCC	DCS	DHW	DKA	DMH	DND	DOS	DPG	DQU	Total
Ha surveyed	5,464	5,086		3,783	10,421	5,790	4,530	2,659	9,589	47,321
No. mapsheets	28	27	4	21	38	21	23	9	31	202
No. polygons	217	223	32	241	350	134	212	109	260	1,778
Ave. % red attack (2008)	6.4	5.0	23.6	12.0	9.8	3.5	6.6	3.8	0.5	
Ave. % red attack (2007)	16.3	17.0	7.0	44.0	34.1	10.2	14.4		29.1	
Ave. % total attack	28.3	10.4	41.9	36.9	37.8	8.9	14.3	40.5	29.2	
% stands affected	91.7	70	96.9	97.5	94	59.7	77.7	95.4	88.1	

Aerial surveys of young stands were conducted within the core and leading edge of the outbreak area each year. The peak red attack mapped occurred overall in 2007, reflecting the severe populations of MPB seen in the 2006 beetle flight (Table 14). The average total attack increased steadily from 2005-2008, as did the percent of stands affected, with over 85% of stands assessed in 2008 having some level of MPB mortality (Table 14).

The aerial surveys conducted in 2008 showed a sharp decline in the number of new stands having greater than 50% mortality (Table 15). Districts in the north and central portion of the MPB outbreak area continued to have the highest number of stands with between 25% and greater stem mortality. The one exception is Kamloops Forest District that has over 32% of young pine stands surveyed with over 50% mortality and 22.5% of stands with 26-50% mortality (Table 15). However, Kamloops Forest District (16,500 ha young pine 20-55 years) has approximately one third the area of young pine that Prince George Forest District has and about one quarter the area of young pine that

Quesnel Forest District has. The districts where the MPB outbreak is still very active, for example Nadina, Cascades and Okanagan Shuswap, had far fewer polygons falling into the higher attack level categories (Table 15). If the outbreak continues to decrease as observed in 2007 and 2008, the threat to young pine stands will be greatly reduced.

Table 14. Average over all districts surveyed of percent red attack, total attack (red + grey attack) and percent stands affected (showing some level of MPB attack) by year surveyed.

	Average MPB attack over all Districts			
	2005	2006	2007	2008
Ave. % red attack	16.1	11.5	21.5	7.9
Ave. % total attack	18.8	13.7	26.9	27.6
% stands affected	50.7	65.2	81.2	85.7

Table 15. Percent of stands surveyed in 2008, in 9 Districts, having no attack (0% stems attacked) to over 50% stems attacked. The total number of stands surveyed in each district is also shown.

% attack (Reds & greys)	Percent of stands within each attack category								
	DND	DPG	DQU	DCC	DMH	DHW	DKA	DCS	DOS
0%	40.3%	4.6%	11.9%	8.3%	6.0%	3.1%	2.5%	30.0%	22.3%
1-10%	38.8%	16.5%	28.8%	20.7%	16.3%	25.0%	22.5%	45.7%	36.0%
11-25%	7.5%	11.0%	11.9%	24.4%	16.3%	12.5%	20.4%	9.4%	19.9%
26-50%	9.0%	30.3%	21.9%	28.6%	27.7%	18.8%	22.5%	7.6%	16.6%
>50%	4.5%	37.6%	25.4%	18.0%	33.7%	40.6%	32.1%	7.2%	5.2%
Total	134	109	260	217	350	32	240	223	211



