

2006 SUMMARY OF FOREST HEALTH CONDITIONS IN BRITISH COLUMBIA



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for British Columbia Ministry of Forests and Range,
Forest Practices Branch

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TABLE OF CONTENTS

Abstract	i
Introduction	1
Methods	3
General Conditions	5
Damaging Agents of Pines	8
Mountain pine beetle, <i>Dendroctonus ponderosae</i>	8
Dothistroma needle blight, <i>Dothistroma septosporum</i>	19
Pine needle cast, <i>Lophodermella concolor</i>	21
Rust diseases of hard pine	21
Damaging Agents of Douglas-fir	22
Western spruce budworm, <i>Choristoneura occidentalis</i>	22
Douglas-fir beetle, <i>Dendroctonus pseudotsugae</i>	26
Douglas-fir tussock moth, <i>Orgyia pseudotsugata</i>	28
Swiss needle cast, <i>Phaeocryptopus gaeumannii</i>	29
Damaging Agents of Spruce	29
Spruce beetle, <i>Dendroctonus rufipennis</i>	29
Green spruce aphid, <i>Elatobium abietinum</i>	30
Damaging Agents of True Fir	31
Western balsam bark beetle, <i>Dryocoetes confusus</i>	31
Eastern spruce budworm, <i>Choristoneura fumiferana</i>	32
2-year-cycle budworm, <i>Choristoneura biennis</i>	32
Damaging Agents of Hemlock	34
Western hemlock looper, <i>Lambdina fiscellaria lugubrosa</i>	34
Western blackheaded budworm, <i>Acleris gloverana</i>	34
Damaging Agents of Larch	35
Larch needle blight, <i>Hypodermella laricis</i>	35
Damaging Agents of Cedar	36
Yellow-cedar decline	36
Cedar leaf blight, <i>Didymascella thujina</i>	37
Damaging Agents of Deciduous Trees	37
Large aspen tortrix, <i>Choristoneura conflictana</i>	37
Gypsy moth, <i>Lymantria dispar</i>	38
Birch leafminer, <i>Fenusa pusilla</i>	39
Serpentine leaf miner, <i>Phyllocristis populiella</i>	40
Miscellaneous damaging agents	40
Damaging Agents of Multiple Host Species	41
Abiotic injury and associated forest health factors	41
Animal damage	43
Black army cutworm, <i>Actebia fennica</i>	46

Forest Health Projects	
1. Mountain pine beetle attack in immature stands – 2006 Project Summary	46
2. Mountain pine beetle attack of age class 2 stands in the Prince George Forest District	47
3. Permanent sample plot establishment to assess the biology and behaviour of mountain pine beetles in young stands	47
4. Underplanting of young stands damaged by mountain pine beetle	48
5. Successful mountain pine beetle emergence from spruce	49
6. Hydrologic sensitivity of watersheds to mountain pine beetle infestation in the BC Interior	49
7. Single tree systemic injection trial using emamectin benzoate and fipronel for protection of lodgepole pine from mountain pine beetle	50
8. MCH Use for Douglas-fir beetle in the Cariboo-Chilcotin	51
9. Forest health and the Forest Stewardship Plan – a case study via the “Nadina District Forest Health – Stocking Standards Sub-Committee”	52
10. <i>Armillaria</i> Map Verification project	53
11. Forest pathology projects	54
12. Summary of <i>Hypholoma/Armillaria</i> research for 2006	55
13. Monitoring and literature review for hemlock dwarf mistletoe	56
14. Yellow-cedar decline project	57
Forest Health Presentations	
Application of the National Forest Pest Strategy’s Risk Analyses framework for pests in BC	
BC conditions report	57
Forest health legislation	58
Biology, population dynamics and management of mountain pine beetle in BC	58
Mountain pine beetle in BC	58
Mountain pine beetle control options in Caribou habitat - the BC experience	59
Observations on mountain pine beetle in young pine in the NIFR (east)	59
Mountain pine beetle successfully attacking spruce	59
Storage, hauling and milling of mountain pine beetle-infested wood in suppression beetle management units of the Mackenzie, Peace and Skeena Stikine Forest Districts	60
Current conditions and the state of our efforts regarding whitebark pine in BC	60
Are free-growing stands meeting timber productivity expectations?	60
Is an unprecedented <i>Dothistroma</i> needle blight epidemic related to climate change?	61
What effects will a changing climate have on lodgepole pine in British Columbia?	62
Forest Health Publications	62
	64

ABSTRACT

The 2006 *Summary of Forest Health Conditions in British Columbia* (BC) is a compilation of the provincial overview forest health survey data supplemented by insect population predictions, other types of surveys observations and special projects conducted by the Ministry of Forests and Range and their associates.

The current mountain pine beetle outbreak continued to be the leading cause of tree mortality in BC, with a record of over 9.2 million hectares of attack recorded in 2006. Over the past two years, expansion rates of area affected has declined substantially. More than half the infested stands were located in the Southern Interior Forest Region (SIFR). Chilcotin Forest District sustained the highest amount of attack for the 2nd consecutive year with 1.3 million hectares of damage. Infestations in the Quesnel Forest District declined slightly to just under 1.3 million hectares, but attack in the Central Cariboo and 100 Mile House Forest Districts increased 16% each to 814,754 ha and 723,008 ha, respectively.

Mountain pine beetle attack in the Northern Interior Forest Region (NIFR) increased slightly to 3.9 million hectares affected. Of this total, four of the most southerly districts contained 91% of the attack. Infestations in the Nadina Forest District dropped slightly to 1,186,684 ha, but increased 11% in the Vanderhoof Forest District to 977,332 ha. Prince George and Fort St. James Forest Districts had 819,819 ha and 574,960 ha of damage recorded, respectively. The largest increase in infestations since 2005 occurred in the Mackenzie Forest District (from 104,212 ha to 285,187 ha) and the Peace Forest District (from 15,611 ha to 50,312 ha). Extensive control efforts continued this year along the BC / Alberta border in the Peace and Headwaters Forest Districts.

Area affected by western balsam bark beetle was down slightly to 1.2 million hectares provincially compared to 1.4 million hectares last year. The majority of this mortality was trace to light in severity (93%) and chronic in nature. Most of the affected stands occurred in the NIFR. Spruce beetle attack was up 50% over last year, with 83,660 ha delineated. The largest percentage of the attack occurred in the 100 Mile House, Quesnel and Central Cariboo Forest Districts. These districts with the addition of the Chilcotin Forest District sustained the majority (87%) of the provincial Douglas-fir beetle mortality as well, which rose for the fourth year in a row to 60,709 ha affected.

Western spruce budworm continued to be the primary defoliator in the province in 2006. Recorded infestations rose to a seven year high of 776,723 ha affected across the southern half of BC. The biological control agent *Bacillus thuringiensis* var. *kurstaki* (Btk) was applied aurally to control infestations over 43,982 ha of high value Douglas-fir stands. This was the largest program of its kind ever undertaken in BC. Large aspen tortrix defoliation to decline for a third year in a row to 123,312 ha affected in the NIFR. Two-year-cycle budworm defoliated (mostly light intensity) 63,490 ha in the northern part of the SIFR, and 4,164 ha in the Skeena Stikine Forest District of the NIFR. Aspen leaf miner defoliated stands throughout the SIFR, with 12,878 ha mapped.

In response to 135 gypsy moths trapped in 2005, a ground spray with *Btk* was conducted this year in Saanich, Nanaimo and Salt Spring Island. High density mass trapping was also utilized at five sites with promising results. Monitoring traps caught 153 moths this summer.

Regarding abiotic damage agents, wildfire continued to cause the most damage with 160,801 ha burned across BC, which was roughly four times the area recorded last year. Dry summer conditions and large areas of mountain pine beetle mortality contributed to the increase. Yellow cedar decline was recorded over 4,137 ha, primarily in the North Island – Central Coast Forest District. Windthrow damage was down substantially to 4,346 ha affected. Drought conditions remained low in the SIFR, but became visible over 2,033 ha in the NIFR.

Larch needle blight defoliated 68,228 ha in the SIFR in 2006. Most of the damage was located in the Rocky Mountain, Arrow Boundary and Kootenay Lake Forest Districts. Dothistroma needle blight continued to be the most significant foliar disease in the NIFR, with 2,891 ha observed during the overview surveys (detailed surveys recorded a total of 18,301 ha of managed stand defoliation).

Other forest health factors such as birch leaf miner, western blackheaded budworm, cedar leaf blight and redbelt caused localized damage in various areas.

2006 SUMMARY OF FOREST HEALTH CONDITIONS IN BRITISH COLUMBIA

INTRODUCTION

The forests in British Columbia (BC) are susceptible to damage from various agents including insects, diseases, animals and environmental factors. The abundance of and effects caused by these damage agents can vary substantially from year to year. Monitoring and recording of damage to the forests in BC is an ongoing process that is the responsibility of the BC Ministry of Forests and Range (MoFR). One of the primary tools for gathering this information is the annual aerial overview survey. The MoFR has conducted this survey for the past ten years and the Canadian Forest Service (CFS) before that.

The aerial overview survey has been designed to denote forest disturbances quickly and cost effectively over large areas. The resulting information is used for a variety of important purposes, including: monitoring changes in forest health conditions over time, providing forest managers with current

damage information and contributing to national indicators for sustainable forest management.

Tree mortality and most defoliation damage are visible from aerial overview surveys. Other forest health concerns, in particular diseases such as rusts, cankers and dwarf mistletoes, are not usually discernable. Methods such as low-level helicopter surveys or ground observations can be used to identify damage caused by these agents. Information collected by methods other than the aerial overview surveys were included in this report if it arose as a concern and/or damage conditions changed since last year, but was not added to the overview data.

Overview information was recorded for individual forest health factors by severity of damage and was summarized by forest districts (Figure 1). Each forest region was responsible for collection of the data, which was then collated by Forest Practices Branch for

inclusion in the provincial Land Data Resource Warehouse.

This report is a summary of the 2006 survey results. MoFR staff and their associates have provided additional insect population predictions, damage agent observations, forest health presentations, projects and publications. The intent of this report is to summarize forest health observations that MoFR personnel were involved with and does not necessarily include research and management of forest health in BC by other sources such as universities and other levels of government.



Mountain pine beetle larvae

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)
DNC · North Coast Forest District (Prince Rupert)
DIC * North Island - Central Coast Forest District (Port McNeill, Hagensborg)
DQC · Queen Charlotte Islands Forest District (Queen Charlotte City)
DSI · South Island Forest District (Port Alberni, Duncan)
DSQ · Squamish Forest District (Squamish)
DSC · Sunshine Coast Forest District (Powell River, Sechelt)

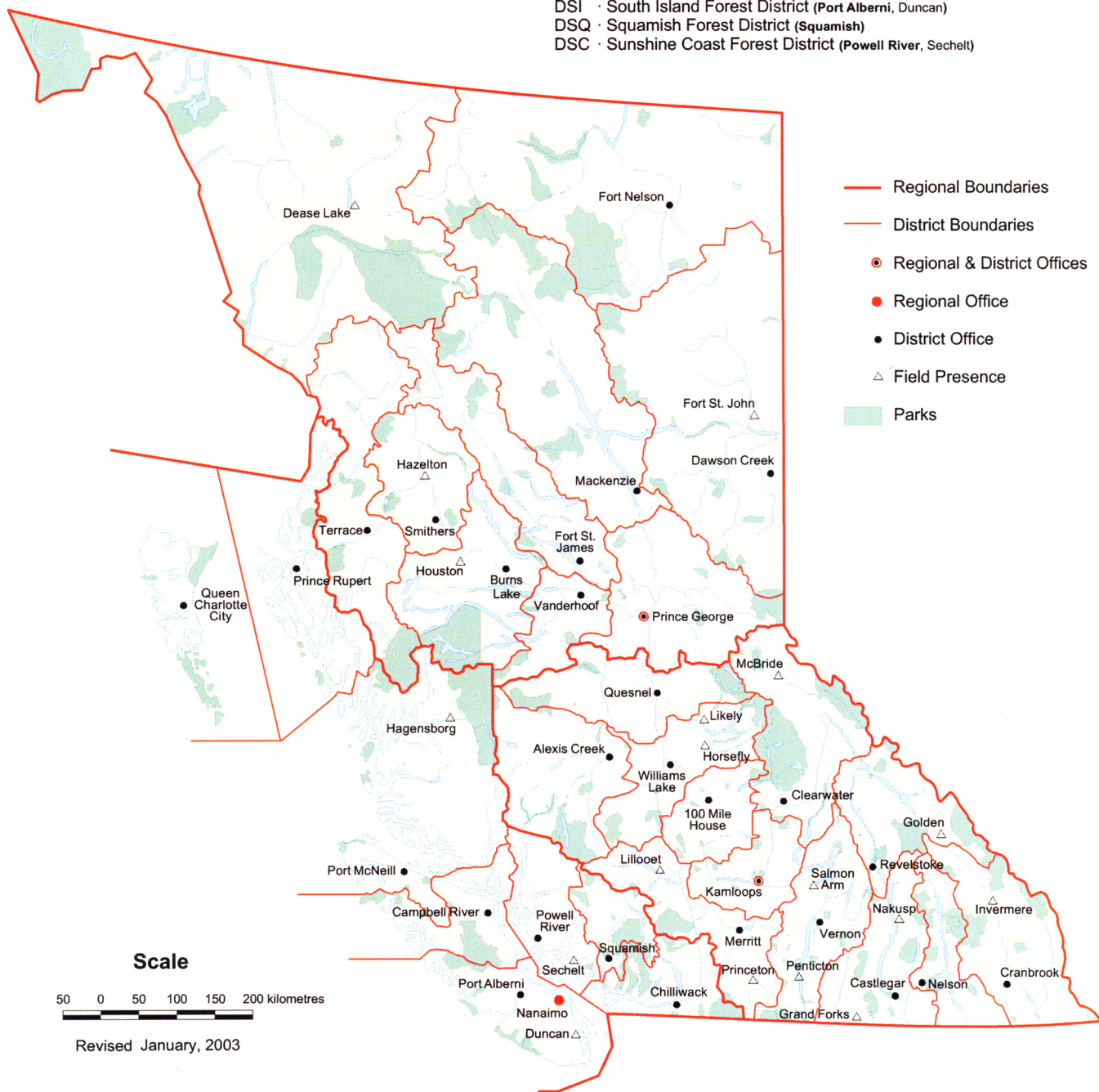


Figure 1. Map of British Columbia outlining regional and district forest boundaries as of April 1, 2003

METHODS

Aerial overview surveys are conducted from fixed wing aircraft flown at relatively high elevations over the forests of BC. Experienced personnel sketch forest health disturbances on 1:100,000 scale maps. Black and white (panchromatic) or colour Landsat 5 satellite images are used as a map base with specific features such as lakes, creeks and roads delineated to improve spatial orientation. Details of survey methodology are available online at the Integrated Land Management Bureau website: <http://ilmbwww.gov.bc.ca/risc/pubs/teveg/foresthealth/index.htm>.

Timing for survey flights is scheduled for when the damage from priority forest health factors are most visible. This can vary by type of damage and location in the province. In 2006, flights were conducted from the second week of July to the end of September. Weather in general was very good in July and August, with sunny conditions. Infrequent but intense periods of rain helped to reduce haze and high wild-fire hazards. The majority of the surveys were completed during this time frame. The last of the surveys conducted in the Northern Interior Forest Region (NIFR) near the end of

September encountered increasingly poor weather conditions. A total of 717.0 hours were flown during the 2006 survey period (Table 1).

With the exception of the Queen Charlotte Islands, hand-held Global Positioning Satellite (GPS) receiver units were utilized to record flight lines, ensuring adequate coverage (Figure 2). Flights were conducted in a grid pattern where topography was relatively flat and by drainages in mountainous terrain. Coverage intensity varied depending on visibility and the extent of damage. The majority of all forested land was surveyed. The exception was the northwest corner of the province, which was a lower priority than the rest of the NIFR. Poor weather and time constraints interfered with completion of that area.

Non-forested types such as alpine tundra were not surveyed. A total of 82% of the province was flown in 2006.

Trees killed by forest disturbances such as bark beetles, fire, flooding etc. were mapped if the mortality occurred within the previous year. This was determined by observing foliage colour. Generally, dying tree foliage turns yellow to bright red, then over time colour intensity fades and foliage is shed. Hectares damaged in past years cannot be added cumulatively, since new mortality may appear in the same areas that had a percentage of trees killed previously.

Large areas of mortality were delineated as polygons on the survey maps. The percentage of recently killed trees by the

Table 1. Number of flying hours required by each Region to complete the 2006 provincial aerial overview surveys.

Region	Zone	Flight hours	Survey Dates
Southern Interior Forest Region	Cariboo	151.4	July 21 st – Aug 20 th
	Kamloops	73.2	July 20 th – Aug 2 nd
	Nelson	115.0	July 20 th – Aug 16 th
Northern Interior Forest Region		280.6	July 7 th – Sept 29 th
Coast Forest Region		96.8	Aug 2 nd – Aug 27 th
Total		717.0	July 7th – Sept 29th

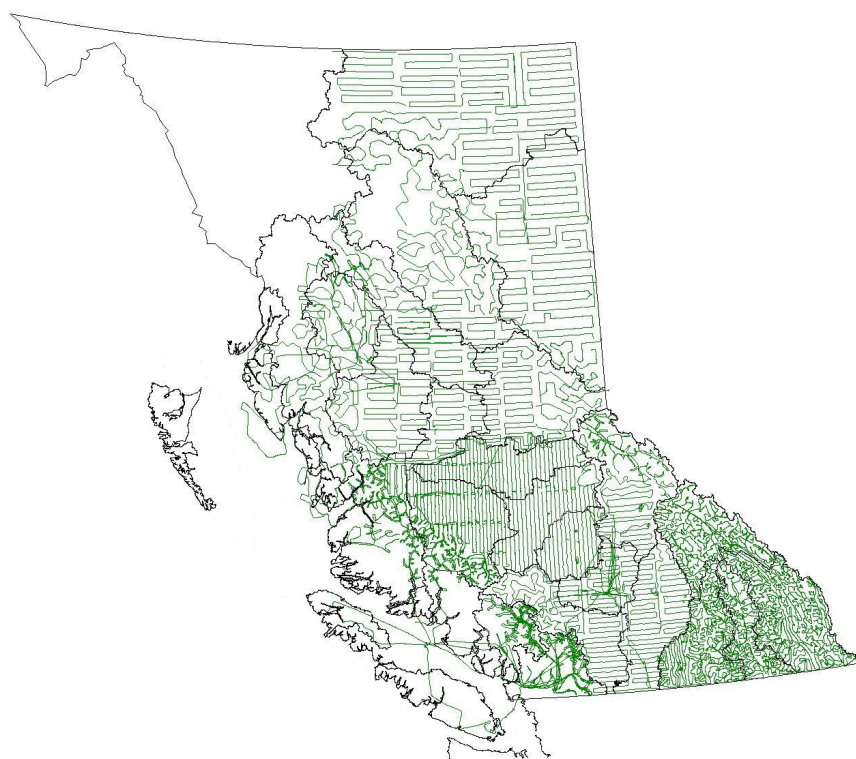


Figure 2. Flight paths flown while conducting the 2006 aerial overview surveys.

Table 2. Intensity classes used in aerial overview surveys for recording forest health damage (mortality and defoliation).

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.

responsible disturbance agent was noted according to intensity classes (Table 2). Five intensity classes ranging from trace to very severe were utilized.

Smaller areas of up to 50 trees were recorded as spots rather than polygons. To include these spots in total hectares affected, 1 – 30 trees were given a size of 0.25 ha and 31 – 50 trees 0.5 ha with an intensity rating of severe.

Broad intensity classes, known errors of omission (i.e. missed trees) and other limitations of the aerial overview survey are recognized, and limits the use of the data for certain applications. For example, accurate mortality volume estimations are not an expected outcome since actual number of trees killed (and consequently, volume killed) is not precise.

Tree defoliation is the other disturbance that may be visible from the air. It can be the result of insect feeding, foliage diseases or several abiotic factors. Defoliator damage tends to be widespread and was therefore mapped only as polygons. Only the current year of defoliation was recorded, which was assessed as a percentage of the foliage

damaged over the entire polygon (Table 2). Hectares of defoliation cannot be added cumulatively to previous years because the same area may experience more than one year of damage by the same forest health factor.

Sketch mapped forest health disturbances were digitized using MoFR Forest Practices Branch standards, available at: <http://www.for.gov.bc.ca/hfp/health/overview/arcinfo.htm>.



Aerial observer recording forest health damage

GENERAL CONDITIONS

Damage to BC forests as recorded during the 2006 aerial overview surveys totalled 11,822,030 ha (Table 3). Mountain pine beetle continued to be the primary forest health factor of concern, with a record of over 9.2 million hectares of pine currently under attack. Mortality caused by western balsam bark beetle was scattered over 1.1 million hectares of mature sub-alpine fir. Other forest health agents that caused significant mortality in stands were fire, spruce beetle and Douglas-fir beetle. Defoliation damage to stands of all ages was primarily caused by western spruce budworm, followed by large aspen tortrix, two-year-cycle budworm and larch needle cast. Various other agents caused smaller, more localized damage. Details of locations, extent and intensity of damage by tree species are noted in the following section of this report.