Mountain pine beetle attack in 2007, DKA blocks
92P028 336 & 337



Mountain pine beetle attack in 2008, DKA blocks
92P028 336 & 337

24. Permanent sample plots and biological assessments

Lorraine Maclauchlan, Forest Entomologist, SIFR

Twenty four permanent sample plots were established (15 plots in 2005, 9 plots in 2006) to monitor and assess the impact, risk and biological parameters of mountain pine beetle, and other forest health factors, in young pine stands. Plots were established throughout a variety of ecological zones susceptible to the mountain pine beetle and were located in chronologically different phases of the outbreak. In 2008, 8 of the 24 plots were re-assessed. These plots are located in areas where the outbreak has recently declined or is still active (Table 16). Of key interest in 2008 was the level and risk of attack by secondary insects (twig beetles), such as *Pityogenes* and *Ips*. The highest levels of secondary insect attack were noted in the Dragon Lake (Quesnel area) and Meldrum Creek (Williams Lake) plots (Tables 16 and 17), with 14.9% and 24.7% respectively. The secondary insects at Dragon Lake primarily attacked trees which had been previously attacked by the MPB (strip or unsuccessful attack), while the trees at Meldrum Creek, were much smaller in diameter, due do

Table 16. Percent of trees attacked by secondary bark beetles such as *Ips* or twig beetles in 8 permanent sample plots re-assessed in 2008. Plot number, District, geographic location, approximate age, biogeoclimatic ecosystem classification (BEC), density (stems per ha) and treatment regime is shown (nat. regen. = natural regeneration; Sp=spaced; Pr=pruned; Fe=fertilized).

Plot #	District	Location	Age	BEC	Density (sph)	Treatment	% trees with twig/ <i>Ips</i>
1	DQU	Dragon Lake	31-40	SBS dw 1	804	spaced	14.9%
2	DQU	Fish Lake	31-40	SBS dw 2	880	Spaced nat.	1.4%
10	DCC	Meldrum Creek	31-40	SBPSxc	1,636	regen	24.7%
11	DCC	Spokin Lake	26-30	SBPSmk	1,228	spaced nat.	3.9%
14	DMH	Little Fort	41-50	IDFdk 3	1,432	regen	9.8%
16	DKA	Jamieson Community	26-30	MSdm2	836	Sp/Pr/Fe	4.3%
17	DKA	Lakes	31-40	IDFdk2	1,644	Spaced	7.3%
18	DCS	Spilus Creek	26-30	MS	996	Sp/Pr/Fe	0.0%

the stand being naturally regenerated and there, the secondary insects behaved more as primary tree killers (Tables 16 and 17).

The highest level of 2008 mountain pine beetle attack was in the Spilus Creek plot, with 13.4% green attack, located south of Merritt (Plot 18, Table 17). All other plots assessed had very low levels of green attack (Table 17). Plots 1, 2, 10 and 14 sustained MPB attack early in the cycle of the beetles' movement into younger age classes when levels of attack in surrounding mature stands were severe (Table 17). Plots 14, 16, and 17 had high attack levels in 2006 and 2007 corresponding to the peak years of attack in surrounding mature pine stands. MPB risk was lower in 2008, due to sub-optimal flight conditions and lower brood survival. Unless the outbreak builds again substantially in the south, the risk to many of the remaining young stands is declining.

Table 17. Percent green attack by year assessed, percent old MPB attack, strip attack and cumulative attack in the 8 plots assessed in 2008.

Plot #	Percent green attack				% old attack	Strip or unsuccessful attack	Cumulative % attack
	2008	2007	2006	2005			
1	0	2.0	13.9	0.5	20.9	7	44.3
2	0	0	0	43.5	12.4	8.1	64.0
10	0	0	0	42.8	0	3.2	46.0
11	0	8.1	16.3	0.0	0	7.8	32.2
14	1.4	13.4	0.3	60.8	0	10.4	86.3
16	0	10.0	70.8	0	0	8.6	89.4
17	4.2	9.9	36.7	11.1	0	3.2	65.1
18	13.4	6.1	9.3	0	0	13.4	42.2



Twig beetle attack on young lodgepole pine

FOREST HEALTH MEETINGS

Forest health field training workshop

October 7 – 9, 2008. Salmon Arm.

There were three specific initiatives addressed at this year workshop:

1. To instruct on the implementation of standardized protocols for Forest Health free-growing district/regional-level resource stewardship monitoring;
2. To describe the business mapping process for TSR and Forest Health input, and instruction on NRL calculations;
3. To provide information on specific and general forest health issues.

The first day was in the 'classroom' with presentations on a variety of topics, followed by breakout groups working on NRL's. The second day was mostly in the field learning the techniques and protocol for the Forest Health free-growing resource stewardship monitoring. The third day was the analysis of the data collected from the field day.

The participants evaluated the workshop, and roles and responsibilities of district and regional staff. Five salient points were indentified:

- Training workshops should include all district forest health staff, which allows for opportunities to share ideas and best practices amongst the participants
- Develop more frequent interactions between regional specialists and district forest health staff to discuss forest health
- Provide more specific 'instruction' on developing forest health strategies
- Provide more 'hands-on' instruction for insect and disease identifications
- Provide more information on how to conduct efficient forest health monitoring



Participants at the forest health field training workshop

Western white pine management workshop

Michelle Cleary, Forest Pathologist, SIFR

Stefan Zeglen, Forest Pathologist, CFR

Vicky Berger, Research Technician, Kalamalka Research Station

Mike Carlson, Research Scientist, Kalamalka Research Station

Diane Douglas, Tree Improvement Branch

Venue:

Western White Pine Management Workshop, Vernon, BC. June 17-18, 2008.

Summary:

Western white pine (*Pinus monticola*) has been decimated throughout its natural range since the introduction of white pine blister rust (*Cronartium ribicola*) to western North America. For several decades now, the selection and breeding of white pines resistant to blister rust has remained a high priority for pathologists, geneticists, and forest practitioners. There has been a reluctance to include western white pine in reforestation plans despite its high ecological and commercial values to forestry. However, high survival rates of genetically improved, blister rust-resistance stock and impressive growth yields have been demonstrated which now warrants us to 'rethink our desire to manage this species. This workshop provided silviculturalists opportunities to gain information on a wide range of topics.

The first day of the workshop focussed on invited speakers who covered the following topics grouped into three themes.

The Rust

1. *History of Cronartium ribicola and Western White Pine in British Columbia* – Richard Hunt, Canadian Forest Service, Victoria, BC
2. *Resistance: What is it?* – Det Vogler, USDA Forest Service, Placerville, CA

The Host

1. *Distribution and Ecology of Western White Pine* – Dennis Lloyd, BC Ministry of Forests and Range, Kamloops, BC
2. *United States Western White Pine Resistance Breeding Program: History, Current and Future Directions* – Mary Frances Mahalovich, USDA Forest Service, Moscow, ID
3. *White Pine Wood Properties* – Les Jozsa, FP Innovations, Vancouver, BC

Management of White Pine in BC

1. *Is white pine a Good Choice for Plantations in the Southern Interior Cedar Hemlock Zone?* – Alan Vyse, BC Ministry of Forests and Range, Kamloops, BC
2. *Western White Pine – The Commercial Climate: Past, Present and Future Perspectives* – Stan Hadikin, Kalesnikoff Lumber, Nelson, BC
3. *White Pine Blister Rust Field Resistance observed in US and Canadian Provenance Trials* – John King, BC Ministry of Forests and Range, Victoria, BC

On the second day, there was a full-day, three stop field tour that covered blister rust resistance trials, realized gain trials, and an area demonstrating the pros and cons of various silvicultural intervention techniques.

Whitebark pine international conference

September 10-11, 2009. Nelson

Declining whitebark pine populations are the subject of an international conference to be held this year. Whitebark pine has been drastically reduced due to the introduced blister rust plague plus the recent beetle epidemic. The focus of this gathering is on science and management in Canada with a host of speakers the first day, followed by a field trip the second day. Topics will include biological status, management, and restoration. For more information, please contact Michael.Murray@gov.bc.ca.

FOREST HEALTH PRESENTATIONS

National pest forum

Venue:

National Pest Forum, Gatineau Quebec, Dec 2 – 4, 2008

Forum Background

The meeting format included pest status reports by representatives of each province and the U.S. Forest Service, and a broad cross section of integrated pest management research presentations by Canadian Forest Service researchers. The goal of the Forum is to foster dialogue and information exchange among researchers, practitioners, policymakers, and regulators on a range of issues, such as exotic pest introductions, and emerging challenges, such as managing for pests within intensive forest management plans. The development team for the National Forest Pest Strategy considers the Forum to be its most vital communication and reporting venue.