The primary forest health factors that have been recorded during the aerial overview surveys over the last seven years have been bark beetles and insect defoliators (Figure 3). Bark beetle damage has been constantly increasing, though the rate of increase has levelled off substantially over the last four

years. The main reason for these high levels was the extensive mountain pine beetle outbreak. The slowing rate of damage expansion reflects the peak and consequent decline of the infestation in areas where most of the lodgepole pine has been killed. However, the mountain pine beetle flight in the summer of 2006 resulted in an unprecedented mass migration of beetles into the Peace Forest District and beyond. The beetle attack spread as far as Slave Lake, Alberta (AB) with the full extent of attack not known at this time. This expansion will be documented in the 2007 aerial overview survey and may show acceleration in damage rather than a slowing. The increases may be offset by the collapse of the infestation in the oldest portion of the outbreak. In contrast, damage due to insect defoliation has fluctuated year to year, reflecting the large population swings that often occur over relatively short time periods with these insects.

Injuries caused by abiotic factors remained the third largest grouping, with wild-fire being the main factor. Most abiotic factors are weather driven and hence tend to change drastically from one year to the next.

Table 3. Summary of hectares affected by forest damaging agents as detected in 2006 aerial overview surveys in British Columbia.

Damaging Agent	Hectares Affected
<i>Bark Beetles:</i>	
Mountain pine beetle ^a	9,243,408
Western balsam bark beetle	1,194,167
Spruce beetle	83,660
Douglas-fir beetle	60,709
Western pine beetle	1
<i>Total Bark Beetles:</i>	<i>10,581,944</i>
<i>Defoliators:</i>	
Western spruce budworm	776,907
Large aspen tortrix	123,312
2-year-cycle budworm	67,686
Aspen leaf miner	12,878
Birch leaf miner	4,635
Western hemlock looper	1,554
Western blackheaded budworm	1,306
Misc. defoliators	491
Satin moth	298
Forest tent caterpillar	241
Green spruce aphid	195
Alder sawfly	180
<i>Total Defoliators:</i>	<i>989,683</i>
<i>Abiotics:</i>	
Fire	160,801
Windthrow	4,346
Yellow cedar decline	4,137
Drought	3,110
Flooding	1,657
Redbelt	309
Slide	166
Fumekill	17
Aspen decline	63
<i>Total Abiotics:</i>	<i>174,606</i>
<i>Diseases:</i>	
Larch needle cast	68,228
Dothistroma	2,891
Cedar Leaf Blight	1,041
Pine needle cast	104
<i>Total Diseases:</i>	<i>72,264</i>
<i>Animals:</i>	
Bear	62
Cattle	7
<i>Total Animals:</i>	<i>69</i>
Provincial Total	11,822,030

^a Includes infestations in parks totalling 845,048 ha.



*Mountain pine beetle boring frass
from mass attacked young
lodgepole pine*

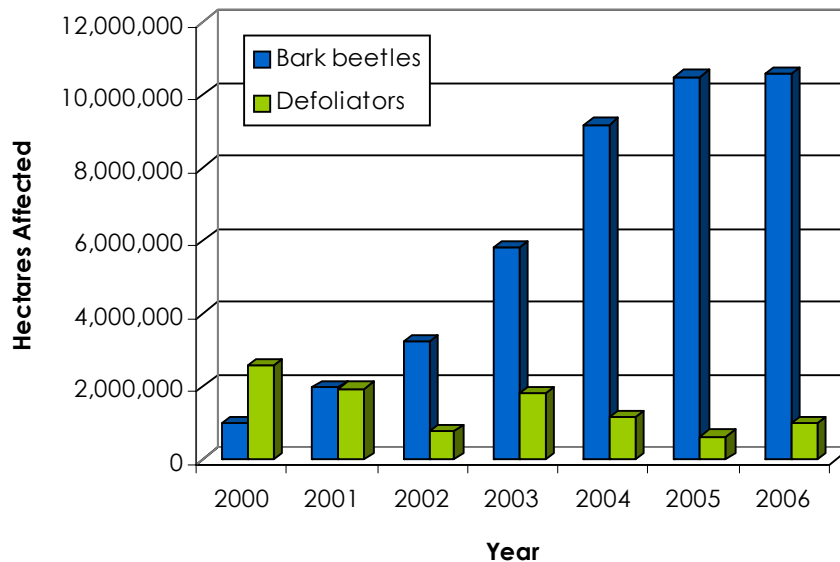


Figure 3. Hectares affected by bark beetles and defoliating insects from 2000 – 2006 in British Columbia.

Disease caused damage was up substantially in 2006, followed by minor recorded incidences of animal damage. Both these categories tend to be underestimated by the surveys however as it is often difficult or impossible to detect the damage from the height of the overview surveys.

The MoFR forest health staff increased substantially in 2006 in response to the significant forest health challenges BC is facing. To bring all the new staff up to speed, two forest health training workshops were held in June and November. The first workshop identified training needs for district forest health staff and the second workshop provided the required knowledge.

The 54th Annual Western International Forest Disease

Working Conference (WIFDWC) was held in Smithers BC from October 2 – 6. Several MoFR staff members were integral to the planning of the conference. WIFDWC is an annually held forum for information exchange among forest pathologists in western North America. This year close to 80 people attended from BC, AB, the United States, Great Britain, the Czech Republic and New Zealand.

The conference program included sessions on forest health and climate change, mountain pine beetle and forest health, foliar diseases of forest trees and sudden oak death. A satellite meeting on *Dothistroma* followed the WIFDWC conference. Based on the discussions from this meeting, a strategy for future research on *Dothistroma* needle blight was developed.



Immature lodgepole pine stand severely damaged by Dothistroma needle blight

DAMAGING AGENTS OF PINES

Mountain pine beetle, *Dendroctonus ponderosae*

Provincial Situation

The current mountain pine beetle (*Dendroctonus ponderosae*) outbreak continued to cause significant mortality throughout the range of pine in BC this year (Figure 4). As recorded by the aerial overview surveys, mountain pine beetle infested a record of 9,243,408 ha across BC in 2006 (of which 845,048 ha were located in provincial parks and protected areas). Historically, attack rose sharply from 165,567 ha affected in 1999 to 784,000 ha in 2001. For the next three years, area infested approximately doubled every year. For the past two years, expansion of attack has begun to decline substantially, with an increase of only 6% from 2005 to 2006. The outbreak is expected to continue to expand and, by 2017, it has been estimated that 80% of the merchantable pine volume will be dead (see <http://www.for.gov.bc.ca/hr/bcmpb/>).

Within the attacked stands this year, 448,467 ha (5%) sustained very severe mortality, 1,119,425 ha (12%) severe, 3,042,393 ha (33%) moderate, 3,303,194 ha (36%) light and 1,329,930 ha (14%) trace mortality. The severe to very severe categories dropped slightly (6% in total) from 2005, the moderate to light categories each increased 9%,

and the trace category dropped by 12%.

Southern Interior Forest Region Damage

Over half of the stands infested by mountain pine beetle provincially in 2006 were recorded in the Southern Interior Forest Region (SIFR). Of this attack, the largest amount of damage in BC (1,356,091 ha) occurred in the Chilcotin Forest District for the second year in a row (Figure 5). Area affected continued to increase (up 4% over 2005) but the rate of increase was slowing compared to 15% from 2004 to 2005 and 29% from 2003 to 2004. Infestations were wide-

spread throughout lodgepole pine stands. Intensity was still increasing in the moderate to younger age classes, particularly to the south and west. The increase in overall intensity was reflected in the proportion of polygons recorded in the moderate to very severe range, which was 4% in 2003, 18% in 2004, 39% in 2005 and 65% in 2006. Range encroachment by young trees has become a problem for Cariboo cattle ranchers due to decades of fire exclusion. The extensive beetle mortality occurring in the young pine on the fringes of open range is actually seen as a benefit by the ranching community.



Young pine mountain pine beetle mortality on edge of open range

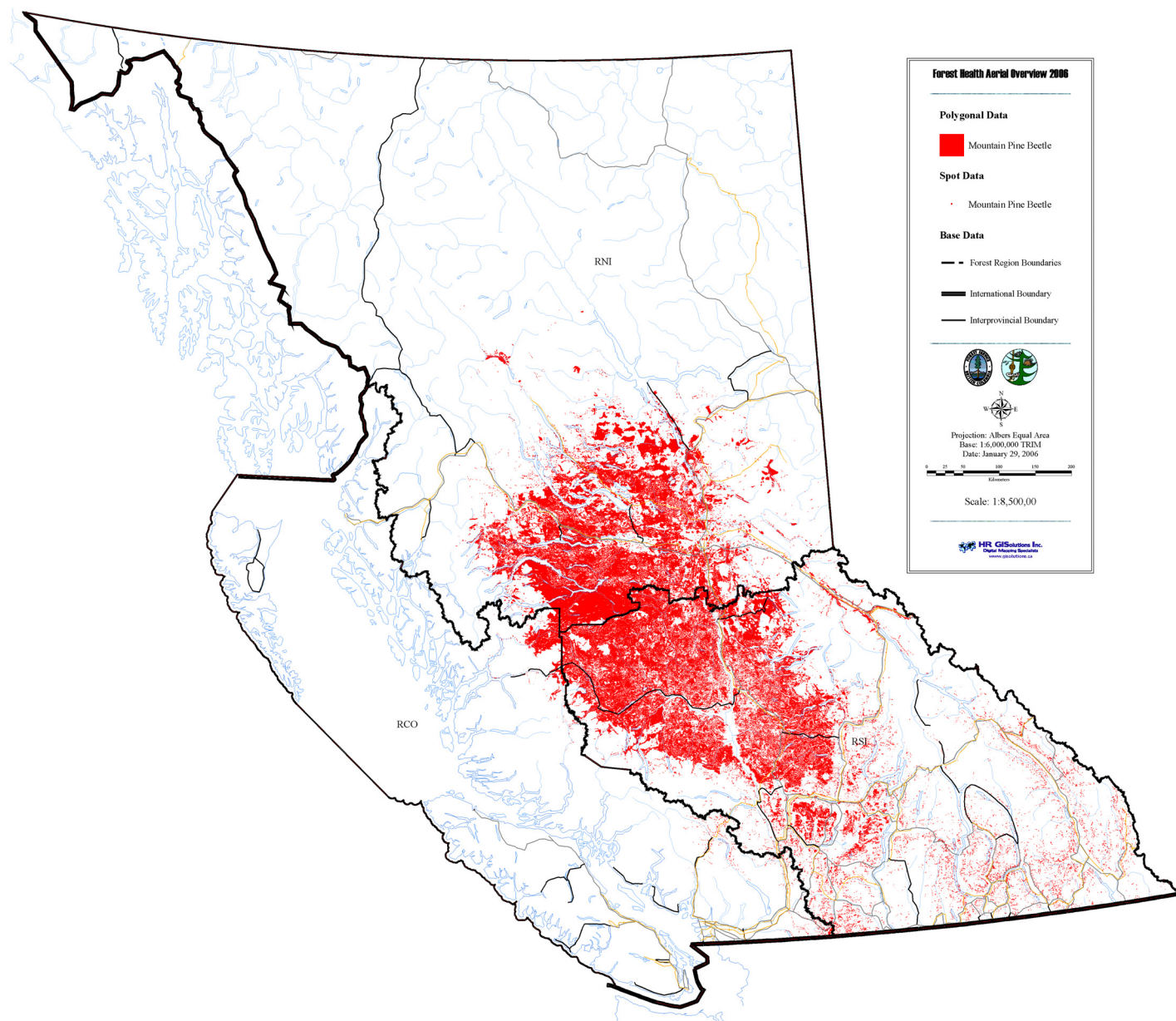


Figure 4. Mountain pine beetle infestations recorded in British Columbia in 2006.

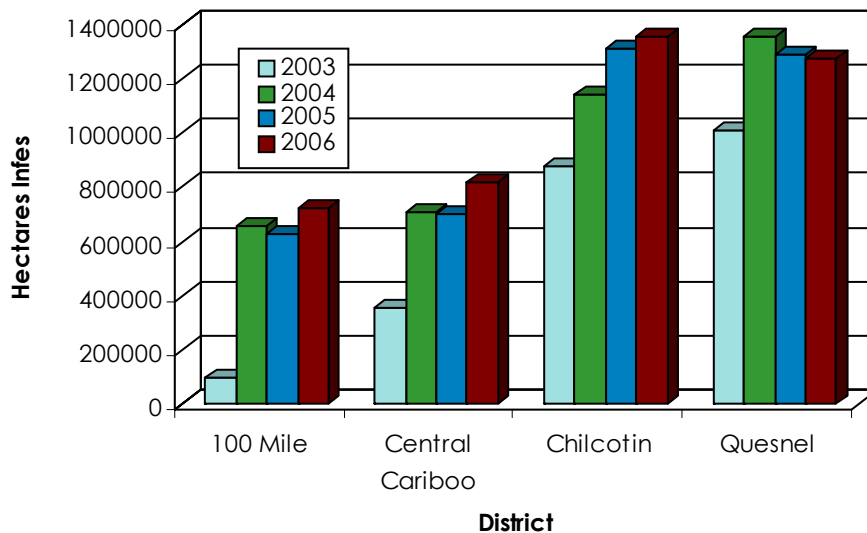


Figure 5. Hectares infested by mountain pine beetle from 2003 – 2006 in the Southern Interior Forest Region (districts with more than 500,000 ha affected in 2006).

In the Quesnel Forest District area affected continued a slow two-year decline, down to 1,271,941 ha from 1,289,002 ha last year. Infestations in this district continued to be the second highest in the province. However, intensity levels reflected that the attack has peaked in most of this district, with 24% recorded as severe and 4% as very severe, compared to 35% severe and 11% very severe last year.

After remaining relatively static for two years, infestations recorded in the Central Cariboo Forest District increased 16% over 2005 levels to 814,754 ha. As in the Chilcotin Forest District, attack was widespread and moving into the younger age classes. No distinct trends in severity changes were noted, with 28% rated trace, 36%

light, 19% moderate, 10% severe and 13% very severe.

The fourth largest area of attack in the SIFR was mapped in the 100 Mile House Forest District, with 723,008 ha affected. Infestations were up 16% over 2005, after a slight dip in 2004. Intensity of attack in the moderate to very severe range continued to increase as well, with a jump from 10% in 2004 to 41% in 2005 and 61% in 2006. The light intensity category fell a corresponding amount this year, with trace remaining constant.

Attack recorded in the Kamloops Forest Region increased slightly to 320,759 ha from 290,466 ha in 2005, after a jump of almost 250% the year before. Infestations intensified however, with 65% in the moderate to severe

range compared to only 45% last year. Light to trace categories both were correspondingly lower.

The remaining 640,871 ha (12%) of the mountain pine beetle affected stands in the SIFR were scattered across seven forest districts. Cascades, Okanagan Shuswap and Headwaters Forest Districts sustained similar levels of attack this year at 195,176 ha, 157,730 ha and 119,138 ha affected, respectively. These were all approximately double the area recorded last year for these districts. Control efforts have been concentrated along the mountain passes between BC and AB in the Headwaters Forest District. Aerially recorded red attack in these sensitive areas have been ground surveyed, and the current attack identified for fall and burn operations this winter. The attacked trees slated for treatment total 7,362 in Renshaw-Morkill, 3,719 in Robson Park and 1,875 in Holmes River areas. An additional 115 red attack sites in the Hugh Allan Creek area will also be surveyed this winter and current attack addressed.

Infestations mapped in the Arrow Boundary, Rocky Mountain, Kootenay and Columbia Forest Districts decreased substantially to

70,776 ha, 46,270 ha, 31,010 ha and 20,771 ha, respectively, in 2006. Reductions in these districts ranged from a third to half of the area affected last year. However, mortality in the severe to very severe intensity classifications rose on average to 40% from only 5% in 2005. This reflected a change in mapping style (different aerial observers this year) as opposed to a decrease in infestations.

Northern Interior Forest Region Damage

The NIFR sustained 42% of the provincial area affected by mountain pine beetle in 2006. Of this, four of the most southerly districts contained 91% of the attack (Figure 6). Overall increases in area infested across the NIFR slowed, with a rise from 3,680,169 ha in 2005 to 3,899,040 ha this year.

Nadina Forest District continued to have the largest area affected, though infestations dropped slightly to 1,186,684 ha from 1,227,007 ha last year, after a sharp increase of 55% from 2004 to 2005. Damage recorded in the Tweedsmuir Provincial Park and Entiako protected areas in this district totalled 199,784 ha. Substantial portions of the attack in the park are now grey and no longer recorded: this was reflected in the 20% decrease in area affected over last year, and the large percentage (51%) of trace intensity delineated. For the Nadina Forest District as a whole, intensity of attack dropped at the extremes with very severe changing from 14% in 2005 to almost zero and trace from 37% to 18%. Mortality in the mid range severity categories increased correspondingly,

particularly for the moderate rating. Expansion of mountain pine beetle attack was most noticeable around Houston, Burns Lake and the area east of Topley to Babine Lake. Intensification of attack was highest around the Morice Lake area. On the east side of the district across Babine Lake infestations were low; this may in part be due to the mixed tree species in this area, with only approximately one-third lodgepole pine.

Infestations in the Vanderhoof Forest District increased a modest 11% over last year to 977,332 ha of attack. Affected area in the Entiako protected area dropped slightly this year to 76,675 ha for this district. The majority of the mature pine in this district is now grey. This was reflected in the substantial drop in high intensity classes since last year: very severe went from 30% to almost zero, and severe from 17% to 7%. Trace remained the same but light went from 15% to 41% with moderate doubling to 30%. Mortality continued to increase in the immature pine stands.

After large increases in affected area in the Prince George Forest District from 2003 to 2005 (275% in total), recorded infestation growth slowed dramatically to 5% from 2005 to 2006. Area of attack this year reached

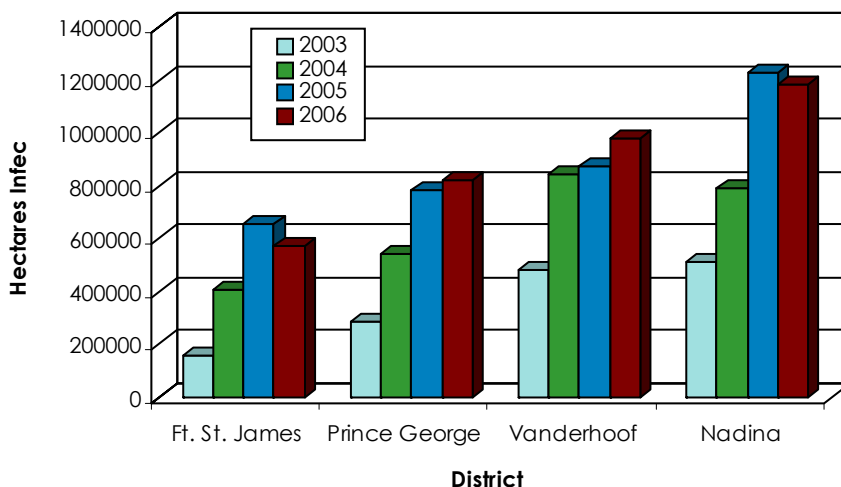


Figure 6. Hectares infested by mountain pine beetle from 2003 – 2006 in the Northern Interior Forest Region (districts with more than 500,000 ha affected in 2006).

819,819 ha. Infestations continued to grow in the east and northeast, while the majority of the mature stands in the southwest have turned grey. Attack in the immature pine types continued to intensify. As in the Vanderhoof Forest District, the increase of old attack was reflected in the recorded severity ratings: severe to very severe dropped from a peak of 21% in 2005 to 6% this year.

Infestations in the Fort St. James Forest District dipped 14% since 2005 to a total of 574,960 ha of recorded attack after several years of rapid increases. Despite the overall drop, infestations continued to intensify in the southern half and to expand into the northern half of the district. The relatively new age of the infestations was illustrated in the growing severity levels over as compared to last year: trace mortality dropped from 40% to 5%, while light attack grew from 26% to 60% and moderate from 21% to 32%.

Damage in the Mackenzie Forest District continued to rise sharply, from only 969 ha

of attack in 2003, to 104,212 ha in 2005, and 285,187 ha this year. Infestations started in the southern portion of this district and are now moving northward towards a large expanse of homogenous pine stands. The continued growth of attack intensification was shown in the movement out of



Severe mountain pine beetle mortality north of Prince George

trace (67% down to 7%) and into light (29% up to 84%) classifications this year as compared to 2005.

Despite extensive control treatments, recorded infestations in the Peace Forest District rose from 23,345 ha in 2005 to 50,312 ha in 2006. Attack was 1st observed in this district in 2003. The majority of the mortality (94%) was rated light, which includes a shift from 21% trace last year to only 1% in 2006. For the

first time, attack was recorded north of the Peace River and extended up to Fort St. John. Infestations ranged from Hudson Hope on the west side of the district to the AB border. On the western edge of the district, mountain pine beetle mortality is already beginning to occur in i m m a t u r e stands.

Large control efforts continued in 2006 were funded primarily by a \$100 million grant from the Federal government. In AB, random surveys were being conducted to find and burn current attack that were not associated with red attack. At this time, these

random surveys indicate that large numbers of current attacked trees are located immediately adjacent to the Peace Forest District and extending eastward as far as Slave Lake. In the Peace Forest District, detailed aerial surveys were conducted and a total of 5,350 identified red attack sites have been surveyed to date with star probes. Due to summer drought conditions, current attacked trees faded noticeably by September, 2006 and

indicated vast areas of attack resulting in major changes in the district's treatment strategy. Many of these newly faded sites were also ground surveyed. Unfortunately, this fading did not occur in AB where summer conditions were cooler and wetter and the full extent of the 2006 beetle flight into AB will not be known until early summer, 2007. The BC ground probes identified a total of 82,835 current attacks. An additional 714 reconnaissance surveys were also conducted where attack was more extensive, and though results are not tallied a further 40,000 currently infested trees are estimated. Extensive harvesting of the larger, more accessible infestations is underway while smaller infestations are being treated with a combination of conventional fall and burn, helicopter assisted burning and a trial with mechanical assisted burning.

Ground surveys indicate that that the majority of the beetles are now in a one-year cycle, with the exception of the Kakwa Provincial Park area where the cycle is longer. Very high gallery densities have been observed in high attack areas, but density varies throughout the district with low densities found on the leading edge of the attack.

Temperatures dropped to very low levels at the end of October, but unfortunately an insulating blanket of ~ 1 m of snow fell just before the cold snap. November temperatures dropped to a decade low of -38°C for approximately four days, but this is not expected to affect the beetle population significantly.

Recorded attack levels in the Skeena Stikine Forest District dropped sharply from 23,345 ha last year to 4,688 ha in 2006. This was most likely due to a change in recording methods of aerial observers. A drop in size of infestations mapped corresponded to an increase in severity, with trace dropping from 76% to 44% while light increased from 18% to 46%. Ground surveys still indicated a slowly increasing population.

The remainder of the attack in the NIFR was noted in the Kalum Forest District with 58 ha of trace intensity mortality. This infestation was first recorded last year in approximately the same location at 112km on Highway 37. Two additional infestations have been reported in the Copper River drainage and near Kemano, but these were not picked up during the aerial overview survey.

Coast Forest Region Damage

Mountain pine beetle infestations in the Coast Forest Region (CFR) declined from 285,675 ha recorded in 2005 to 216,943 ha this year, which is very similar to 2004 levels. Consistently through the present outbreak, the majority of the attack has occurred in the North Island - Central Coast Forest District. This continued to be the case in 2006 when 185,766 ha of damage was recorded, of which 173,914 ha (93%) of the mortality was located in Tweedsmuir Provincial Park. Area affected was down by 40% in the park over last year, which reflects the declining beetle population there.

Infestations in the Chilliwack Forest District rose slightly to 19,257 ha from 18,389 ha mapped last year. Most of the mortality in this district was in Manning Park (13,554 ha) and the remaining attack was primarily located in high elevation inaccessible rocky areas.

The rest of the mortality recorded during the overview surveys was 11,921 ha located in the Squamish Forest District. An additional 10 trees killed by mountain pine beetle were reported from other sources on Vancouver Island about 10 km southeast of Sayward. The attacked trees are within a patch of

lodgepole pine growing within a rocky bluff area on the north side of Highway 19. No current attack was discovered near the red attack. Mountain pine beetle is native to Vancouver Island and has caused outbreaks in the 1940s, 50s and 60s that, together with white pine blister rust, eliminated much of the mature white pine on the island. The last time mortality was noted on this island was an infestation of approximately 30 trees in 1984. This small outbreak is the result of an incipient build-up of local beetles and is not the result of immigration from the mainland. Aerial and ground surveys will be conducted this spring to locate current attack and assess control options.

Ponderosa, Whitebark and Western White Pine Mortality

In the southern portion of the SIFR, mountain pine beetle caused significant mortality to other native pine species besides lodgepole pine in 2006. Ponderosa pine was most affected, with 46,775 ha of attack on this species delineated during the overview surveys.

At the higher elevational range of ponderosa pine trees were killed by mountain pine beetle, whereas at the lower elevations and in some specific areas, mortality was caused by a mixture of mountain pine beetle and western pine beetle (*Dendroctonus brevicomis*). Both beetle species have sometimes been

found in the same tree. Therefore, in most cases it was impossible to determine the causal agent without extensive ground surveys. Surveys of 112 ponderosa pine infestations were conducted in the Kamloops Forest District in 2006 and showed that 77% were caused by mountain pine beetle, 12% by western pine beetle and 12% by both. In the City of Kamloops, a mix of the two beetles killed an estimated 90% of mature ponderosa pine as well as some younger trees.

A larger percentage of the ponderosa pine mortality in the Okanagan Shuswap Forest District, in particular around Kelowna, was attributed to the western pine beetle. The urban landscape in Kelowna and on Okanagan Lake were most affected, with an estimated 600 trees killed. This was the only area that overview surveyors were certain of the beetle species and one ha of mortality was recorded.

Surveys in 21 stands in the Cascades Forest District showed 90% of the mortality was due to mountain pine beetle with the remaining caused by western pine beetle. Approximately 60% of the mature ponderosa pine at its most northerly range around Clinton and Loon Lake in the 100 Mile House Forest District



Ponderosa pine mortality due to bark beetle in the Kamloops Lake area

succumbed to mountain pine beetle attack this year.

Whitebark pine and western white pine were also killed, with 8,812 ha and 232 ha affected, respectively by the mountain pine beetle. Both of these tree species are already threatened with serious white pine blister rust (*Cronartium ribicola*) infections. Between the rust, lack of successional replacement due to fire exclusion and beetle attack, the subalpine whitebark pine is in serious decline as a species in BC.



White pine blister rust infection

Beetle Flights

With the dry, warm weather experienced throughout BC for the majority of the beetle flight season, flights were well synchronized. In the SIFR, the main flights occurred in late July through early August. As is normal in the NIFR flights occurred a bit earlier, with the majority of the mountain pine beetles flying from the end of June to the end of July.

Tree Response to Attack

Rainfall in 2005 was plentiful during the growing season and generally adequate in 2006 (in short bursts followed by dry weather). As a result many pine trees were growing vigorously enough to produce pitch tubes in response to beetle attack. However, in areas with heavy beetle populations (in conjunction with co-ordinated flights), trees were overwhelmed quickly and often did not have a chance to try and pitch the beetle out. Trees in drier ecosystems and on rocky microsites also had greater difficulties producing a pitch response. In general, mass-attacked immature pine did not express many pitch tubes: instead, a high amount of frass was often visible at the base of the trees.

Early colour change (fading) of current “green” attacked trees in the fall instead of next spring varied across the province, but seemed more widespread than it was in 2005. Early fading was most prevalent in the southern half of the NIFR where approximately 50% of the trees started colour change in late September and early October. It was noticeable throughout the rest of the NIFR as well, particularly in attacked immature pine stands. As noted above, the Peace Forest District experienced substantial fall colour change, which assisted in

early identification which was a boost for control efforts.

In the SIFR early fade was not as widespread as in the NIFR, though it was still noticeable. Okanagan Shuswap and Kamloops Forest Districts reported the highest amount of early colour change, while in the Kootenay Lake and Rocky Mountain Forest Districts current attack was still primarily green in the fall.

Population Fluctuations

Overwintering brood samples were collected from attacked trees in the early spring (2006) in the SIFR. The results from assessment of these samples were utilized to estimate mortality and determine health and vigour of progeny. Data collected included the number of dead and live beetles in all life cycles and the number of galleries originating within the samples. This was used to calculate what is known as the “R” value number for an area, which indicates whether a population is decreasing (< 2.6), static ($2.6 - 4.0$) or increasing (> 4.0). A total of 1,522 trees were sampled across 153 sites this year (Table 4). Average R values for all districts predict increasing populations, with the exception of a distinct decline in the Quesnel Forest District, and slightly decreasing populations in the Robson TSA of the Headwaters Forest District.

Table 4. 2005/2006 mountain pine beetle overwinter mortality estimates for the Southern Interior Forest Region.

District (TSA)	# of Sites Sampled	# of Trees Sampled	Average % Mortality	Average R Value
100 Mile House	10	200	40.6%	9.0
Arrow Boundary	11	114	44.3%	9.7
Central Cariboo	10	200	37.5%	6.0
Chilcotin	10	200	41.7%	11.0
Columbia (Golden)	9	84	37.6%	9.5
Headwaters (Robson)	10	200	67.7%	2.3
Headwaters (Clearwater)	15	150	27.1%	16.2
Kamloops	15	150	22.0%	17.0
Kootenay Lake	10	102	53.5%	7.9
Cascades (Lillooet)	16	161	45.0%	7.8
Cascades (Merritt)	15	150	35.5%	13.8
Okanagan Shuswap	11	110	47.8%	7.4
Quesnel	5	100	89.5%	1.0
Rocky Mountain	6	51	51.0%	5.4
Totals/Averages	153	1,522	45.8%	8.9

To compliment the overwintering samples, some districts collected green attack to red attack (G:R) ratio data during fall/winter (2006/2007) ground surveys. This statistic is another tool for projecting the growth rate of the mountain pine beetle population for a given area. In general, >1 G:R ratio indicates an increasing population, and <1 a declining population.

G:R ratios must be interpreted carefully. Exceptionally high ratios (usually greater than the generally accepted biological limit of 5:1) may indicate that the sample area was inundated by beetles from other sources, and may not be truly representative. Many districts are experiencing this situation

with the current outbreak and hence have quit gathering this statistic. In the case of the CFR, most of the attack occurred within provincial parks and no surveys were conducted to obtain G:R ratios.

For the districts that did gather G:R ratios, the data is summarized in table 5. In general these numbers are not finalized, as ground surveys will continue throughout the winter. Many other factors in addition to outside beetle

Table 5. Green to red mountain pine beetle attack ratios observed in 2006.

Region / District	High	Average	Low
NIFR – Mackenzie (NE)	11:1	6.7:1	3:1
Mackenzie (NW)	2.5:1	1.8:1	0.8:1
Peace	163:1	12:1	1.1:1
Skeena Stikine	3:1		0.5:1
SIFR – Headwaters (NE)	7:1	2.3:1	1:1
Columbia	21:1	1:1	<1:1
Okanagan Shuswap	20:1	4:1	0.3:1
Rocky Mountain	3:1	1.8:1	0.5:1
Kootenay Lake	9:1	5:0	0.6:1:1

pressure affected the ratios, including elevation, aspect and control measures. Where differences were very distinct, district divisions were noted in table 5.

In the SIFR, G:R ratio data on average predicted an increasing beetle population with the exception of the Columbia Forest District where the average G:R indicated a static population. Ratios varied widely in this district however (from 21:1 to <1:1) and may not be as reliable as the average R value which indicated an increasing population. The increase predicted by the G:R ratios in the Headwaters Forest District was obtained from surveys concentrated in the control areas, as opposed to the R value survey which was spread out over the entire Robson TSA.

Data for G:R ratios was only available from three districts in the NIFR. Overall, indications are that populations are still on the increase, though to varying degrees. The data collected from the Peace Forest District (from a large number of surveys) suggests the highest populations (12:1), with the average greatly increased over last year's 1.6:1 ratio.

Related Forest Issues

As mature pine hosts are depleted, the mountain pine beetle has been successfully

attacking progressively younger stands. This was first noted three years ago in areas where the beetle had been the most active for the longest period, such as Prince George, Vanderhoof and Quesnel Forest Districts. In 2006, this trend became more prevalent and has been reported in many other forest districts. The MoFR has undertaken various projects to document and identify the ramifications of this unprecedented attack (Projects 1 - 3, pgs. 46 & 47).

The significant amount of mortality occurring in immature stands due to mountain pine beetle is causing regeneration concerns. Various options to rehabilitate these stands are being considered (Project 4, pg. 48).

Pine engraver bark beetle (*Ips pini*) usually breed in recently killed or heavily stressed pine, in particular trees of smaller diameter or tops of trees. Historically, pine engraver bark beetle populations often have built up in the later stages of a mountain pine beetle outbreak to the point where they can attack living trees. This has not been documented to any large extent so far in the current outbreak, in part due to the masking effect of the high mountain pine beetle mortality. Scattered attack has been noted however, particularly in smaller

diameter immature stems left behind in a stand attacked the previous year by mountain pine beetle. *Ips pini* accounted for 20% of the young lodgepole pine mortality in plantations in the Bowron-Willow drainages of the Prince George Forest District in 2006. A complex of black stain root disease (*Leptographium wageneri*) and pine engraver bark beetle was observed and ground checked during the 2006 aerial surveys in the northwest corner of the Arrow Boundary Forest District.



Ips pini galleries on young pine as uncovered by woodpecker

A significant threat to regenerating pine stands following the mountain pine beetle outbreak is Warren root collar weevil (*Hylobius warreni*). The weevil is both concentrating in and migrating from residual stands into nearby immature pine stands. In some areas, up to 40% mortality has been

observed in young stands. Drs. Staffan Lidgren and Michael Gillingham of the University of Northern BC (UNBC) with graduate student Matthew Klingenberg and co-operators from the BCMoF are presently examining how spatial patterns of salvage harvesting may affect weevil pressure.

Successful mountain pine beetle attack was documented on a few interior spruce trees in 2006 (Project 5, pg. 49). This is a newly recorded phenom-



Mortality in young pine stand due to Warren root collar weevil

enon, as any attack previously noted on spruce did not result in tree mortality or new beetle emergence.

Hydrologic change is anticipated in many interior watersheds due to mountain pine beetle related forest mortality, associated harvesting and

road construction. Watershed planning recommendations and research initiatives are being developed in view of water management issues around hydrologic change (Project 6, pg. 49).

Mitigating Beetle Impacts

The *Mountain Pine Beetle Action Plan*, initiated in 2001, provides a framework for all levels of government, communities, industries and stakeholders to mitigate the impacts of the beetle outbreak. This plan was updated for the second time in 2006. To date, the province has made significant progress towards achieving the plan's following seven objectives.

1. Economic sustainability for communities includes a *Northern Development Initiative Trust* to help communities diversify their local economies. Government has also signed agreements with several First Nations bands to help manage the beetle infestation.
2. Worker and public safety is being addressed through road improvements, fuel management treatments to help protect communities and tree removal / fuel reduction programs in beetle-impacted provincial parks.
3. To recover value from beetle infested wood, temporary increases in the

allowable annual cut of 2.4 million m³/yr were approved after 2005/06 timber supply analyses. Major licences were also awarded to TallOil Canada to use the wood for bio fuels. Investments in research and development have led to the creation of various new and improved products.

4. The *Future Forest Ecosystem initiative* is exploring opportunities to adjust forestry legislation, policy and practice in response to rapidly changing forest conditions to conserve long-term forest values.
5. To limit further damage, beetle control measures are being conducted along the BC / AB border and other edges of the infestation.
6. The *Forests for Tomorrow* program is aimed at restoring forest resources through such efforts as wildlife habitat restoration, seed and seedling production, site preparation, planting, fertilization and research.
7. Co-ordinated planning and mitigation measures are being addressed through eleven ministries and provincial agencies working on projects, as well as a *First Nations' Mountain Pine Beetle Initiative*.

The full action plan is available on the MoFR website (http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/actionplan/2006/).

At a smaller scale, a few treatments to protect individual high value pine trees were investigated this year. Trials were established in the 100 Mile House Forest District to test the efficacy of injecting trees with emamectin benzoate and fipronil to protect them from successful attack by the mountain pine beetle (Project 7, pg. 50). The efficacy of the treatments will be evaluated in the early spring of 2007.

In urban forest settings use of the pheromone repellent verbenone, by itself or in conjunction with the insecticide Sevin® (sprayed on boles), produced variable results. These measures in general worked best in areas with low beetle populations. Various fertilizer formulations were also tried to increase vigour of trees so they could withstand beetle attack. Care must be taken with this preventative measure, as fertilizers with high nitrogen content were observed to actually attract the beetles.

The City of Kelowna developed a method for wrapping boles of susceptible trees in their parks with fibreglass

screen for beetle protection. This process is best done by crews with the proper equipment, as the beetle will find their way through any small unprotected gaps in the screen. A small experiment was conducted by placing a beetle attractant pheromone on a screened tree to see if they could get past the barrier. The screen held, while a nearby unprotected tree was mass attacked.



Ponderosa pine wrapped with screening to prevent beetle attack

Dothistroma needle blight, *Dothistroma septosporum*

Dothistroma (redband) needle blight (*Dothistroma septosporum*) damage was detected on 2,891 ha of lodgepole pine plantations during the 2006 overview surveys. The majority (82%) was of severe intensity, with the remaining 18% light. The recorded damage was split between the Skeena Stikine and Kalum Forest Districts of the NIFR, and was more than double that of 2005.

Being able to identify older dying needles underneath current foliage flush is difficult using the overview survey methodology. Hence, the increasing number of hectares and level of intensity recorded this year is indicative of increased infection.

Detailed aerial surveys using helicopters and lower flight elevations were also conducted specifically to map Dothistroma damage in 2006. The surveys targeted primarily managed stands and not surprisingly, they delineated damage over a wider area than the aerial overview survey. The Skeena Stikine Forest District sustained the most damage with 13,560 ha infected, of which 2,600 ha were recorded as severe. Stands in the western portions of the Bulkley TSA and eastern

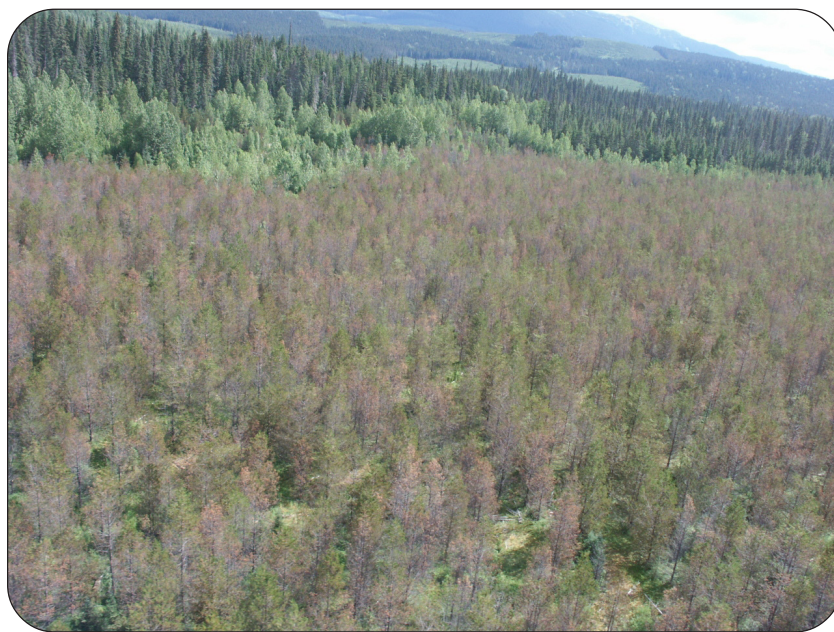
portions of the Kispiox TSA were most heavily affected. Of the 4,741 ha mapped in the Kalum Forest District, a third of the stands were severely damaged. Approximately eighty young stands were surveyed by helicopter in the eastern portion of the Prince George Forest District, and about 150 ha of severe and 1,500 ha of moderate damage were observed. A flight conducted in the Headwaters Forest District classified more than 3,600 ha of moderately affected lodgepole pine of all age classes and over 300 ha of severe damage (primarily younger age classes).

Damage in mature stands is more difficult to quantify, as infection tends to occur in small dispersed patches, particularly along river drainages. Approximately 1,000 ha of this type of scattered damage were noted along the Babine River corridor in the Skeena Stikine Forest District.

No surveys were conducted elsewhere, but a needle disease (suspected *Dothistroma*

needle blight) was noted in ponderosa pine plantations on Texada Island and in localized patches throughout the Arrow Boundary, Kootenay Lake and lower elevations of the Rocky Mountain Forest Districts.

Underplanting of severely affected stands in the NIFR occurred in 2002 and 2003. However, high mortality of the seedlings due to snowshoe hare browsing curtailed further operational planting.



Damage to lodgepole pine stand caused by Dothistroma needle blight near the Nangeese River

In the spring of 2006, four trial areas were set up to study hare damage to underplanted seedlings in areas where the dead and dying overstory pine had been removed prior to planting. In each area, three one ha plots were treated and three one ha plots were left as controls. A mix of interior

spruce, western hemlock and subalpine fir were planted in both the cleared areas and the areas with dead and dying overstory trees.

Initial monitoring results confirmed that over 90% of browsing damage was due to snowshoe hares. Over twice as many seedlings were browsed in uncleared plots (34%) *vs.* cleared plots (14%), and spruce seedlings were the preferred species, sustaining more damage than the other two species combined.

Abundant summer precipitation provides ideal conditions for *Dothistroma* needle blight infection. In the NIFR, 2005 summer precipitation levels were far above normal in most areas and resulted in the pronounced

increase of foliage damage that was visible in the spring of 2006. This year however was very dry, which may result in reduced damage in 2007.

Pine needle cast, *Lophodermella concolor*

Damage from pine needle cast (*Lophodermella concolor*) remained at low levels in 2006, with only 104 ha recorded in the SIFR. Most of the noted damage was light and occurred in the Okanagan Shuswap Forest District.

Infections caused by pine needle cast were detected during ground surveys in various other parts of the province where lodgepole pine grows. These areas included scattered sites in the Nadina Forest District, and the western portion of the Prince George Forest District. Summer weather was predominantly dry across the province in 2006, which should keep damage due to pine needle cast at low levels in 2007.



"Lion's tail" appearance of branches after the loss of infected needles

Rust diseases of hard pine

Pine stem rusts such as comandra blister rust (*Cronartium comandrae*), stalactiform blister rust (*Cronartium coleosporioides*) and western gall rust (*Endocronartium harknessii*) affect lodgepole pine throughout much of BC. Major infection events occur in 'wave years' where sporulation coincides with suitable weather conditions in the late spring or early summer. These 'wave years' typically occur once every 5-10 years, however, field observations in the SIFR suggest that the rate at which these major infection events occur may be more frequent and that the high-risk period for rust may also extend beyond the commonly quoted

maximum susceptibility age of 15 years for lodgepole pine.

The abundance of alternate host species, terrain and host genetics all affect the frequency and severity of infection. Damage tends to be greatest in younger stands while large amounts of infection can impact such stands both pre and post free growing. Stem infections can lead to serious stem deformities, reduced tree growth and mortality. Significant mortality in 12 - 14 year old pine due to stem rusts in the Nadina and the western half of the Quesnel Forest Districts have resulted in some not sufficiently stocked (NSR) stands. These stands require fill planting to meet stocking standards.