Contributors

Tim Ebata, Forest Health Project Specialist, Forest Practices Branch (prepared report)

Harry Kope, Forest Pathologist, Forest Practices Branch (presented report)

Abstract:

A British Columbia summary of forest health conditions update of the status of insects and diseases and other items for 2007/2008. Highlights included: Mountain Pine Beetle; Douglas-fir beetle; Douglas-fir Tussock Moth; Septoria musiva; new personnel added to the forest health group; a mention of the preparation of a forest health and climate change document amongst other things.

Alex Woods, Forest Pathologist, NIFR

Abstract:

A paper entitled “Are diseases of young trees in Central BC increasing?.....due to Climate Change?” was presented in the session called *Potential Impacts of Climate Change on Forest Pest Management in Canada*. The paper challenged the listener to understand the strong link between foliar diseases, and climatic and environmental conditions. If climate models are correct, there will be an increase in the occurrence and damage to forest trees caused by foliar diseases.

Richard Reich, Forest Pathologist, NIFR

Abstract:

A paper entitled “Multi-scale testing an operational *Armillaria* root disease mapping procedure for British Columbia” was presented in the session called *Forest Pathology*. The paper reported on the latest work on comparing different methods for mapping root disease areas. Whichever technique is chosen, the resulting information can be used to build risk and hazard maps that will aid in reforestation efforts.

Harry Kope, Forest Pathologist, Forest Practices Branch

Abstract:

Harry organized and chaired the session entitled *Forest Pathology*. This session was specifically organized to draw attention to the different topics of forest pathology that are being researched and practiced in Canada. It is envisaged that a forest pathology session will be occurring each year at the Forum.

Western international forest disease working conference

Harry Kope, Forest Pathologist, Forest Practices Branch

Michelle Cleary, Forest Pathologist, NIFR

Richard Reich, Forest Pathologist, NIFR

Venue:

Missoula Montana, October 28 – 31st, 2008

Abstract:

The conference consisted of four sessions including:

- A Student papers session that Michelle organized and moderated,
- A Climate change session,
- An invasive species session, and;
- A special papers session where Richard made a presentation entitled “Multi-scale testing of an operational *Armillaria* root disease mapping procedure for BC”.



Western gall rust infection

The conference also had six different committees that had specific breakfast or lunch meetings in which short items and presentations were made and discussed. The committees included:

- Nursery pathology,
- Root diseases,
- Hazard trees,
- Rusts,
- Dwarf mistletoe, and;
- Foliage and Twig pathology, which Harry Kope organized and chaired. This session included an update from David Shaw, director of the Swiss Needle Cast Cooperative (SNCC) on the cooperative and work to date. He also explained the functions, objectives and membership within the cooperative which is comprised of private, state and federal organizations. Bill Jacobi, of Colorado State University, presented some preliminary findings on Black Walnut

decline in Colorado. He also discussed aspen bark beetle with an associated fungus (unknown at this time) that is causing main stem death/deterioration of aspen. Jim Walla, of North Dakota State University, presented information on *Stigmina lautii*, which has been found on spruce in eastern and central North America. Harry presented some preliminary data on *Septoria musiva*, a poplar disease introduced from eastern North America into BC. Glen Stanosz of the University of Wisconsin presented information on *Diplodia* on Spruce.

Entomological observations from the Northern Interior Forest Region (east)

Robert Hodgkinson, Forest Entomologist, NIFR

Venue:

Forest Health Committee of BC meeting, UNBC, Prince George, Jan. 30, 2008 and Alberta/B.C. Intermountain Forest Health Meeting, Kamloops, April 22, 2008.