Branch and stem galls caused by western gall rust



Canker caused by stalactiform blister rust

DAMAGING AGENTS OF DOUGLAS-FIR

Western spruce budworm, *Choristoneura occidentalis*

Recorded Defoliation

After a large drop in defoliation by western spruce budworm (*Choristoneura occidentalis*) in 2005, recorded infestations rose to a seven-year high of 776,723 ha affected provincially (Figure 7). Severity also increased, with 459,462 ha (59%) light, 256,178 ha (33%) moderate and 61,267 ha (8%) severe intensity delineated.

Most of the damage (97%) occurred to Douglas-fir stands in the SIFR, where expansion of infestations was recorded in all affected forest districts in

2006 (Figure 8). For the fourth consecutive year, area defoliated was highest in the Central Cariboo Forest District where 246,053 ha of damage were noted. Primarily, infestations occurred west of Williams Lake to the boundary with the Chilcotin Forest District.

Cascades Forest District experienced the largest jump in defoliation from 92,293 ha in 2005 to 240,034 ha in 2006. The main areas of damage were west of Lillooet near Carpenter Lake and south of Merritt near Spius Creek,

Coldwater River, Aspen Grove, Tulameen, Allison Creek and Princeton. Generally, defoliation in the Douglas-fir stands is moving to higher elevations than historically reported for this district. Just above the Douglas-fir infestations, defoliation in sub-alpine fir stands along the Coquihalla highway (first reported in 2005) continued to intensify this year.

Infestations in 100 Mile House Forest District resulted in 128,373 ha of damage, up slightly from last year but still almost half of what was recorded in 2004. Areas of significant defoliation were mostly located south of 70 Mile House to the southern boundary with Kamloops Forest District.

Kamloops and Chilcotin Forest Districts sustained similar levels of defoliation, at 71,600 ha and 58,997 ha affected, respectively. However, infestations have been active in Chilcotin Forest District stands over the previous two years whereas Kamloops defoliation has jumped significantly just this year. This was reflected in severity of defoliation in 2006, which was recorded as 23% light, 27% moderate and 50%

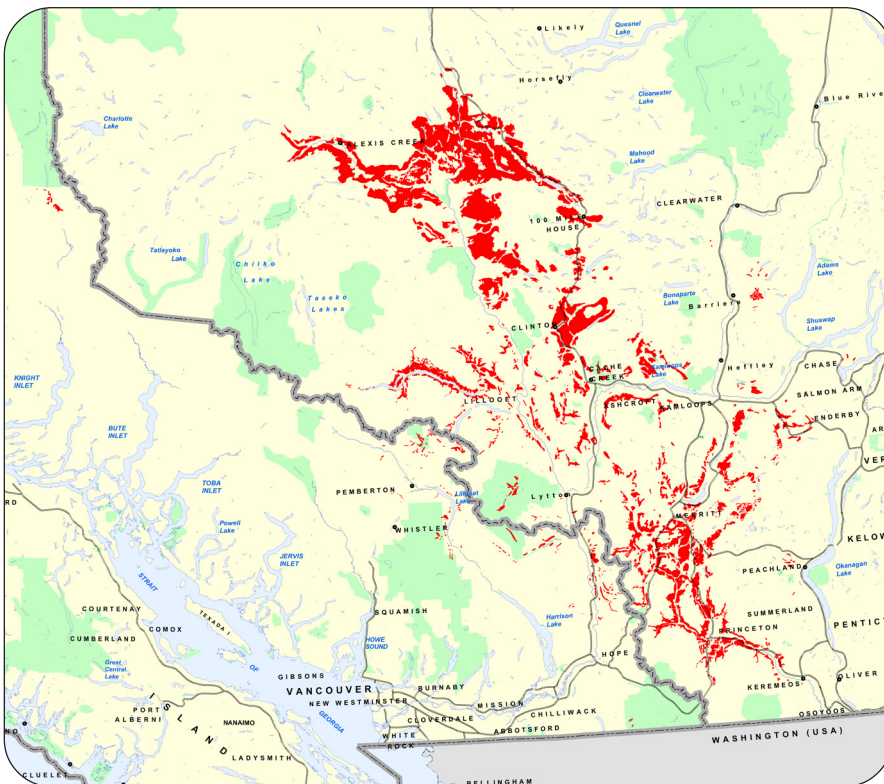


Figure 7. Areas defoliated by western spruce budworm in BC in 2006.

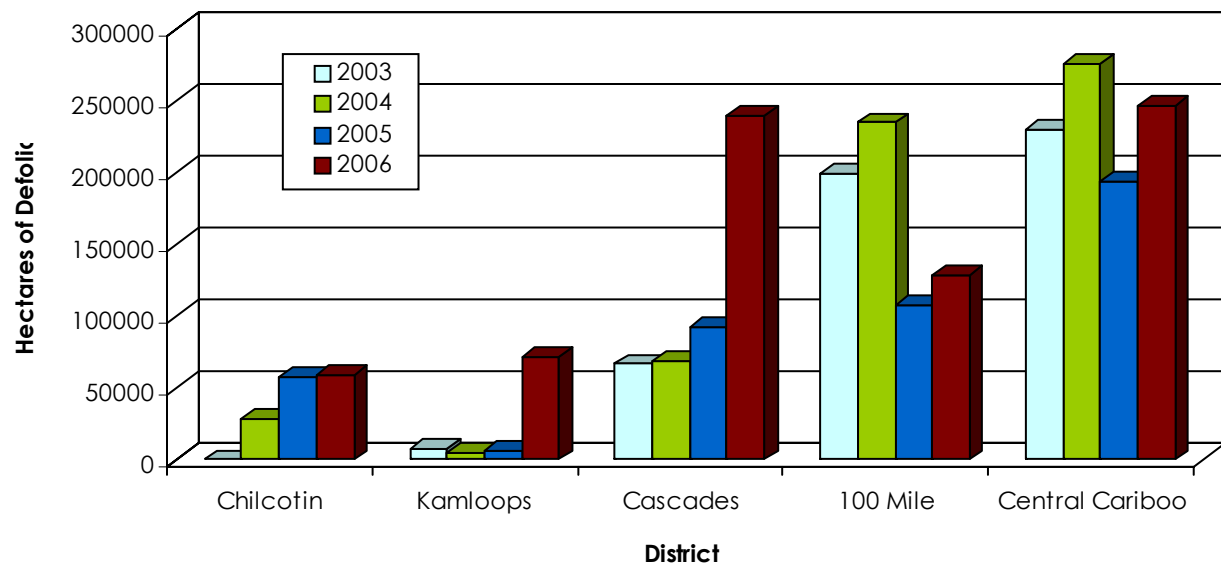


Figure 8. Hectares of western spruce budworm defoliation from 2003 – 2006, for districts with over 50,000 ha damaged in 2006.

severe in the Chilcotin Forest District *vs.* 60% light and 40% moderate in the Kamloops Forest District. Kamloops Forest District damage occurred primarily from Kamloops to just west of Cache Creek, though defoliation was also observed as far north as Barriere River. Chilcotin Forest District defoliation was mapped throughout the Douglas-fir types in this district, which occur from the eastern district boundary almost to Puntzi Lake in the west.

The only other defoliation by western spruce budworm in the SIFR was reported in the Okanagan Shuswap Forest District at 10,859 ha. Damage was recorded around Peachland Creek, the Similkameen River and northwest of Vernon.

The outbreak in the CFR peaked at 16,203 ha of damage in 2003, and then dropped for two consecutive years. A resurgence of infestations occurred in 2006 however, with a total of 20,991 ha of defoliation. Damage intensity also increased; with 26% in the moderate category *vs.* 16% in 2005 (remaining defoliation was coded as light). Chilliwack and Squamish Forest Districts contained the majority of the attack, with 10,925 ha and 7,832 ha affected, respectively. The main infestations were mapped in the Fraser Canyon near Boston Bar and just north of Whistler. Defoliation occurred at higher elevations than in the past few years, and showed distinct elevational banding. For the first time, 2,233 ha of primarily light defoliation were recorded in

the North Island – Central Coast Forest District, south of Tweedsmuir Park in the Knot Creek area.

Treatment Program

Based on the results of the summer 2005 aerial overview surveys, fall egg mass surveys (used to predicted defoliation the following spring) and various stand criteria, direct control with the biological agent *Bacillus thuringiensis* var. *kurstaki* (*Btk*) was undertaken. One application of the *Btk* product Foray 48B® was applied at a rate of 2.4 l/ha. The program occurred in three forest districts in the SIFR from mid to the end of June in 2006, encompassing 43,982 ha. This was the largest *Btk* treatment program ever undertaken in the province.



AT 802 Air Tractors loading operations at Williams Lake airport

Six areas totalling 21,558 ha were treated in the Chilcotin Forest District around Alexis Creek, Hanceville and Kloh Lake. An additional 5,924 ha were sprayed in bordering areas in the Central Cariboo Forest District near Bald Mountain and Gaspard Creek. This portion of the program was conducted with two fixed wing AT 802 Air Tractors utilizing a fixed boom system with 32 - 8006E T-Jet nozzles operating at 32 psi.

In the Cascades Forest District, 16,500 ha received treatment in sixteen areas located between Merritt and Tulameen. One Lama AS315B helicopter equipped with a Simplex spray system utilizing four Micronare® AU 4000 rotary nozzles and one Hiller helicopter outfitted with a Western Aerial spray

system with four Beecomist® rotary nozzles carried out this portion of the program.

The fixed wing aircraft were most efficient on the larger Cariboo blocks, while the helicopters were best suited to the smaller Okanagan sites. Pre and post spray larval sampling conducted during the first years of *Btk* use in BC demonstrated the effectiveness of this treatment in reducing western spruce budworm populations. Pre and post egg mass sampling, though not a direct indicator of treatment success, continued to suggest population reductions were realized in the 2006 treatment blocks.

Egg Mass Results

Egg mass surveys were conducted in the fall of 2006 to predict 2007 defoliation in

specific areas. A total of 307 sites were surveyed across seven forest districts (Table 6). Central Cariboo Forest District had thirteen sites with severe defoliation expected. Areas of concern due to predicted severity and multiple years of defoliation were between Gaspard Creek and Farwell Canyon, Riske Creek north through Meldrum Creek and Till Lake north to Buckskin Lake.

Fewer sites were surveyed in the Chilcotin Forest District as Douglas-fir is not a widespread tree species in this district. However, at all but one site moderate to severe defoliation is expected, as depicted by the highest number of average egg masses per 10m² of foliage of all the districts. Primary areas of concern are around Haines Lake, Bull Canyon, Hanceville, west Chilcotin and west Chilko east of Redstone.



Western spruce budworm larva

Table 6. Summary of 2006 western spruce budworm egg mass survey results.

Forest District	Number of Sites by Defoliation Category				Total Sites	Ave. # egg masses/10m ² foliage
	Nil	Light	Moderate	Severe		
100 Mile House	6	57	24	8	95	58.9
Cascades	8	50	11	0	69	25.0
Central Cariboo	10	34	13	13	70	64.1
Chilcotin	0	1	9	8	18	152.7
Chilliwack	2	4	0	0	6	10.1
Kamloops	1	13	19	1	34	59.3
Okanagan Shuswap	1	13	0	0	14	21.0
Squamish	0	1	0	0	1	19.71

100 Mile House Forest District egg mass results indicated numerous moderate to severe defoliation sites, in particular south of 70 Mile House, north and south of Clinton, and north of Loon Lake.

Many of the Kamloops Forest District sites predict significant defoliation, primarily around Hat Creek, Cache Creek, Barnes Creek, Sabiston Creek, Criss Creek, Tranquille River, Monte Creek and the Walhachin area. The moderate defoliation sites predicted for the Cascade Forest District were in the Lillooet TSA near Yalakom River, Pavilion Lake, Lilly Lake, Maka Creek and Iron Mountain. Most of these sites were widely scattered between light sites, unlike

many of the Kamloops sites that were consistently predicting moderate damage across a given geographic area.

Predictions at Chilliwack, Okanagan Shuswap and Squamish Forest District sites were for nil to light damage. However, due to very poor access to the defoliated areas in the Chilliwack Forest District (in the canyon near Boston Bar), samples were not ideally positioned. For the samples in the Okanagan Shuswap Forest District near Monte Creek, sites in the Kamloops Forest District just over the boundary were consistently moderate, and may indicate defoliation moving into this area.



Douglas-fir severely defoliated by western spruce budworm larvae

Douglas-fir beetle, *Dendroctonus pseudotsugae*

Douglas-fir beetle (*Dendroctonus pseudotsugae*) disturbances rose provincially for the fourth year in a row to 60,709 ha affected, which was up 42% over last year. Intensity of mortality was primarily low at 34,160 ha (56%) trace, 20,790 ha (34%) light, 3,750 ha (6%) moderate and 2,009 ha (3%) severe to very severe.

Most of the recorded attack (87%) continued to occur in the Cariboo area of the SIFR. In the spring of 2006, overwintering brood assessments were conducted in three of the four Cariboo districts (Quesnel was excluded). The resulting R values indicated an increasing population (Table 7). This was further confirmed by the average G:R ratios obtained from fall surveys. Many of the current attack areas surveyed this fall were small scattered patches, but some were unusually large for Douglas-

fir beetle infestations: in one area over 700 trees were killed. A large trap tree program combined with salvage logging is presently underway. Many trap tree sites have experienced considerable overflow into the surrounding stands.

Central Cariboo Forest District continued to report the majority of attack with 40,087 ha affected, which was almost double that of last year. This was reflected in the detailed helicopter survey results as well, where 6,000 infestations were recorded, up from 2,650 sites in 2005. Areas of concern were northwest of Williams Lake past the military reserve, along the Fraser River corridor and in the Gaspard Creek area.

Infestations in the Quesnel Forest District rose sharply in 2006 to 6,077 ha *vs.* less than one ha in 2005. It is suspected that Douglas-fir beetle

mortality was just easier to identify in this district this year as much of the mountain pine beetle attack was turning grey. Most of the recorded attack was located in woodlots along the Fraser River, where the majority of the Douglas-fir in the district grows.

100 Mile House Forest District experienced a 35% rise in 2005 attack levels to 4,120 ha affected. Mortality was



Mortality caused by Douglas-fir beetle

recorded throughout the district, in particular at Timothy Lake, Wilcox Lake, Canim Lake, Bowers, Deka,

Table 7. Douglas-fir beetle population survey results for 2006 in three Cariboo districts.

Forest District	Overwintering Brood Assessment Results		Fall Survey Results
	% Winter Mortality	R Value	Average G:R Ratio
100 Mile House	57.9	3.34	2.6:1
Central Cariboo	54.8	4.58	3.3:1
Chilcotin	45.6	4.46	6.9:1

Lac Des Roche, Young Lake, Jeep Lake, Kelly Lake and Canoe Creek.

Recorded infestations fluctuated greatly in the Chilcotin Forest District over the past two years, rising from 3,069 ha in 2004 to 13,234 ha in 2005 and back down to 2,656 ha in 2006. Attack was primarily

mapped along the Chilcotin River valley from the eastern district boundary to Puntzi in the west. An aggressive trap tree program (4,500 trees) is underway.

A project was undertaken in the Cariboo this year to test the effectiveness of Methylcyclohexenone (MCH) anti-aggregation pheromones in dispersing small populations of Douglas-fir beetle. Overall, the results were very promising (Project 8 pg. 51).

Rocky Mountain Forest District sustained 1,095 ha of Douglas-fir beetle mortality, with the Galton Range being the main area of concern. Most infestations were localized and tended to occur

in conjunction with root disease. The southwestern portion of the Arrow-Boundary Forest District contained mostly spot infestations on south facing slopes, totalling 669 ha. Small infestations were scattered throughout the remaining SIFR, with less than 500 ha recorded for each district.



Douglas-fir beetle infestation

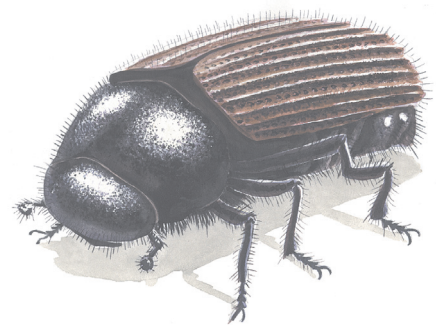
For the NIFR, 3,191 ha of primarily light intensity attack was noted in the Prince George Forest District though only 1 ha was mapped last year. The majority of the damage was located in the southern portion of the district, along the Alexander Heritage trail to the western border. This follows the pattern in Quesnel Forest District of Douglas-fir beetle mortality being previously masked by the mountain pine beetle attack. Small

infestations have also been reported in the Fort St. James Forest District, but these were not picked up during the over-view survey.

In the CFR, 78% (1,093 ha) of the recorded Douglas-fir beetle mortality occurred in the Chilliwack Forest District, which was approximately the

same level as the past several years. The worst infestations were in the Fraser Canyon and a few locations in the Fraser Valley. Most of the remaining attack (266 ha) was located in the Squamish Forest District. Defoliation in this region followed specific

elevational gradients unlike the damage recorded in the SIFR.



Douglas-fir beetle

Douglas-fir tussock moth, *Orgyia pseudotsugata*

Douglas-fir tussock moth (*Orgyia pseudotsugata*) populations were monitored with pheromone trapping sites in high hazard areas of the Cascades, Kamloops, Okanagan Shuswap and 100 Mile House Forest Districts. Over the past eight years trap catches have fluctuated considerably within the monitored forest districts (Table 8). However, average catches have not reached the level where an outbreak is likely (25 moths/trap for 2-3 years). Variations within districts have been greater, which reflects the localized nature of many Douglas-fir tussock moth outbreaks.

Trap catches in the Kamloops Forest District were the highest in the province for 2006. A site at Six Mile has exceeded threshold levels for two years in a row, and one at Barnes Lake increased substantially in 2006 to an average of 52 moths per trap (six trap cluster). Several blue spruce scattered around the City of Kamloops were severely defoliated by Douglas-fir tussock moth this year.

Moth numbers in the Okanagan Shuswap, Cascades and 100 Mile House Forest District decreased in 2006, with no sites over 25 moths

per trap. The very low trap catches in the 100 Mile House Forest District the past two years may have been partially due to high levels of gnats that saturated many traps.

No Douglas-fir tussock moth defoliation was observed in BC during the 2006 aerial overview surveys.

Table 8. Average number of Douglas-fir tussock male moths caught per trap, 1999 – 2006.

Year	District			
	Kamloops (90 traps)	Okanagan Shuswap (135 traps)	Cascades (57 traps)	100 Mile House (144 traps)
1999	4.8	14.6	14.0	5.9
2000	3.6	10.8	12.0	0.8
2001	8.4	7.0	10.1	1.0
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



Douglas-fir tussock moth larva defoliating a blue spruce in Kamloops

Swiss needle cast, *Phaeocryptopus* *gaeumannii*

Swiss needle cast is caused by the fungus (*Phaeocryptopus gaeumannii*) which parasitizes needles of all ages of Douglas-fir. Infection produces variable symptoms that can result in a mildly chlorotic to brown crown colour. Damage can resemble some symptoms of root disease or *Rhabdocline* needle cast. Most diagnostic of Swiss needle cast are the tiny black fruiting bodies, which appear as two parallel “sooty” bands on the undersides of infected needles. Needles are infected in the spring during periods of rainfall: primarily new foliage is infected but one-year-old needles can also be infected. Affected needles are killed and shed at varying times. Heavy needle loss may lead to overall growth loss.

Douglas-fir along the Washington and Oregon coastline have been heavily infected in recent years. In BC, Swiss needle cast was reported throughout the range of Douglas-fir in the Prince George Forest District in 2006. Douglas-fir populations show significant variation in resistance and tolerance to infection.

DAMAGING AGENTS OF SPRUCE

Spruce beetle, *Dendroctonus rufipennis*

Spruce beetle (*Dendroctonus rufipennis*) infested 83,660 ha across BC in 2006. Recorded mortality was up 50% over last year, but was still well below the peak of 315,953 ha noted in 2003. Intensity of attack was lower than in 2005, with 48,547 ha (58%) trace, 23,154 ha (28%) light, 10,919 ha (13%) moderate and 1,040 ha (1%) severe to very severe.

The majority of the damage (88%) occurred in three Cariboo area forest districts (Figure 9). Infestations were highest in the Central Cariboo and Quesnel Forest Districts, where 29,765 ha and 28,483 ha were affected, respectively. For both of these districts, the two-year life cycle of the

spruce beetle seems to be expressed in the pronounced dip in damage levels in 2005, followed by a resurgence in 2006. Sanitation harvesting of infested wood is underway, particularly on TFL 52 in Quesnel Forest District. Most of the attack in the Central Cariboo Forest District was located in the southeast corner. Overwinter mortality sampling results indicated a growing spruce beetle population in the Central Cariboo Forest District with only 29.4% mortality and an average 10.8 R value. Similarly, samples showed 34% mortality and an R value of 7.3 for the Quesnel Forest District.

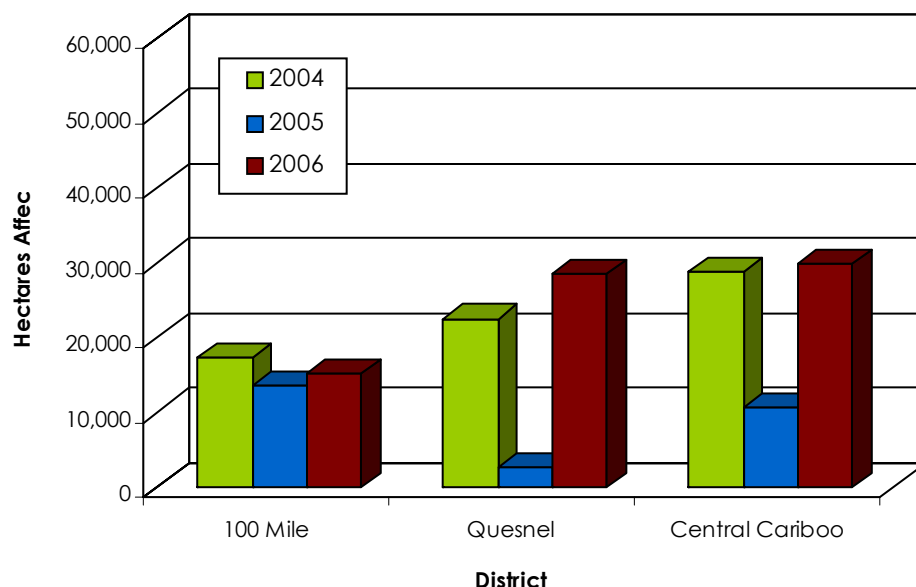


Figure 9. Hectares affected by spruce beetle in BC from 2004 – 2006, for districts with over 15,000 ha of damage in 2006.

Area attacked remained relatively stable in 100 Mile House Forest District with 15,279 ha affected in 2006. Infestations were in the same general eastern geographic locations as noted in 2004 and 2005. Intensity levels were greatly reduced compared to the past two years however, indicating a declining population.

Cascades Forest District experienced a slight increase in spruce beetle mortality to 3,551 ha of damage in 2006. The majority of the infestations were west of Lillooet near Carpenter Lake, Lost Valley Creek and Downton Creek. Most of the remaining attack occurred in the Kamloops, Headwaters and Okanagan Shuswap Forest Districts with 1,955 ha, 1,302 ha and 1,020 ha affected, respectively. The largest concentrated area of attack in the Kamloops Forest District was located at Sun Peaks. Most of the damage in the Okanagan Shuswap Forest District was mapped in Cathedral Park. Infestations recorded in the Headwaters Forest District dropped to an eighth of that noted last year (when ground checked, most of the 2005 infestations were found to be mountain pine beetle attack on lodgepole pine).

Other infestations mapped across the province were small and scattered. This indicated endemic beetle populations. Ground surveys however revealed a rise in spruce beetle mortality in the southern part of the Prince George Forest District, in particular on the Dunkley TFL near Hixon. Vanderhoof and Fort St. James Forest Districts also reported that spruce beetle populations are on the increase. The large area of blowdown that occurred in 2004 in the Nadina Forest District was expected to result in building spruce beetle populations, but to date this has not been observed.

Green spruce aphid, *Elatobium abietinum*

Green spruce aphid (*Elatobium abietinum*) is a defoliator of spruce that occasionally causes extensive damage in the Queen Charlotte Islands Forest District. In 2006, 195 ha of light defoliation were recorded at a number of bays on the west side of south Moresby Island. This was the first observed occurrence of green spruce aphid damage in BC since the late 1990's.



Spruce beetle infestation east of 100 Mile House

DAMAGING AGENTS OF TRUE FIR

Western balsam bark beetle, *Dryocoetes confusus*

Area affected by western balsam bark beetle (*Dryocoetes confusus*) was down slightly to 1.2 million hectares provincially in 2006, compared to 1.4 million hectares in 2005. Intensity of attack was up somewhat, with 820,564 ha (64%) trace, 349,735 ha (29%) light 22,321 ha (2%) moderate and 1,547 ha severe to very severe (<1%) levels recorded.

Biogeoclimatic zones where sub-alpine fir grows are most abundant in the NIFR, hence the majority of western balsam bark beetle mortality occurs in the northerly districts (Figure 10). Mackenzie Forest District continued to sustain the highest damage with 367,242 ha affected, down from 451,792 ha last

year. For the past four years Fort St. James Forest District had the 2nd highest levels of attack. In 2006, recorded mortality dropped by more than half to 169,171 ha. However, intensity increased with light mortality rising from 7% last year to 25%, with a corresponding drop in the trace category. This would suggest that surveyors defined more precise areas of attack. Local forest health staff indicated that western balsam bark beetle attack is on the increase in the central and northern portions of the district. In the Skeena Stikine Forest District infestations dropped from 183,689 ha affected in 2005 to 84,350 ha in 2006. In contrast, area of attack has been slowly but steadily rising in the Prince

George Forest District, where a modest 14% increase was reported over last year, with 107,031 ha infected. The Peace Forest District experienced a slight drop to 85,756 ha, whereas Nadina Forest District infections sharply decreased almost three-fold to 41,181 ha. Levels of attack remained relatively low in the Fort Nelson and Kalum Forest Districts, at 28,073 ha and 16,236 ha respectively.

In the SIFR, Okanagan Shuswap Forest District experienced both the largest increase and the highest amount of western balsam bark beetle attack at 93,193 ha affected, an increase of 21% over 2005. Conversely, infestations in the Headwaters Forest District dropped to

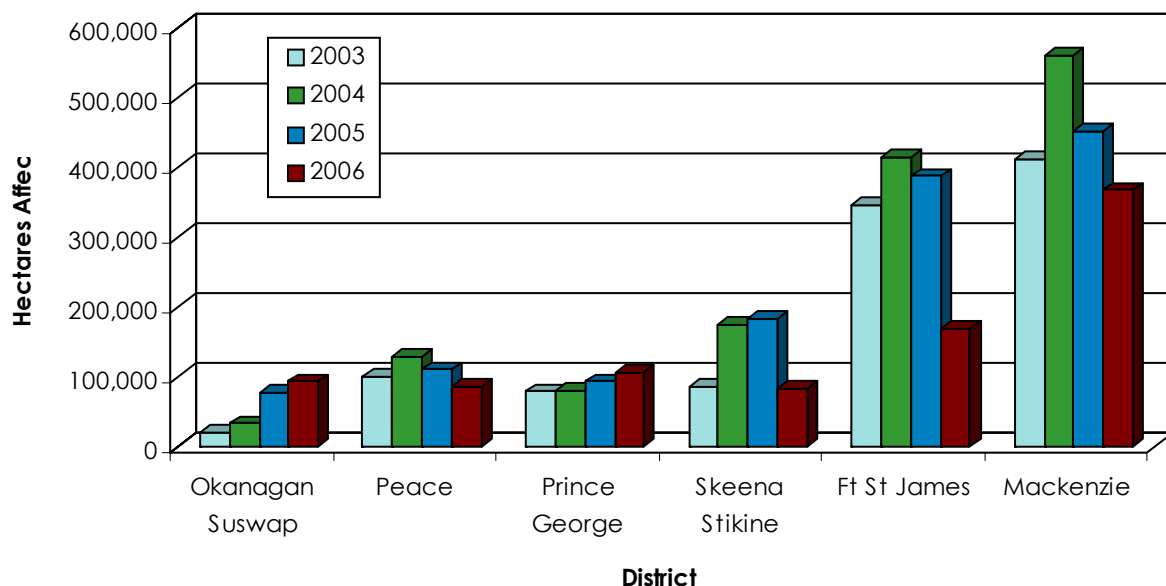


Figure 10. Hectares affected by spruce beetle in BC from 2004 – 2005, for districts with over 15,000 ha of damage in 2006.

50,589 ha from 96,175 ha noted last year. Area affected also decreased to 40,650 ha in the Quesnel Forest District. Attack in the Central Cariboo Forest District remained relatively stable at 29,000 ha. Chilcotin and 100 Mile House Forest District sustained similar levels of mortality, with 12,947 ha and 12,488 ha infested, respectively. The only other attack noted in the SIFR was 5,405 ha in the Rocky Mountain Forest District and 4,990 ha in the Kootenay Forest District.

The North Island – Central Coast Forest District continued to have the highest levels of attack in the CFR, though area affected dropped for the 2nd year in a row to 7,949 ha. Infestations in the Chilliwack Forest District almost doubled, to 3,261 ha of damage.



Western Balsam bark beetle
mortality

Eastern spruce budworm, *Choristoneura fumiferana*

The primary forest health concern in northeast BC for many years was defoliation by the eastern spruce budworm (*Choristoneura fumiferana*). The outbreak peaked in 2001 with 1.6 million hectares of recorded damage. In 2004, area affected dropped off sharply and only endemic levels were recorded in 2005. No current defoliation was noted during the 2006 overview surveys.

To predict expected defoliation levels for the coming year, overwintering early instar larvae sampling is conducted annually in the Fort Nelson Forest District. Larval densities have reflected the decreasing budworm population, with densities decreasing until no larvae were found in 2004 and 2005. Due to administrative difficulties, sampling was deferred this fall. Based on past history, visible defoliation levels and results from larval density sampling in chronic areas of defoliation in neighbouring stands in AB, negligible defoliation is expected for 2007.

Two-year-cycle budworm, *Choristoneura biennis*

The majority (94%) of the two-year-cycle budworm (*Choristoneura biennis*) defoliation was detected in the SIFR in 2006, with 63,490 ha affected. In 2005, only 1,998 ha were mapped. This corresponds to the even year cycle that the budworm is on south from the Prince George Forest District. Despite the large increase in hectares affected, 97% of the recorded defoliation was light, with the remaining damage noted as moderate.

Defoliation was most prevalent in the Quesnel Forest District, where 34,851 ha of damage were delineated, primarily northwest of Barkerville in the Willow River area and west to Cottonwood House. Central Cariboo Forest District sustained 14,166 ha of damage east of Quesnel Lake in the Niagara River and Penfold River areas. Two-year-cycle budworm feeding in the northern portion of the Headwaters Forest District affected 10,479 ha, while 100 Mile House contained the majority of the remaining attack on 3,667 ha around Hendricks Lake.

Larval feeding was in the off year for the majority of the NIFR, though 4,164 ha of light defoliation were recorded northeast of Smithers. Last

year only 5,457 ha were noted in the NIFR in the Fort St. James Forest District from the overview survey, but conditions were poor for aerial detection and ground surveys estimated that infested hectares were five times that aeri-ally mapped.

Permanent sample plots have been established by the CFS with the support of the MoFR to determine the impacts of the two-year-cycle budworm. Plots were placed in the Fort St. James and Mackenzie Forest Districts in 1999, and in the Prince George and Headwaters Forest Districts in 2000. A subset of these plots (17 in Fort St James, 4 in Mackenzie, 4 in Prince George and 6 in Headwaters Forest Districts) have

been assessed every year since with the exception of 2005. A slow decline in average defoliation since 2001 was noted, but active feeding still continued.

Plots in the Fort St. James and Mackenzie Forest Districts were located in the SBSmk, SBSwk and ESSFmv biogeoclimatic subzones. Defoliation levels and top kill were higher on subalpine fir than spruce hosts in these stands. Since 2001, defoliation has been consistently higher on both hosts in the SBSwk and ESSFmv, as compared to the SBSmk. For top kill, the SBSwk had the highest levels, followed by the ESSFmv and lastly the SBSmk. Interestingly, cumulative mortality is

highest in the SBSmk (16% subalpine fir and 18% spruce), and lowest in the ESSFmv (10% subalpine fir and <1% spruce).

The budworm impact plots established in the Prince George and Headwaters Forest Districts were placed in the ESSFwk and ESSFmm biogeoclimatic subzones. Recent sampling showed that all plots had higher levels of defoliation on subalpine fir than spruce. Since 2003, defoliation has been substantially lower in the ESSFwk than in the ESSFmm. Overall, cumulative mortality was higher for subalpine fir than for spruce at 13% *vs.* 2% in the ESSFmm and 14% *vs.* 4% in the ESSFwk.



Two-year-cycle budworm defoliation of young sub-alpine fir

DAMAGING AGENTS OF HEMLOCK

Western hemlock looper, *Lambdina fiscellaria lugubrosa*

Western hemlock looper (*Lambdina fiscellario lugubrosa*) populations appear to be at endemic levels across BC following outbreaks in the CFR and SIFR that peaked in 2002 and 2003, respectively. A total of 1,554 ha of defoliation were reported in 2006, with 98% of that recorded at light intensity.

Noted damage was specific to three areas. In the northwest corner of the Headwaters Forest District, 683 ha of attack were delineated. The area was not accessible to ground surveys, so the damaging agent could not be confirmed. Local forest health staff suspect it may even be red flagging on cedar. The Okanagan Shuswap Forest District had two small infestations totalling 318 ha around Queest Mountain northeast of Sicamous and in Ratchford

Creek. In the Kalum Forest District 553 ha of defoliation was recorded, primarily around Kalum Lake with a small infestation on the Khyx River east of Prince Rupert. Again, ground confirmation was not possible due to inaccessibility.

Western hemlock looper populations have been monitored in the SIFR for several years in chronic areas (Table 9). The number of male moths caught in the pheromone traps in 2006 continued to reflect an endemic population, after the peak of 2003.

In the CFR, approximately 50,000 m³ of trees killed during the outbreak were harvested. An equal amount could not be salvaged however, due to significant wood deterioration and non-economic feasibility.

Western blackheaded budworm, *Acleris gloverana*

Western blackheaded budworm (*Acleris gloverana*) larvae feed preferentially on western hemlock and true firs, but occasionally damage spruce and Douglas-fir. Damage recorded this year in the SIFR was almost entirely on western hemlock, totaling 1,306 ha. Severity was primarily categorized as light (85%) with the remaining stands noted as moderate.

Kootenay Lake Forest District sustained the majority of the defoliation, with 1,167 ha affected. Infestations were at Kid, Leadville, Grohman and Kokanee Creeks, plus a small site near Creston (the only area to have sub-alpine fir damaged as well). A small patch of 129 ha was recorded in Valhalla Provincial Park in Arrow Boundary Forest District, and the remaining 10 ha were noted in the Rocky Mountain Forest District in the east Middle-White drainage.

Table 9. Average number of western hemlock looper male moths caught per trap at various MoFR sites (6-trap clusters per site), 2002 - 2006.

Forest District (# sites)	Year				
	2002	2003	2004	2005	2006
Headwaters (5)	307.4	79.2	7.5	9.2	5.0
Okanagan Shuswap (11)	627.4	878.9	45.3	8.0	3.7
Columbia (11)	No traps	No traps	4.8	1.2	4.1

DAMAGING AGENTS OF LARCH

Larch needle blight, *Hypodermella laricis*

Damage due to larch needle blight (*Hypodermella laricis*) was recorded over 68,228 ha in the SIFR in 2006. Defoliation was significant, with 8% recorded as light, 24% moderate and 68% severe. Larch needle blight infections were last recorded in 2003 (32,478 ha) and were primarily confined to valley bottoms whereas this year damage was observed in most areas where larch stands are predominant. Western larch is the most prevalent larch species in the SIFR, which was reflected in the high proportion (92%) of the damage occurring on this species. The remaining

defoliation occurred on alpine larch.

Rocky Mountain Forest District sustained the most damage, with 26,932 ha affected. Defoliation was widespread, but heaviest in the St. Mary and Moyie drainages. Kootenay Forest District had 21,249 ha of damage, primarily in the southern third of the district. Defoliation in the Arrow Boundary Forest District totalled 18,786 ha and was worst in the Kettle and Conkle Lake areas. Several stands (1,142 ha) in the southwest corner of Okanagan Shuswap

Forest District were damaged, and the Columbia Forest District sustained 119 ha of defoliation.

Damage due to larch needle diseases has fluctuated widely over the past few years, with just 703 ha of light larch needle cast (*Meria laricis*) damage noted last year. Both needle diseases often occur together. Prolonged periods of rain in the spring (as in 2005) are ideal for infection, and the results become apparent the next year. With the dry spring of 2006, damage should be substantially reduced in 2007.



Severe defoliation due to larch needle blight infection

DAMAGING AGENTS OF CEDAR

Yellow-cedar decline

Although recognized as a damaging agent of yellow-cedar, the occurrence of yellow-cedar decline was not extensively investigated in BC until recently. In 2004, the first wide-scale assessment for yellow-cedar decline was conducted in the North Coast Forest District. It found that the decline, prevalent in Alaska for many decades, was indeed present over significant areas of the north coast from the Portland Inlet south as far as Banks Island (approximately 53° 30' N and the limit of the survey). This assessment was reported in the 2004 summary and the

surveyed areas can be seen in the northern portion of the map shown in Figure 11. Since this was primarily a reconnaissance, no exact tally of affected area was attempted at that time.

This year a more extensive survey was attempted with the objective of locating a southern limit to the extent of the decline. Four days were spent flying during July and August covering the coast from Powell River up to Bella Coola. While poor weather conditions did hamper portions of the flights it was established that noticeable areas of yellow-cedar

decline do occur from roughly Burke Channel south to Kingcome Inlet (approximately 51° N) although the distribution tended to become sparser the further south you go (Figure 11). No evidence of decline was noticed south of Knight Inlet. While priority was not placed on quantifying the area affected, over 4,000 ha of decline were mapped this year. Additionally, the annual CFS survey of the Queen Charlotte Islands reported decline occurring in several places in Gwaii Haanas National Park Reserve.

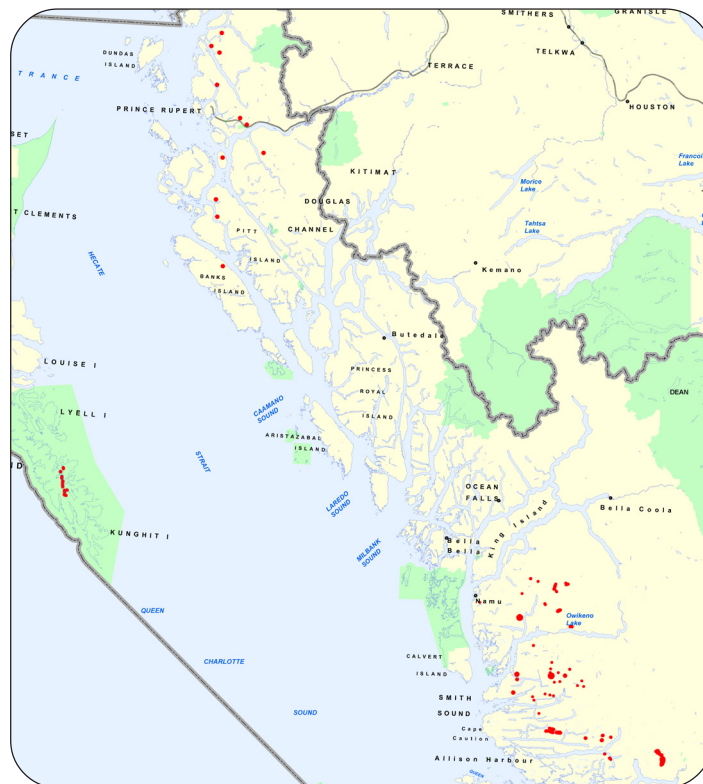


Figure 11. Yellow-Cedar Decline damage recorded in BC in 2006.

Cedar leaf blight, *Didymascella thujina*

For the first time during recent aerial overview surveys, cedar leaf blight damage (*Didymascella thujina*) was visible in the NIFR. Samples were collected from several ground locations and the damaging agent was confirmed. As with many other foliage diseases, high humidity presents ideal conditions for infections. The wet spring and summer of 2005 in the NIFR resulted in damaged foliage becoming visible during the summer of 2006. Western red cedar is the only host for this fungus.

In total, 848 ha of damage were noted over three forest districts. Skeena Stikine and North Coast Forest Districts had 633 ha and 193 ha of primarily light damage. In the Kalum Forest District, 215 ha were recorded as moderately damaged.

DAMAGING AGENTS OF DECIDUOUS TREES

Large aspen tortrix, *Choristoneura conflictana*

A large aspen tortrix (*Choristoneura conflictana*) outbreak has caused widespread damage to trembling aspen and balsam poplar stands in the NIFR over the past four years. The largest area affected was 794,303 ha in 2003: since then, infestations have steadily declined, with 123,312 ha of damage delineated in 2006. Intensity of attack was higher than last year however, with 28% light, 70% moderate and 2% severe.

Ground surveys noted the distinctive rolled leaves (a result of larval feeding) but actual larvae or pupal cases were extremely rare. This may indicate a downturn in

the large aspen tortrix population.

Defoliation in the Peace Forest District rebounded to 62,324 ha in 2006, after a sharp dip to 22,351 ha affected in 2005. Fort Nelson Forest District sustained the 2nd highest level of damage, with 50,898 ha defoliated, down from 89,360 ha last year. With no damage noted in 2005, infestations in the Skeena Stikine Forest District totalled 7,926 ha this year. Minor levels of defoliation occurred in the Mackenzie, Fort St. James and Nadina Forest Districts at 1,172 ha, 787 ha and 205 ha recorded, respectively.



Aspen defoliation caused by large aspen tortrix larvae

Gypsy moth, *Lymantria dispar*

Gypsy moths attack both natural forests and urban trees, and are a threat to BC's ecology and economy. The presence of moths in a jurisdiction poses a quarantine threat and potential trade restrictions.

The MoFR has taken the lead role in managing infestations of the North American strain of European gypsy moth (*Lymantria dispar*) in BC. They are working together with other provincial ministries, provincial and local health authorities and other levels of government.

Aggressive detection programs and prompt eradication measures employed over the last 27 years (1979 to 2006) have been successful. There have been no established infestations in BC since the moths were first discovered in 1978.