Abstract:

Progression of mountain pine beetle attack in selected young lodgepole pine plantations mostly in the Prince George Forest District was discussed with the aid of “time-lapse” photographs from March 2004 to October 2007. Mountain pine beetle also continued to successfully attack small random numbers of interior spruce in greater Prince George. Beetles even attempted attacks on black spruce, albeit unsuccessfully, near Lintz Lake in Prince George District in 2007.

In several mature spruce types killed by the spruce beetle in the Bowron River valley in the early 1980's, some of the replanted lodgepole pine was killed by mountain pine beetle in 2006 and 2007.

A Douglas-fir beetle outbreak in the southwest portion of Prince George Forest District continued with 27,000 m³ killed with average green-red ratios of 10:1. Pheromone-baited Lindgren funnel traps in clusters of 3 will be deployed at 10 sites in an attempt to mop up emerging beetles in 2008.

FOREST HEALTH PUBLICATIONS

Cleary, M, B van der Kamp, and D Morrison. 2008. Armillaria root disease stand establishment decision aid. BC Journal of Ecosystems and Management 9(2):60-65.

Jacobi, W.R., S. Zeglen and J.D. Beale. 2008. Black stain root disease progression in coastal Douglas-fir in British Columbia. Can. J. Plant Pathol. 30: 339-344.

Kurz, W., C.C. Dymond, G. Stison, G.J. Rampley, T.E. Neilson, A.L. Carroll, T. Ebata and L. Safranyik. 2008. Mountain pine beetle and forest carbon feedback to climate change. Nature 452(24 April 2008): 987-990.

Woods, A. and Bergerud, W. 2008. Are free-growing stands meeting timber productivity expectations in the Lakes Timber Supply Area? BC Min. For. Res., For. Prac. Br., Victoria, B.C. FREP Ser. 013.



Ministry of Forests and Range, Forest Practices Branch

Acknowledgements:

Many thanks to the contributors to this document:

Data and project information:

MoFR Practices Branch -	Harry Kope, Provincial Forest Pathologist
MoFR Southern Interior Forest Region -	Lorraine Maclauchlan, Forest Entomologist
	Leo Rankin, Forest Entomologist
	Michelle Cleary, Forest Pathologist
	Michael Murray, Forest Pathologist
	Kevin Buxton, Forest Health Specialist
MoFR Northern Interior Forest Region -	Ken White, Forest Entomologist
	Robert Hodgkinson, Forest Entomologist
	Alex Woods, Forest Pathologist
	Richard Reich, Forest Pathologist
	Gordon Dow, Silviculture Specialist
MoFR Coast Forest Region -	Don Heppner, Forest Entomologist
	Stefan Zeglen, Forest Pathologist
Consultants -	Alta Vista Management
	BA Blackwell & Associates Ltd.
	JCH Forest Pest Management
	Nazca Consulting
	Pro-Tech Forest Resources Ltd.
	TimberWright Contracting

Photographs:

Aaron Bigsby (cedar decline, Chehalis slide)
Andrej Kunca (Douglas-fir needle cast)
Alex Woods (Rhizosphaera damage, Phaeoseptoria contorta, Dothistroma needle blight)
Art Stock (birch decline, woolly adelgid)
Donald Owen (spruce aphid)
Ben Andrew (western balsam bark beetle stand and coastal windthrow)
Don Heppner (western spruce budworm helicopter treatment)
Don Wright (snow windthrow)
Ed Lussier (western spruce budworm treatment ground operations)
Harry Kope (forest health training workshop, Septoria canker)
Joan Westfall (various)
Julie Castonguay (squirrel damage, mountain pine beetle Kootenay Lake, larch needle blight, unknown Douglas-fir defoliation)
Lorraine MacLauchlan (twig beetle, MPB attack of young pine in DKA, verbenone flake trial)
Michael Murray (white pine blister rust infection and screening, disease resistant whitebark pine)
Rick McCutcheon (hemlock looper)
Robert Hodgkinson (satin moth, Bruce spanworm, cluster funnel traps)
Tom Sullivan (bear damage)
USDA Forest Service Rocky Mountain Archive (hemlock dwarf mistletoe)

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