In response to 135 male moths caught in pheromone traps in 2005, treatment programs were undertaken in 2006. Ground spraying with *Btk* was conducted in Saanich, Nanaimo and on Salt Spring Island. Three treatments per area were applied in the spring when weather and

insect development were optimal. Two different *Btk* formulations were used: Dipel 2XDF on Salt Spring Island and Foray 48B in Saanich and Nanaimo.

High density mass trapping was utilized in the summer for the Salt Spring Island and Nanaimo treatment areas, as well as at Duncan, Gabriola Island, Saanich, Sidney and Langley. Mass trapping efforts on Gabriola Island and in Duncan showed very promising results. Moths were not trapped at either of these sites in 2006 following dramatic reductions in catches from

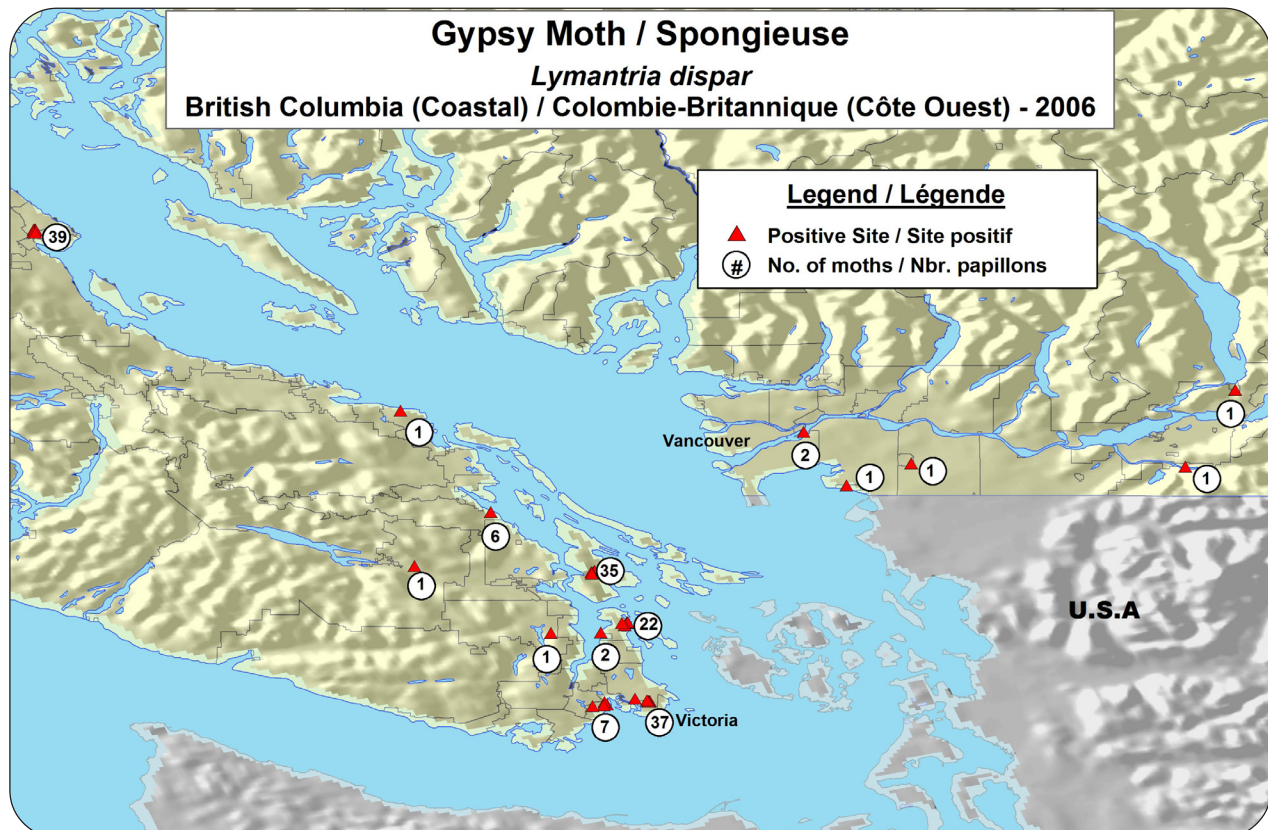


Figure 12. Gypsy moth trap locations with positive catches in 2006.

2004 to 2005. The mass trapping grid in Sidney resulted in the recovery of a non-viable egg mass.

At monitoring pheromone trap sites, 153 male moths were caught in the summer of 2006. Grand Forks was the only interior location with a positive trap catch of 1, while 5 were caught in the Lower Mainland, 35 on Salt Spring Island and 112 on Southern Vancouver Island (Figure 12). Egg mass searches resulted in the discovery of viable egg masses in Saanich (4) and Belmont Park (1).

Treatment with *Btk* is planned by air for the Courtenay area, and by ground at three additional sites (Saanich, Salt Spring Island and Belmont Park) in 2007. Other locations where male gypsy moths were found in the summer of 2006 will be monitored next summer with sampling grids using various trap densities.

For a more in-depth description of both the current status as well as the historical record of the gypsy moth population monitoring and eradication programs in BC, please visit the MoFR's gypsy moth web site at <http://www.for.gov.bc.ca/hfp/gypsymoth/index.htm>.

Birch leafminer, *Fenusa pusilla*

Area infested by the birch leafminer (*Fenusa pusilla*) in the SIFR increased by 63% over last year to 4,635 ha. Intensity however decreased from primarily moderate to 65% light, 30% moderate and 5% severe.

The majority of the defoliation occurred in the Kamloops Forest District, where 2,128 ha were delineated. Infestations were located near Louis Creek, Fadear Creek and Adams Lake. Defoliation totalled 891 ha in the Arrow Boundary Forest District, with the heaviest infestations occurring in the Kaslo and New Denver areas. Okanagan Shuswap Forest District sustained 825 ha of damage, primarily around Scotch

Creek, Turtle Valley and Outlet Creek. Infestations in the Kootenay Lake Forest District occurred along Kaslo River, Duncan River and Duncan Lake, affecting 587 ha. Minor attack was noted in the Columbia and Rocky Mountain Forest Districts at 179 ha and 24 ha, respectively.

In the southern most areas of the SIFR, damage is often actually a combination of drought stress, old age, birch leafminer and bronze birch borer (*Agrilus anxius*). This complex of forest health factors is referred to as *birch decline*. It has been observed that paper birch is more susceptible to the factors of *birch decline* than water birch.



Birch leafminer damage

Serpentine leaf miner, *Phyllocristis populiella*

Serpentine leaf miner (*Phyllocristis populiella*) damage was recorded on 12,878 ha of aspen in the SIFR this year. Defoliation intensity was relatively evenly split, with 25% light, 36% moderate and 39% severe.

Columbia Forest District sustained the highest defoliation, with 5,669 ha mapped along the bottom of the Highway 1 corridor. Damage in the Arrow Boundary Forest District totalled 4,244 ha and was concentrated around Kalso and New Denver. Kootenay Lake Forest District had 2,006 ha of defoliation along Kaslo River, Duncan River and Duncan Lake. The remaining 958 ha of attack occurred in the Rocky Mountain Forest District.

Serpentine leaf miner damage has also been observed throughout the 100 Mile House Forest District over the past five years and in the southern part of the Central Cariboo Forest District the last two years. Mapping of extensive bark beetle infestations in these districts has precluded delineation of the widespread, scattered serpentine leaf miner damage.

Miscellaneous damaging agents

Satin moth (*Leucoma salicis*) populations appear to be at endemic levels for the second year in a row. In the North Island – Central Coast Forest District 292 ha of primarily light defoliation was recorded. Two infestations were mapped near the mouth of the Franklin River and one up the Klinaklini River affecting cottonwood trees. The only other damage noted in BC was a severe infestation of 6 ha in the Cascades Forest District.

Forest tent caterpillar (*Malacosoma disstria*) defoliated at total of 241 ha in the SIFR in 2006. Severity was categorized at 78% moderate, 15% severe and 7% light. Kootenay Lake Forest District had the largest infestation of 156 ha and Rocky Mountain, Quesnel and Arrow Boundary Forest Districts recorded the remainder at 37 ha, 33 ha and 15 ha, respectively.

Alder sawfly (*Eriocampa ovata*) damage was recorded in the North Island Central Coast Forest District. Light defoliation affected 180 ha at Knight Inlet.

Aspen and poplar leaf and twig blight (casual fungi *Venturia* spp.) damage was prevalent across the NIFR from 2001 to 2004, with a peak of 82,376 ha of damage recorded in 2002. In 2005 and 2006, damage levels were endemic and too low to be

detected during the aerial overview survey. Ground observations found scattered damage this year, primarily between Smithers and Burns Lake. In the aftermath of several years of severe damage, some mature aspen mortality (<1%) in the SBSdk biogeoclimatic zone was noted, which is very unusual.

Poplar and willow borer (*Cryptorhynchus lapathi*) caused heavy damage to willow along the Highway 16 corridor from Smithers to Terrace in the Skeena Stikine and Kalum Forest Districts this year. Mortality caused by these introduced pests has been very high, particularly in stems under 12 cm DBH. Homeowners lost decorative willows, and concern is growing regarding the impact from the loss of willow groves for wildlife cover. Historically, damage has been further west along the Skeena River Drainage, though it is hypothesized that the borer is running out of hosts in that area.



Poplar & willow borer damage

DAMAGING AGENTS OF MULTIPLE HOST SPECIES

Abiotic injury and associated forest health factors

Abiotic injuries generally do not follow the same cycles that biological insects and pathogens do. Therefore, yearly records of damage due to these agents are recorded from aerial flight time to the next annual flight and are not necessarily a reflection of the calendar year.

Wildfire was the predominant abiotic agent in 2006. Severe damage due to wildfires was recorded at 160,801 ha provincially, roughly four times the area mapped in 2005. The majority of the large fires were fuelled by vast expanses of lodgepole pine killed by mountain pine beetle.

Very dry conditions in the NIFR led to an early start to the fire season and 65% of the area burned across BC. A total of 104,811 ha were damaged, with the Peace and Fort Nelson Forest Districts sustaining the majority of the damage at 46,382 ha and 33,230 ha, respectively.

Dry conditions in the SIFR were often tempered during the 2006 fire season with short, intense rainfalls that reduced fire hazards when they reached high levels. The SIFR had 52,805 ha burned, with half (21,785 ha) recorded in the Quesnel Forest District alone.

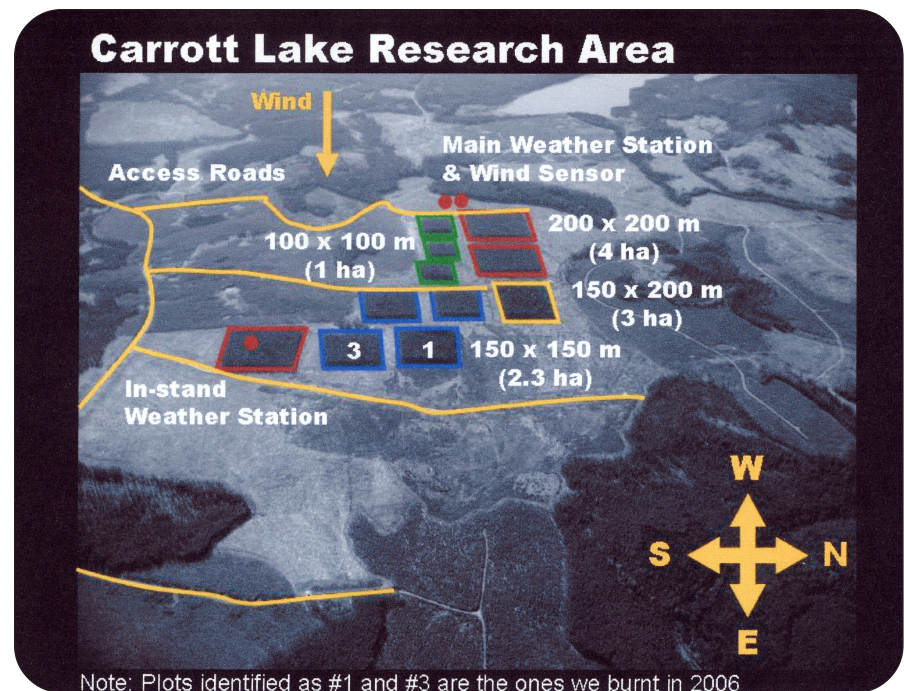
Conditions are traditionally wetter in the CFR, which corresponded to only 3,185 ha of damage in 2006.

Modifications to the fire environment induced by the mountain pine beetle outbreak may be leading to various changes in potential fire behaviour, and associated wildfire threat, in portions of the province affected by the outbreak.

The MoFR Protection Program is currently working on this question. With collaborators and partners (e.g., CFS, Canfor), researchers are using experimental fires to adequately document fire behaviour under a range of

environmental conditions in beetle-affected stands. Eleven plots, protected by fireguards, have been established at Carrott Lake, located southwest of Vanderhoof.

Two plots were burnt in August 2006. The work will continue during the next fire seasons. The fire environment will be documented in each remaining plot which vary in size between 1 and 4 hectares. Experimental fires will be ignited and specialized scientific equipment will be used to monitor fire behaviour. Whenever possible, observations from wildfires and prescribed fires will be used to complement the information collected at Carrott



Carrott Lake Research Area

Lake. Finally, fuel data will be combined with fire weather information and fire behaviour observations to develop supplemental information to the Canadian Fire Behaviour Prediction (FBP) System.

Knowing more about wildfire threat and fire behaviour in beetle-impacted stands will help the MoFR Protection Program respond more effectively and more safely to fires in those areas. This knowledge will also be very valuable in preparedness planning and for fuel management operations in affected portions of the province.

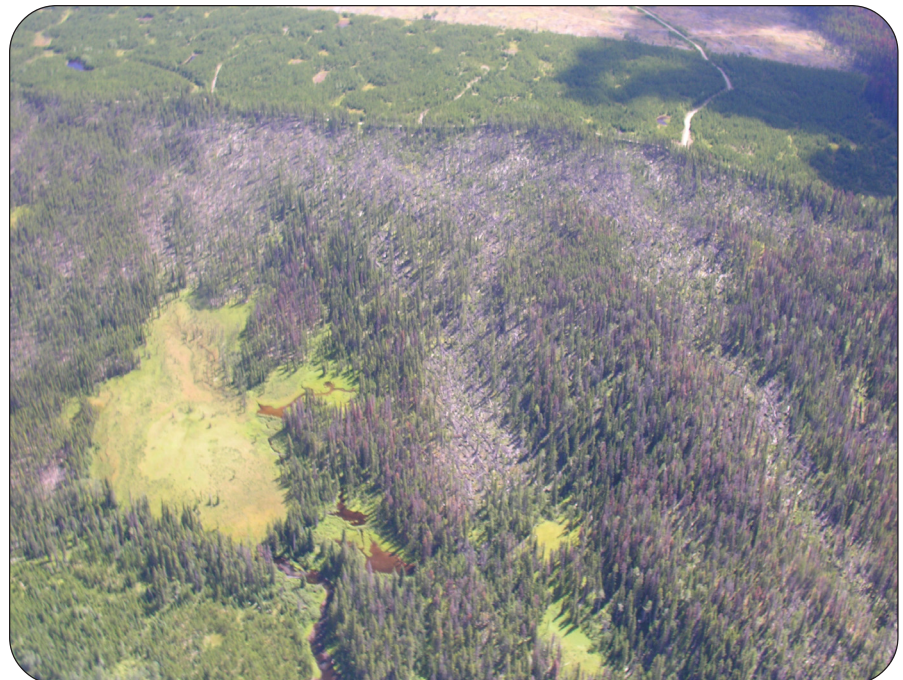
Drought damage is often difficult to detect during aerial overview surveys and therefore tends to be underestimated. In 2006 the effects of drought were most visible in the NIFR due to unusually dry weather in the fall of 2005 onwards. A total of 2,033 ha of severe damage were mapped in the NIFR. Peace and Mackenzie Forest Districts had the highest levels of damage, with 1,237 ha and 494 ha recorded, respectively. Deciduous trees were the most affected and damage was concentrated on edges of fields, highway road cuts, rock outcroppings and the dry eastern foothills of the Rocky Mountains. Small, scattered polygons of damage under 120 ha were also noted in the Fort Nelson, Kalum, Nadina

and Skeena Stikine Forest Districts. The northern portion of the North Coast Forest District in the CFR experienced similar weather patterns that resulted in 1,052 ha of drought damage. In this district, lodgepole pine was affected near Terrace and a mix of hemlock, cedar and deciduous trees were damaged in the north coastal area. Ground observations in the South Island Forest District also noted drought damage in the Qualicum Beach and Port Alberni areas associated with exposed rocky areas.

Visible drought damage in the SIFR was negligible this year, with only 24 ha recorded in the Central Cariboo Forest District. However, the effects of a prolonged drought period that peaked in 2003 were still

being felt in some areas. For example, western pine beetle infestations in ponderosa pine, a product of wildfire and drought damage, continued to expand.

Recorded **windthrow** damage was down almost four fold from 2005 to 4,346 ha affected. Most (93%) of the mapped damage was severe, which is the easiest to detect aerially. Scattered understory windthrow damage is not usually detected during the overview survey. The NIFR sustained 2,759 ha of damage, with 90% of it occurring in the Peace Forest District. The species affected were lodgepole pine and aspen in small areas scattered along the eastern slope of the Rocky Mountains. Windthrow in the SIFR damaged 1,587 ha of



Windthrow damage

primarily conifer stands in small scattered patches throughout eight districts. The largest windthrow site occurred in the Moffat Lake area (bordering Central Cariboo and 100 Mile House Forest Districts) in primarily lodgepole pine.

Flooding caused 1,657 ha of severe intensity mortality in 2006. The majority (1,297 ha) was located in the NIFR, scattered throughout all districts except Vanderhoof Forest District. Minor damage occurred in the CFR and SIFR as well with 199 ha and 161 ha affected, respectively.

Red belt damage decreased substantially in 2006 to only 306 ha affected, after a peak of 26,639 ha last year. Damage occurred in the mountains and foothills of the eastern portions of the Peace and Fort Nelson Forest Districts, in the same general areas where red belt was the most prevalent last year. All recorded damage was of severe intensity.

Slides severely affected 166 ha provincially in small localized areas. Forest Districts with slide damage recorded were the North Island – Central Coast, North Coast, Vanderhoof and Okanagan Shuswap.

Animal damage

Animal damage occurs to a wide range of tree species throughout BC. Some animal populations are very cyclical with corresponding peaks in damage, whereas others are relatively stable, resulting in chronic ongoing tree injuries. Forest health issues caused by animals are usually underestimated in the overview surveys, primarily because most of the damage is not conspicuous enough to be visible aerially.

Several species of **vole** (*Microtus* and *Clethrionomys*) are known to feed on the bark of young coniferous crop trees, often resulting in seedling mortality. In particular, the meadow vole (*Microtus pennsylvanicus*) and long-

tailed vole (*M. longicaudus*) have been documented causing significant feeding damage within young plantations throughout BC's interior. Both of these species of vole prefer the food and cover provided by a well-developed herb and shrub layer typically found within young seral habitats, such as recent clearcuts. Feeding damage generally occurs during the winter when other preferred food sources are limited. Newly planted seedlings appear to be preferred to naturally regenerated seedlings, presumably because of the elevated nutrient levels present within fertilized nursery stock. The red-backed vole (*Clethrionomys gapperi*) may also cause



Vole damage to juniper bush

feeding damage to coniferous seedlings; however, because this vole prefers habitat with some tree cover, damage within clearcut plantations is not likely.

Over the winter of 2005/2006, various species of juniper shrubs (both native and exotic) sustained significant chewing damage on branches. This damage became visible in the spring. Several sightings were also made of similar damage to selected patches of antelope-brush shrubs in the Okanagan. These shrubs are unusual food sources for voles.

Losses due to feeding damage by voles can be significant and cause plantation failures over a wide area. While feeding damage can occur at any time, significant losses generally coincide with periods of high vole numbers. Both the meadow and long-tailed voles undergo population fluctuations that peak every three to four years. This population cycle can be described as a gradual increase occurring over a two or three year period, followed by a population outbreak during the final year of the cycle. The size of the outbreak, and thus potential for causing plantation damage, is difficult to predict and varies from one cycle to the next. Population outbreaks are observed within the preferred young seral

habitat and tend to be synchronous over multiple regions. Recent population outbreaks have been observed within BC's interior during 1998 and 2002. Relatively high densities were observed during 2006 throughout the dry, lower elevations of the SIFR and may indicate the most recent peak. Interestingly, vole numbers crash



Vole damage to antelope brush

during the over-winter period following outbreaks, resulting in very low densities during the subsequent spring.

While vole population outbreaks and subsequent crashes tend to be regionally synchronous, exceptions do occur. Wildfires, and in particular, large wildfires, have a direct impact on the population cycle of voles. Immediately following wildfires, habitat is largely denuded of the food and cover required

by voles, resulting in very low vole densities. During the first post-fire growing season, herb and shrub layers are often quick to reestablish within the burned-over areas, due in large part to the nutrients released by the fire. By the second post-fire growing season, herb and shrub layers are often well developed and thrive, creating large areas of ideal vole habitat. The availability of this preferred vole habitat sets the stage for a significant population outbreak. Such peaks predictably occur two growing seasons following large wildfires and are directly related to the development of an abundant ground cover of herbs and shrubs. This trend has been observed within several wildfires throughout BC's interior. An ongoing study is documenting vole populations within areas impacted by the wildfires of 2003. During 2005, this study observed a dramatic peak two growing seasons after the wildfires. Consequently, significant feeding damage and plantation failures within these burned areas were common during 2005, particularly in the Okanagan Mountain Park fire zone. However, live trap monitoring in the summer of 2006 in this fire as well as the McLure and McGillvary fires near Kamloops indicate a dramatic decline in vole populations this year.

Large wildfires can cause burned areas to be “out-of-synch” with the population cycle occurring outside of the burn. For example, it was mentioned above that 2006 was likely a peak year for vole populations throughout BC’s interior; however, within areas burned in 2003, outbreaks occurred the previous year and virtually no voles remained during 2006.

The practice of grass seeding that commonly takes place immediately following wildfires may further enhance vole habitat, potentially exacerbating the feeding damage problem and impeding the establishment of new plantations. This premise has been disputed vigorously but no studies have specifically addressed the impact of grass seeding on vole populations. A study is currently investigating this within three areas that burned during the wildfires of 2003.

There are also examples of areas where vole populations do not experience the dramatic three to four year population fluctuations described above, but instead maintain relatively high numbers. Research continues within such habitats but it is unclear why these anomalies occur.

Snowshoe hares (*Lepus americanus*) are found

throughout BC. Populations have historically followed a nine to ten year cycle that usually peaks at the end or start of a decade, with the most dramatic changes occurring in the central and northern interior. These areas are where the majority of damage is reported. Damage to trees is caused by hare feeding, both through clipping of shoots and gnawing of bark.

For conifers, feeding damage tends to be highest on seedlings, particularly in areas that provide suitable cover for the hare. This is an ongoing concern for young pine stands in the NIFR that have sustained significant mortality due to Dothistroma needle blight and mountain pine beetle that are being considered for underplanting.



Hare damage to lodgepole pine

Brush cover combined with overstory dead and dying trees provides good hare habitat. Optimal habitat and warmer weather patterns appear to be keeping populations high, despite traditional cyclical patterns. Many stands fill planted due to Dothistroma needle blight in 2002 and 2003 have sustained serious hare damage, and initial trials for underplanting young mountain pine beetle damaged stands have reported noticeable hare feeding on seedlings.

Girdling due to feeding on sapwood by **black bear** (*Ursus americanus*) and **porcupine** (*Erethizon dorsatum*) can result in dead tops or mortality. This type of damage occurs primarily to intermediate aged trees and is relatively visible aerially, although current mountain pine beetle mortality has masked much of it. Severe mortality by bear was recorded on 62 ha in the Chilcotin Forest District near the Franklin Arm of the Chilko Lake and nearby Sticelan Pass. Bear damage also continued in the Quatam River, Ramsey Arm and at the mouth of Toba Inlet in the Sunshine Coast Forest District. Bear caused mortality in juvenile spaced stands in these areas is cyclic and has been ongoing since 1990. No porcupine damage was discernable in 2006 but is known to be occurring in scattered locations.

Black army cutworm, *Actebia fennica*

Black army cutworm (*Actebia fennica*) larvae preferentially feed on herbaceous plants and shrubs. In areas that are devoid of this vegetation, such as those created by wildfire, black army cutworm can heavily damage new conifer seedlings of all species.

This situation occurred in the Chilcotin Forest District in the spring of 2006. Areas burned by wildfires near Charlotte Lake in 2003 and 2004 were replanted with 200,000 trees. Preliminary surveys this summer indicated that black army cutworm has heavily defoliated approximately 50% of these seedlings. Spring surveys in 2007 will be conducted to determine if this defoliation has resulted in mortality.



Black army cutworm larvae

FOREST HEALTH PROJECTS

1. Mountain pine beetle attack in immature stands – 2006 Project Summary

*Lorraine Maclauchlan, Regional
Entomologist, SIFR*

Young pine stands in ten districts in the central interior were assessed for mountain pine beetle and associated insect attack again in 2006. The 2006 attack in young stands appears to be more extensive and severe than previously observed. Stand-targeted aerial surveys, ground surveys and 24 permanent sample plots made up the compliment of 2006 assessments. Fourteen percent coverage by area was achieved in the 2006 aerial surveys, ranging from 24% coverage in Vanderhoof to 3% in the Chilcotin. Greater than 80% of all stands assessed over 30 years of age and 54.6% of very young stands (20 to 25 years) had some level of mountain pine beetle attack. Attack ranged from less than 1% to over 95%. Of the total 2,528 stands assessed by air, 74% had some level of attack with 9% of these having >50% visible mortality.

A total of 285 stands were ground surveyed and 73% of these stands had some level of attack. Average green and red attack levels were 30% and 11%, respectively. Average in-stand green attack levels

were highest in Kamloops and 100 Mile House, with 79.1% and 62.2% stems attacked, respectively. In the permanent plots established in 2005, results show that 2006 attack occurred in those stands that did not have 2005 attack and a similar trend was observed throughout the ground surveys. Stands which had high levels of 2005 attack did not receive much fresh attack in 2006. MPB that successfully emerged from these young trees do not seem to remain in the stand or at least be able to initiate successful mass attacks without the help of immigrating populations of beetles. For more information on this study and a copy of the full 2006 report, check the SIFR Forest Health website.



Young pine mortality

2. Mountain pine beetle attack of age class 2 stands in the Prince George Forest District

*Jeff Burrows, Stewardship Officer,
Prince George Forest District*

With the continuing mountain pine beetle epidemic, mid-term timber supply and review processes need to consider the impact on projections of young pine plantations that may be lost. To investigate the extent of attack and the levels of associated understory in age class two pine stands for the Prince George Forest District, Stewardship staff developed a sampling strategy. A random selection of 112 leading pine VRI polygons (33 of which are completed) was drawn from the timber harvesting landbase. Random 5.64 m fixed radius plot locations were generated at a density of one plot per 10 ha with a minimum of three plots per sample. Data collected



*Mountain pine beetle mortality in
young spaced stand*

included a general inventory of all stems greater than 10 cm in height.

Using the partially completed sample data collected during the fall of 2006, it was found that 94% of stands were attacked by mountain pine beetle. Of those stands, the mean rate of attack was 46.4% (ranging from 10% - 84%). Stage of attack across all plots was similar between red (53.7%) and current (45.8%) with grey attack comprising only 8.3%. Comparing individual samples, stands had more current attack than red attack. The data showed that the incidence of mortality was actually greater in unspaced stands than in spaced stands. Spaced stands had a higher proportion of red attack than unspaced stands. Summarizing the data by biogeoclimatic unit did not show any clear spatial trends. Stand age also was not significant in predicting incidence; however, stands less than 25 years of age had the least incidence. Where mountain pine beetle pressure was intense, stem as small as 2 cm were found to have pitch-tubes but on average, the minimum attacked diameter was 9.9 cm. It is hoped that these findings can be incorporated with other ongoing work to improve future management decisions.

3. Permanent sample plot establishment to assess the biology and behaviour of mountain pine beetles in young stands

*Lorraine Maclauchlan, Regional
Entomologist, SIFR and Julie
Brooks, Consultant*

Twenty-four 0.25 ha permanent monitoring plots were established in 2005-2006 in young pine stands (20-55 years) throughout the core outbreak area of BC. The plots were located in stands between 20 to 50 years old. The attack behaviour and sequence, brood development and emergence of the bark beetle complex attacking these young trees are being monitored. The influence of other factors such as surrounding hazard and risk, treatment, density, and ecosystem are being evaluated.

Location rather than any of the above attributes is most important, with respect to MPB attack in these young stands. The total percent attack (grey, red and current) ranged from 0-81.5%. The older plots had the highest level of attack; however, even in very young stands, the percent current attack could be high. In both 2005 and 2006 attack densities were very high, ranging from 178-293 galleries/m². Such high densities are not conducive to successful mountain pine beetle development and

emergence. In 2005, 6 of the 15 plots had between 27%-63% current attack. Successful emergence from those plots ranged from 12% to 79% in 2006. Lower emergence levels were sometimes due to heavy woodpecker activity in the affected stand, feeding on the developing pupae, thus not allowing beetles to reach maturity. Larger diameter trees had greater emergence success than smaller trees.

In plots established in 2005, preliminary results show that 2006 attack occurred in those stands that did not have 2005 attack. Stands which had high levels of 2005 attack, did not receive much fresh attack in 2006. The beetles that successfully emerged from the plot trees did not remain in the stand. This project is ongoing and next year's assessment will add to our information regarding attack patterns in young stands. The rate of decay (bark sloughing and checking) is also being assessed. It appears that stands in wetter ecosystems are more susceptible to degrade than those in the drier sites.

4. Underplanting of young stands damaged by mountain pine beetle

Gord Dow, Regional Silviculture Specialist, NIFR

With funding from the MoFR *Forests for Tomorrow* program, trial underplanting of young stands that have suffered significant mortality due to mountain pine beetle was undertaken in the summer of 2006. Three 40-year-old juvenile spaced stands were chosen for the treatment. In each stand, 3 ha were planted with alternating rows of Douglas-fir, spruce and lodgepole pine. The sites were located in the NIFR southwest of Vanderhoof, at Lintz Lake southwest of Prince George and on Dunkley's TFL 53. An assessment of the trials will be done in 2007. Initial results report snowshoe hare damage, in particular at the Lintz Lake site where an estimated 40% of the lodgepole pine seedlings were killed.

Reconnaissance surveys to assess stocking in young juvenile spaced lodgepole pine stands attacked by mountain pine beetle are presently being conducted on 35,000 ha in the Vanderhoof and Prince George Forest Districts. In stands that are not sufficiently stocked (NSR) regeneration options will be considered, in particular underplanting. The results of the 2006 trials will assist in determination of regeneration recommenda-

tions. If snowshoe hares present a significant problem in the areas for underplanting, machine piling the present stands and replanting may be considered but it would not be the preferred option due to cost. Additionally, most stands surveyed to date only have partial beetle mortality, and it is desirable to retain the trees that are still alive. Consideration will also be given to the quality of the remaining trees however: the mountain pine beetle generally seems to have killed the larger, more vigorous trees and left behind smaller, suppressed stems.

Operational underplanting in a selection of these damaged stands will occur on approximately 250 ha in the summer of 2007 southwest of Prince George.



Hare scat with undigested flagging from Lintz Lake trial

5. Successful mountain pine beetle emergence from spruce

Robert Hodgkinson, Regional Entomologist, NIFR

In 1989 Amman, McGregor and Dolph reported that spruce and other non-host species could occasionally be attacked by mountain pine beetle but, because these trees were not true hosts, broods rarely developed. They also explained that attacks on non-host trees usually occurred when nearby pines were heavily infested. While we had seen unsuccessful mountain pine beetle attacks on interior white and black spruce in the NIFR in the past, in April 2006 we documented 2 interior spruce that had been successfully attacked and killed on a private property just west of Prince George at Miworth. Living 3rd instar mountain pine beetle larvae were found in these spruce from an attack that occurred in 2005.

Screened emergence traps were placed on these spruce in late spring as well as on 2 nearby attacked lodgepole pine for comparison purposes. Emerging adults were collected weekly from all traps during the summer. Last fall the 4 trees were cut into bolts and sent to UNBC for further examination.

Six sites around Prince George and one near Vanderhoof had

confirmed mountain pine beetle attacks on interior spruce in 2006. Approximately 95% of the attacked spruce either pitched out the beetles or prevented egg gallery establishment. Some spruce had been unsuccessfully attacked by mountain pine beetle for two consecutive years. A few black spruce were attacked albeit unsuccessfully.

A trial is planned for 2007 to see if mountain pine beetle will attack pheromone-baited spruce and to see if attacks will be successful under various conditions. If attacks are successful the progeny will be reared and further tests will be undertaken to see if these new generation adults can successfully attack spruce. Beetle fungal associations will also be examined to document differences between spruce and pine. This project is a joint effort between MoFR, UNBC, CFS and Oregon State University.



Trapped mountain pine beetle emerging from spruce

6. Hydrologic sensitivity of watersheds to mountain pine beetle infestation in the BC Interior

Rita Winkler and Pat Teti, Research Hydrologists, SIFR; John Rex, Research Hydrologist NIFR and David Maloney, Technical Advisor Watershed Signs, FPB

As mountain pine beetle spreads through the interior of BC, the extent of lodgepole pine mortality and salvage logging will be significant in many watersheds. Stand mortality, salvage logging and road construction each have the potential to affect hydrologic processes.

A reduction in forest canopy can result in:

- increased water reaching, stored in and flowing from hillslopes,
- earlier onset of spring snowmelt,
- increased spring and total annual streamflow volumes,
- changes in summer and fall flows, and
- more rapid streamflow response to storms.

The magnitude of hydrologic change will depend on:

- the severity and time since attack,
- presence, density and extent of understory vegetation,
- the extent of salvage logging within stands and across a watershed,

- the occurrence of fire,
- the physical characteristics of the watershed, and
- the weather.

In April 2006, the Assistant Deputy Ministers of the MoFR, Environment and Transportation and the Executive Director of the Provincial Emergency Preparedness Program signed a charter to provide information which could be used in the assessment of flooding risks associated with mountain pine beetle related forest mortality and logging. The MoFR was assigned the task of putting together maps showing medium sized watersheds in the NIFR/SIFR and identifying the potential for hydrologic change in these watersheds.

A summary of expected hydrologic change, water management issues, watershed planning recommendations, research initiatives and sources of information related to mountain pine beetle mortality and salvage logging along with a series of maps illustrating the extent of lodgepole pine leading stands in the NIFR/SIFR are available at:

http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/hydrology/index.htm

7. Single tree systemic injection trial using emamectin benzoate and fipronil for protection of lodgepole pine from mountain pine beetle

Leo Rankin, Regional Entomologist, SIFR

During the fall of 2005 and the spring of 2006, trials were established to test the efficacy of emamectin benzoate (EB) and fipronil (Fip) to protect lodgepole pine trees from successful attack by mountain pine beetle. Trees were selected and injected at the base with an Arborjet Tree IV injection pump system. The experimental site was located approximately 25 km east of 100 Mile House in the 100 Mile House Forest District. The site was located around 2050 metres elevation in the SBSdw1 biogeoclimatic zone. Trees between 18.2 and 39.1 cm DBH were injected at the base. The average tree diameter injected was 26.6 cm DBH. Three tree groupings were selected at 25 meter spacing including a non-treated control tree, an EB injection tree and a Fip injection tree. The average uptake of the injected chemical was approximately sixty minutes during a tree injection. The trees were assessed for beetle attack in early August and it was determined that no aggregation baiting was required to initiate attack as most trees were mass attacked. The injected systemics should provide

protection for the pine trees and allow them to survive the mountain pine beetle attack. The efficacy of the treatments will be evaluated in the early spring of 2007.



Injecting fipronil with an Arborjet Tree IV pump system

8. MCH Use for Douglas-fir beetle in the Cariboo-Chilcotin

*Leo Rankin, Regional
Entomologist, SIFR*

During the late winter and early spring of 2006, MCH anti-aggregation pheromone release devices were distributed to disperse small populations of Douglas-fir beetle Central Cariboo, Chilcotin and 100 Mile House Forest Districts. Anti-aggregation pheromones provide a chemical message to beetles that host trees are completely occupied by infesting beetles and that they should search further for appropriate susceptible hosts. The beetles disperse in all directions and in most cases do not succeed in finding new host trees to successfully attack.

Small infestation centres were treated at a concentration of 75 pouches per hectare which is approximately a 12m by 12 m grid distribution. Sites were selected in areas where harvesting was not an available option due to access, topographical impediments or management restrictions such as those linked to mule deer winter ranges and old growth management areas (OGMAs). Besides treating small infestations, fresh isolated windthrow patches may be treated to prevent beetle attack. MCH may also be employed as a post-

sanitation harvesting treatment to prevent trees stressed by logging, residual logging debris and stumps from being attacked by residual beetle populations. In some cases, larger infestations were treated with a "push-pull" system where anti-aggregant pouches were placed to push the beetles out, and trap trees were placed to pull the beetles into a more accessible logging site. Initial surveys in the fall indicate that MCH was very effective at reducing infestation size, preventing attack of windthrow patches and dispersing small infestations.

In Central Cariboo Forest District 436 sites were treated by MoFR. In addition, BC Hydro treated more than 75 sites where Douglas-fir hazard trees were felled adjacent to power lines in DCC. Overflow attack was minimal in sites checked.

The 100 Mile House Forest District had 88 sites grid baited with MCH in spring 2006. The baited areas varied in size between 0.5 and 2.0 ha. Sites using a Push-Pull treatment with MCH and trap trees were very successful. MCH sites established without trap trees, which were re-surveyed, had no current attack in the MCH treated areas.

In the Chilcotin Forest District there were a total of 144 sites treated with MCH out of 631 (23% of total sites) total sites mapped during the aerial survey. The district staff inspected 72 MCH sites (50%). Of the sites inspected 40 (56%) had no spillover. The 32 sites containing overflow attack included 329 current attack trees. There was tremendous variation between sites with one site containing 101 overflow attack. If we exclude the one large overflow site, the average attack for the remaining sites is 7.4 new infested trees/site. The situation in the Chilcotin was an extreme test of MCH because the Douglas-fir beetle pressure was very high and in many cases survey information around MCH treated sites was incomplete. Extensive overflow attack in a few of the MCH sites was almost certainly due to large adjacent undetected beetle infestations.

Overall, the MCH treatment program of Douglas-fir beetle control was very successful. However there were a few lessons learned. If possible, it is important to try to avoid treating spots with incomplete beetle population information. A push-pull treatment program using trap trees and MCH is recommended for infestations over 10 trees in order to reduce risk of over-

flow. The larger the treatment site, the greater the risk of overflow attack into the surrounding forest. Pushing beetle infestation centres greater than 25 trees is not recommended without the trap trees.



Boring frass on tree attacked by Douglas-fir beetle

9. Forest health and the Forest Stewardship Plan – a case study via the “Nadina District Forest Health – Stocking Standards Sub-Committee”

Dave Weaver, Regional Silviculture Specialist, NIFR

Forest Stewardship Plans (FSPs) submitted to the Nadina Forest District to date contain stocking standards that are similar to default stocking standards, with little variance for forest health issues. Forest health strategies for the TSAs highlight forest health issues that are not specifically addressed by the default stocking standards and district staff are concerned they do not address immediate and long-term forest health challenges. Therefore, a local sub-committee was created (initially by Stewardship staff Leigh-Ann Fenwick and now chaired by Pat Brochez) to develop variances to district stocking standards, given the local climate and forest health factors. The intent is that FSPs would be amended once these variances are developed. The group is comprised of all Nadina Forest District licensees, district stewardship staff and NIFR specialists.

The committee met several times in 2006, and established eight key topics of concern in random order as follows:

- Alternative species – birch, aspen, Douglas-fir and larch;
- Seed Transfer Guidelines – how to amend;
- Natural Regeneration – lodgepole pine viability;
- Higher Densities – cost allowances;
- Risk Issues – thresholds;
- Default Standards – identify perennial controversial items;
- Primary/Secondary/Tertiary species – preferred and acceptable approach;
- Parallel Processes – Provincial/Regional.

Recommendations from discussions of these topics will result in establishment of measurable outcomes. The variances are targeted to be developed by March 2007.

Refinements and recommendations were also developed to assist other districts if similar committees are struck. Further information can be obtained from David. Weaver@gov.bc.ca.

10. Armillaria Map Verification project

*Richard Reich,
Forest Pathologist, NIFR*

Landscape level detection and mapping of Armillaria root disease is one of the most challenging forest health activities. The end product reaps large dividends due to vastly enhanced silviculture and timber supply planning.

The reason for the challenge is that the fungus occupies a largely below ground niche of classical “icebergian” proportions. Stand level symptoms of Armillaria root disease are evident above ground by a ring-like spatial pattern of dead and dying trees that spreads out from the

center, with the interior area converting to less susceptible, typically deciduous species. Over long periods of time these disease centers become so large and fragmented that their boundaries become indistinguishable from a collection of unique, but smaller infection centers. How could this seemingly esoteric issue possibly be an operational problem? Correctly interpreting disease biology and stratifying for Armillaria root disease can greatly assist silviculture and timber supply

planning by not overestimating diseased area.

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



Young stand showing symptoms of Armillaria root disease

starting in 1991 using detection methods ranging from specialized low-level aerial sketch mapping using rotary wing aircraft, to detailed ground surveys. The detailed aerial sketch mapping was conducted extensively across the district and worked well for mapping above ground symptoms of Armillaria root disease centers in older plantations and unmanaged stands, especially for moderately to highly susceptible species. The detailed ground surveys provided reliable

spatial and incidence data, but are expensive and were therefore conducted on a limited number of openings.

In 2006 a verification project was initiated in collaboration with Michelle Cleary of the SIFR to determine the reliability of the Armillaria map by surveying a number of repre-

sentative young stands. This project also addresses the question of how well can Armillaria be operationally detected in relation to plantation age and species composition. The stands were selected to

provide generally

uniform coverage of the spatial distribution across the district, and to represent the full range of species composition found in young stands. Approximately 28 stands were surveyed in the fall of 2006. The survey recorded: species composition, an estimate of the tree based incidence of Armillaria, and the GPS location of each transect segment on a 50 meter interval. Observations were also made on the general detectability of Armillaria symptoms by tree species.

Preliminary results show that the current Armillaria map is largely reliable in showing the distribution of Armillaria at a landscape level. However, there is lots of room for improvement based on the following observations:

- On several openings, which were rated as “uninfected”, Armillaria was located during the ground survey. The reason for this may be because the initial aerial assessment was done at too young of an age (prior to observable symptoms). On other sites it may be that the species composition was not conducive for aerial detection.
- On other openings the level of incidence was much higher than originally observed. This appeared to be related to conducting detection surveys at too young of an age.
- Conversely, there were also examples of entire plantations rated as “infected” at a low level, which contain only a few discrete centers, which could easily be mapped, but had not been delineated.
- Finally, there were numerous openings where the “uninfected” rating was maintained. The reliability of stands rated as “uninfected” is

particularly important for silviculture and timber supply.

At the landscape level, the spatial pattern of disease centers was not uniform. This indicates that various environmental and ecological factors may play a role in the distribution of the root disease. Investigation of the role of these factors will be facilitated by the ongoing verification of the reliability of the Armillaria map.

Future planned work includes:

- Ground surveying additional stands to improve the reliability of the map in high risk areas.
- Transfer of all verified disease stratum into the MoFR forest inventory in the forest health layer to be used as an on-line planning tool.
- Investigation of local Armillaria population genetics through DNA characterization of disease centers (into unique genets) in order to interpret landscape level infection patterns as they relate to operational surveys.
- Comparing the verification survey results of this study with the free growing results recorded in the RESULTS database.

11. Forest pathology projects

Michelle Cleary, Forest Pathologist, SIFR

Root diseases, particularly Armillaria root disease, are the most significant forest pathogens impacting coniferous forests in the SIFR. The presence and impact of root disease on stand productivity is often undetectable, unmeasureable, and underestimated. Strategies to reduce losses due to root disease are limited to inoculum removal via stumping or planting species that are less susceptible to killing by the fungus.

Of particular concern is the uncertainty and/or lack of published information in BC regarding the effectiveness of inoculum removal techniques in minimizing or mitigating the impacts of root disease and the use of alternative treatments to control root disease, namely mixed species plantations including resistant hosts or inoculation of stumps with a saprophytic fungus (*Hypholoma fasciculare*) which is hypothesized to out-compete fungal inoculum in stumps. The latter option strictly remains experimental at this stage and is not recommended for use operationally. The following projects are underway to evaluate the effectiveness of various other

root disease control treatments:

Stumping Trials:

Several 20+ year old root disease stumping trials in the Southern Interior Region will be re-measured to quantify the effects of inoculum removal on early mortality caused by *A. ostoyae* and *P. sulphurascens* (syn. *P. weirii*) and growth responses following stumping and root raking treatments.

Pre-commercial Thinning and Pop-up Spacing Trials:

Several 15+ year old trials established on sites infested with *A. ostoyae*, *P. sulphurascens* (syn. *P. weirii*), and *Inonotus tomentosus* in the SIFR, CFR, and NIFR will be evaluated to determine the effects of thinning on the epidemiology of root disease in young plantations.

Armillaria root disease - Western redcedar Operational Trials:

Recent information pertaining to effective root disease resistance operating in western redcedar against *A. ostoyae* led to the establishment of several field trials in the SIFR. This study will compare the effects of stumping versus mixed conifer plantations including western redcedar on mortality and growth responses in Douglas-fir.

12. Summary of Hypholoma/Armillaria research for 2006

*Bill Chapman, Research Soil Scientist, SIFR and
Bruce Schellenberg, Consultant*

In 2006 we tried to catch up on measurements of some of our trials that involved unusual circumstances. We have used Hypholoma in situations where no other treatment options were practicably available; for example, with brushing, with partial cutting, in blocks that had quite advanced regeneration and others. We have also been testing some other treatments like stump notching to speed decomposition of stumps, interplanting of birch, these alone and in conjunction with Hypholoma inoculation. We used aerial photography to assess a treated block this year but due to technical problems analyzing the image, have not yet completed our analysis of that block. Three trials are reported here:

Cedar Creek: Installed with Weldwood (West Fraser), this trial had high Armillaria and high aspen levels. It was feared that brushing would exacerbate the Armillaria so three treatments were applied: brushing alone, brushing plus Hypholoma and no treatment. There were four replicates for each treatment and the plots were about 2.5 ha in size. Since the block was about 10 years old at the time of treat-

ment, there was little fresh woody material on site in which to inoculate the Hypholoma. Therefore, we tried to inoculate the Hypholoma into piles of the stems from brushed trees. This proved to be an ineffective way to inoculate Hypholoma. Nevertheless, the outcome from the brushing treatment was interesting. The brushing did not exacerbate the Armillaria and though the differences were not significant, the brushed area plus Hypholoma and brushed area had lower fresh mortalities/ha infected (5.8 tr/ha and 6.1 tr/ha, respectively) than did the untreated plots (10.1 tr/ha).

Kellington Lake: This is a block in the ICHdk which was operationally stumped in 1995 and we have been monitoring it at intervals just to see what is happening on it. Excluding germinants, 1.5% of the examined trees on the block were recently dead (red trees dead within a year usually but sometimes two years). This is very slightly up from the last time the block was assessed when the mortality rate was 1.3% and is similar to the untreated plots in a nearby trial at Boas Creek where the mortality rate is 1.37%. Interestingly, cedar had the lowest mortality rate at 0.44%, which is consistent with recent

observations about cedar's resistance to *Armillaria* root disease. The worst species by a considerable amount (7.76%) was *Abies lasiocarpa*. Another very interesting observation on this site was that areas of the block which became very wet post harvest are now virtually devoid of *Armillaria* root disease, even though they were heavily infected prior to harvest.

CP669: This trial was installed with Weldwood in 2000 on three blocks in the ICHdk. Several replicated spot treatments were applied in three separate blocks to try to contain *Armillaria* in wildlife tree patches (WTP) that were scattered throughout the block. Treatments included notching stumps to increase decay rates (based on work done after the Yellowstone fire), planting birch and grass around the WTP, stumping, and treating with *Hypholoma*. It is still too early to tell if the WTP are serving as a source of inoculum for the surrounding block. However, we assessed the effectiveness of stump notching to speed up the decomposition of the stumps (the idea being to create a rough surface more like a natural stub so that water is trapped and soaks into the stump). To this date, the stump notching is having no effect on decomposition.

13. Monitoring and literature review for hemlock dwarf mistletoe

*John Muir, Consultant and
Provincial Forest
Pathologist (retired)*

With funding from the Forest Investment Account, we have been working for the last three years on developing and implementing methods for monitoring spread of hemlock dwarf mistletoe in retention-harvested western hemlock forests and on establishing monitoring plots on Vancouver Island. With a few notable exceptions, incidence of hemlock dwarf mistletoe in young stands is very low. However, retention harvesting was implemented relatively recently, and many potentially suitable areas were inaccessible. We also have monitored dispersal of hemlock dwarf mistletoe seeds around two infected residual trees north of Ucluelet. Our data, although limited, suggested that monitoring hemlock dwarf mistletoe seed dispersal could give an early indication of the amount of spread and infection that can be expected. A summary of this project is being prepared for publication. John Muir collaborated with Paul Hennon, research scientist, USDA Forest Service, forestry sciences lab, Juneau, Alaska, to draft an extensive review of scientific literature on hemlock dwarf mistletoe. The

technical report is proposed as a Pacific Northwest station paper. Roderick Negrave, BCMOF, Nanaimo, is preparing a shortened version of the review for use in BC as a research extension paper. For further information contact John Muir (tel: 866 477 1805 (toll-free); e-mail: johnmuir@consultant.com) or Warren Warttig (tel: 250 286 5168; e-mail: warren.warttig@interfor.com).



Examining regeneration in retention-harvested western hemlock forest

14. Yellow-cedar decline project

Stefan Zeglen, CFR Forest Pathologist

Although some preliminary work to identify the extent of yellow-cedar decline has occurred on the coast, we are just scratching the surface of the problem. Aerial surveys to date indicate that the decline occurs in yellow-cedar from the Alaska boundary south to at least Kingcome Inlet. Like the situation in Alaska, the decline appears to have been occurring for years but with only occasional reports of mortality. One reason for the lack of reporting is that in BC yellow cedar is commonly intermixed with western redcedar and dead tops of yellow cedar are often dismissed as just spike tops of redcedar, a common occurrence. Now that the extent of the decline is becoming clearer we are beginning work to more closely examine the problem.

Our projected work regarding yellow-cedar decline falls into three areas. The first is to more precisely quantify the area where decline is occurring in BC. Recently, updated aerial photos have been taken of the north and mid-coasts. These new photos can be interpreted to identify areas where decline is significant enough to appear and record. This project is expected to take 2-3 years due to the number of photos involved and the problem of an acute shortage of qualified

interpreters. Ground truthing of some areas will also be required to ensure the quality of the calls.

Next, is to quantify the impact of widespread mortality on future stand growth and, ultimately, its effect on timber supply forecasts. This will require building on the previous step to find what proportion of yellow-cedar are affected by decline in various stand types and geographic areas and determine the rate of mortality. Also of interest, since yellow-cedar is a desirable and marketable species, is identifying the characteristics of the dead trees and assessing the salvage potential of any stands that may be accessible.

We do know that dead cedar remain upright and relatively sound for up to 80 years following death but we are unsure of what this means in terms of stand development and succession. Thus, the third area of interest is ecological. What is happening in stands that are experiencing mortality and how is it affecting stand characteristics like vigour, succession, regeneration and local site conditions?

FOREST HEALTH PRESENTATIONS

Application of the National Forest Pest Strategy's Risk Analyses framework for pests in BC

Tim Ebata, Forest Health Project Specialist, Forest Practices Branch

Venue: National Pest Forum, Ottawa, December 4th - 7th, 2006.

Abstract:

Two presentations were given regarding the application of the National Forest Pest Strategy's (NFPS) risk analyses framework for forest pests in BC. The NFPS is a Federally lead initiative designed to seek efficiencies and coordination of federal, provincial, municipal and other agencies responsible for managing forest pests regardless if they are native or invasive.

The first presentation was given to the Forest Pest Management Technology Group and was part of the National Forest Pest Strategy provincial stakeholders meeting. This presentation described how the NFPS risk analysis framework would apply to four pests in BC - mountain pine beetle, western spruce budworm, *Armillaria* root disease and gypsy moth. The three insect examples were relatively well supported with survey, treatment and impact information compared to the

Armillaria root disease example. The presentation demonstrated that the proposed NFPS risk analysis framework approach could be used to prioritize management efforts for both native and invasive pests and, in fact, that it is nearly identical to existing procedures used to justify funding requests for large-scale forest health projects. The second presentation to the main forum audience was a specific examination of the NFPS risk analysis framework applied to the mountain pine beetle situation in BC. Although risk analysis is no longer required due to the current state of the outbreak, the presentation served as a retrospective description of the lessons learned to benefit other provinces that are potentially facing the mountain pine beetle if it continues spreading eastward.

BC conditions report

Tim Ebata, Forest Health Project Specialist, Forest Practices Branch

Venue: National Pest Forum, Ottawa, December 4th – 7th, 2006.

Abstract:

Two presentations were made regarding forest health in BC. The first presentation was BC's report as part of the "provincial cross-country check-up" of pest conditions. The results of the annual overview survey were presented along with interesting anecdotes and information on ongoing projects (e.g., Dothistroma surveys, gypsy moth eradication program, Provincial Forest Health strategy, and recent staffing changes). The second presentation was a summary of the ongoing activities that BC has been carrying out to mitigate the impacts of the mountain pine beetle disaster. This talk borrowed heavily from existing slides used by the Emergency Response Team to explain the government's *Mountain Pine Beetle Action Plan's* initiatives relating to community stability, spread control, forest resource protection, value recovery, and public safety. The presentation was well-received and clearly communicated the significance of the outbreak and the efforts the province (with the assistance of the federal government) have undertaken so far to attempt to limit the pest's impact.

Forest health legislation

Robert Hodgkinson, Forest Entomologist, NIFR

Venue: Association of B.C. Forest Professionals Policy Seminar, Prince George, B.C., Sept. 16, 2006, and Third Year Forest Health Seminar, University of Northern B.C., Nov. 29, 2006.

Abstract:

Outlined forest stewardship plans and exemptions, site plans, approval in emergency cases, the former "Bark Beetle Regulation", the new "Forestry Licence to Cut Regulation", free growing requirements, invasive plants, the former "Defined Forest Area Management" experiment, Provincial Bark Beetle Strategy, and other changes and challenges.

Biology, population dynamics and management of mountain pine beetle in BC

Robert Hodgkinson, Forest Entomologist, NIFR

Venue: Annual Meeting of the B.C. Institute of Agrologists, Prince George, B.C., June 15, 2006.

Abstract:

Presented mountain pine beetle biology, population dynamics and modelling, outbreak status, threat to AB, control tactics, provincial bark beetle strategy, and a discussion of attacks on spruce.

Mountain pine beetle in BC

*Don Heppner,
Forest Entomologist, CFR.*

Venue: North Island Woodlands Advisory Group meeting, Campbell River BC, December 7, 2006.

Abstract:

Reviewed the mountain pine beetle situation in BC, including past history, how the current infestation developed, its impacts and possible future scenarios. At a local level, a small new infestation on Vancouver Island was detailed along with options for control. Other beetle infestations in western North America were discussed as well, from spruce beetle in Alaska and the Yukon to Ips beetles in New Mexico.

Mountain pine beetle control options in Caribou habitat - the BC experience

*Robert Hodgkinson, Forest
Entomologist, NIFR*

Venue: Impact of Mountain Pine Beetle on Caribou Conference. Edmonton Alberta, January 27, 2006.

Abstract:

Presented advantages and disadvantages of using: fall and burn, fall and peel, MSMA, sanitation harvesting, pheromone, verbenone, beetle proofing, carbaryl insecticide, and hauling and milling restrictions. Recommended using various tactics as appropriate, avoiding excessive road building, and minimizing stand fragmentation.

Observations on mountain pine beetle in young pine in the NIFR (east)

*Robert Hodgkinson, Forest
Entomologist, NIFR*

Venue: B.C. Forest Health Committee Meeting, Victoria, B.C, Jan. 25, 2006.

Abstract:

Discussed age class 1-3 lodgepole pine killed by mountain pine beetle in 2004-2005 in the Northern Interior Forest Region. Summarized the findings of UNBC M.Sc. student Patience Rakochy in the SBS dk 01, 03, 05 and UNBC silviculturist Dr. Chris Hawkins' results in the SBS dw2, 3 & mc2. The observations from a field trip in January 2005 were presented.



Harvesting mountain pine beetle infestations in the Central Cariboo Forest District

Mountain pine beetle successfully attacking spruce

Robert Hodgkinson, Forest Entomologist, NIFR

Venue: Delivered during a field trip of the Interior Regional Executive Directors and District Managers, Prince George District, September 20, 2006, and at the Northern Interior Bark Beetle Management Committee Meeting, Vanderhoof, Sept. 26, 2006.

Abstract:

At the first event, Forest Service managers were shown 2 spruce at Miworth (west of Prince George) that had been successfully attacked by mountain pine beetle in 2005. New generation mountain pine beetle managed to survive in these spruce and some new adults were captured in emergence traps when they attempted to leave. A subsequent office presentation at Vanderhoof District summarized these initial findings.

Storage, hauling and milling of mountain pine beetle-infested wood in suppression beetle management units of the Mackenzie, Peace and Skeena Stikine Forest Districts

Robert Hodgkinson, Forest Entomologist, NIFR

V e n u e : A l b e r t a - B . C . Intermountain Forest Health Meeting, Radium, B.C., April 13, 2006.

Abstract:

The success of sanitation harvesting in suppression beetle management units is contingent upon the expeditious extraction, transportation and processing of beetle-infested logs before beetles can emerge in the forest, escape from loads in transit, or fly from mill yards. Proper hauling and milling procedures can minimize or prevent beetle spread from infested logs and enable licensees to maximize the efficacy of their sanitation harvesting during the summer. A traditional "no-haul" window can be reduced to 6 weeks or even 3 weeks if a "monitored temperature approach" is used.

Current conditions and the state of our efforts regarding whitebark pine in BC

Stefan Zeglen, Forest Pathologist, CFR

Venue: White Bark Pine: a Pacific Coast Perspective Conference. Southern Oregon State University, Ashland Oregon, August 28 – 31, 2006.

Abstract:

Recent surveys in BC have indicated that roughly one in five whitebark pine (*Pinus albicaulis*) are dead, at least half of these due to infection by white pine blister rust (*Cronartium ribicola*). Another 30% of living trees are infected by blister rust with up to two-thirds of these having potentially lethal stem cankers. Both incidence of disease and mortality vary widely across the natural range of whitebark pine. In addition, over the last decade, a large infestation of mountain pine beetle (*Dendroctonus ponderosae*) has exploded across the province threatening all native pines. Given these threats, and the realization of the meaningful role whitebark pine plays in high-elevation forests, new research has emerged around this species. Several of these projects were briefly described.

Are free-growing stands meeting timber productivity expectations?

Alex Woods, Forest Pathologist,
NIFR, Smithers RSC.

Venue: Southern Interior
Silviculture Committee (SISCO)
annual spring meeting,
Penticton BC, March 6-8, 2006.

Abstract:

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 stand is on a trajectory that will result in a productive mature stand. Currently, there are no monitoring procedures in place to determine if free-growing stands are meeting these expectations. The purpose of this study was to examine whether the reliance that has been placed on this policy is supported by stand performance from a timber yield perspective.

Sixty randomly sampled free-growing stands were evaluated in the Lakes Timber Supply Area (TSA) in central BC. Sample stands were grouped into two classes based on the number of years since free-growing declaration: half were declared 1987-1994 (early), and the other half declared 1995-2001 (late). All sampled stands were greater than 15 ha in size, and were surveyed using 15 - 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 are 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 338 and 336 m³/ha, respectively. Using 2005 stand attributes, projected volume for the early and late groups were 342 and 338 m³/ha, respectively. There was a significant increase in site index (mean of 18.4 m at declaration vs. 20.2 m in 2005) for stands in the early group. The increase in site index resulted from the use of standardized site index assessment procedures, not improved growth rates. 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 (wsph)¹.

The only significant difference for the late group was the marked increase in forest pest incidence, which was also found in the early group. Over 27% of all declared free-growing pine leading stands had >20% hard pine rust incidence, with pine leading stands representing 90% of the sampled managed stands. The increase in pest incidence is probably due to a combination of increased recognition, as well as real increases in forest pests. One of the stands in the early group was attacked by mountain pine beetle, with 70-75% of the trees infested.



*Free-growing lodgepole pine stand with significant mortality
caused by comandra blister rust infections*

Is an unprecedented *Dothistroma* needle blight epidemic related to climate change?

Alex Woods, Forest Pathologist,
NIFR, Smithers RSC.

Venue: International Conference "Climate changes and their impact on boreal and temperate forests" Ural State Forest Engineering University, Ekaterinburg, Russia, June 5 – 7th 2006.

Joint Meeting of the American Phytopathological Society, Canadian Phytopathological Society and the Mycological Society of America, Quebec City, Canada, July 29-August 2nd, 2006.

Abstract:

Dothistroma needle blight caused by the fungus *Dothistroma septosporum* is a major pest of pine plantations in the southern hemisphere, where both the host and the pathogen have been introduced. In northern temperate forests where the pest and host trees are native, damage levels have historically been low, however, *Dothistroma* is currently causing extensive defoliation and mortality in plantations of lodgepole pine in northwest BC. The severity of the disease is such that mature lodgepole pine trees in the area are succumbing, which is an unprecedented occurrence. This raises the question whether climate change might be responsible by surpassing an environmental threshold that

has previously restricted the development of a pathogen in temperate regions. Establishing a causal relationship between climate change and local biological trends is usually difficult, but we found a clear mechanistic relationship between an observed climate trend and the host: pathogen interaction. A local increase in summer precipitation, not climate warming, appears to be responsible. We examine whether the recently observed climate change trend exceeds natural fluctuations of local climate.



Lodgepole pine needles infected
with *Dothistroma* needle blight

What effects will a changing climate have on lodgepole pine in British Columbia?

Alex Woods, Forest Pathologist,
NIFR, Smithers RSC.

Venue: Western International Forest Disease Work Conference (WIFDWC), Smithers BC, October 2-7, 2006.

Abstract:

The foliar compliment of ever-green conifer trees is dependent on the crown ratio and foliar longevity. Variation in foliage longevity is one of the important traits that often favours the genus *Pinus* over its competitors. Healthy lodgepole pine in BC typically retain needles for 4 to 5 years. Foliar diseases have a profound influence on foliar longevity and crown ratio and lodgepole pine as a species is susceptible to a large suite of foliar pathogens. Foliar diseases may be some of the more responsive forest disease organisms to climate change as their ability to sporulate and infect strongly tied to temperature and precipitation.

In this study we build upon the foundation of a recently established link between *Dothistroma* needle blight and climate change in northwest BC. We assessed the foliar longevity and crown ratio of lodgepole pine trees across 25 sites of the Illingsworth lodgepole pine provenance trial

from Hazelton to McBride, Barkerville to MacKenzie. We correlated the foliar complement of trees at the 25 sites to changes in climate between the decade of the 1920's and the 1990's using the model Climate BC. We found a strong relationship ($R^2 = 0.4773$) between an increase August minimum temperatures (1920s-1990s) and mortality of lodgepole pine attributed to foliar diseases such as *Dothistroma*. We found a similarly strong relationship between increases in August minimum temperatures and a decrease in Live Crown ($R^2 = 0.559$). Sites in Region 7 of the Illingsworth trial (Robson Valley) consistently have the least foliage and have consistently experienced the greatest increases in; August minimum temperature, July precipitation, and decreases in May maximum temperature. Region 9 (Nechako Plateau) sites consistently have the most foliage and have consistently experienced the least change in August minimum temperature, July precipitation, and greatest increases in May maximum temperature.

Changes in climate already appear to have occurred at some of the sites and these changes are affecting the health of lodgepole pine. Future projected changes in climate such as those proposed by Hamann

and Wang (2006) in conjunction with foliar pathogens could have profound effects on the health of lodgepole pine in BC.

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Ministry of Forests and Range, Forest Practices Branch

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