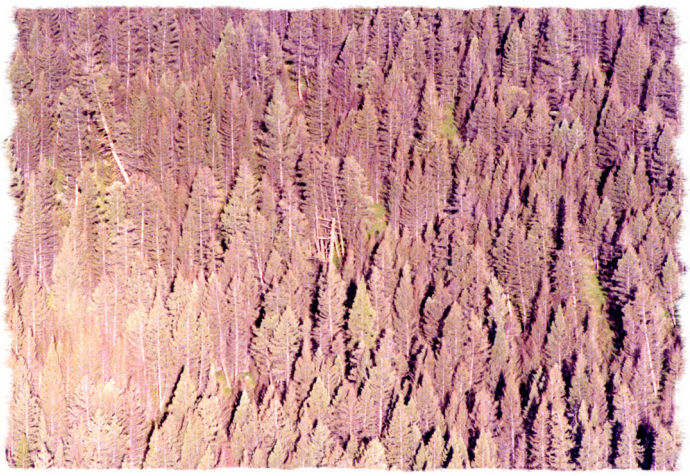
2005 Summary of Forest Health Conditions in British Columbia



Prepared by Joan Westfall
for British Columbia Ministry of Forests and Range,
Forest Practices Branch

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Abstract

The *2005 Summary of Forest Health Conditions in British Columbia* was compiled from provincial aerial overview survey data, insect population predictions, ground reports on forest health agents not aerially detectable and special projects information.

The mountain pine beetle epidemic continued to cause extensive mortality throughout the range of pine in BC, with over 8.7 million affected hectares. In areas where infestations have killed the majority of the mature pine, beetles are moving into younger stands. The Cariboo zone of the Southern Interior Forest Region (SIFR) continued to sustain the highest level of attack. Infested hectares in the Chilcotin Forest District rose to 1.3 million, followed closely by attack in Quesnel Forest District. Damage remained relatively constant in the Central Cariboo Forest District, with 700,225 ha affected. After experiencing the largest provincial increase last year, attack in the 100 Mile House Forest District dropped slightly to 623,603 ha. Infestations in the Northern Interior Forest Region (NIFR) continued to rise and totalled 3.6 million hectares. The largest increase and highest level of attack in the NIFR occurred in Nadina Forest District where recorded damage affected 1,226,775 ha, up over half from last year's total. Fort St. James, Prince George and Vanderhoof Forest Districts sustained the bulk of the remaining attack in the NIFR. The majority of the mountain pine beetle control efforts are now focussed in the Peace Forest District, to keep the beetle from moving across Canada. Factors indicate the beetle outbreak will continue next year across most of the province.

Western balsam bark beetle mortality continued in a light, chronic pattern over 1.4 million hectares of subalpine fir stands. The majority of attack occurred in the NIFR. Area affected by spruce beetle dropped for the second year in a row, from 315,953 ha in 2003 to only 55,628 ha. Most of this attack was situated in the SIFR, in particular the 100 Mile House, Central Cariboo and Headwaters Forest Districts. These three districts also contained the majority (88%) of the provincial Douglas-fir beetle mortality, which rose for the third year in a row to 42,752 ha of damaged stands.

Various insects caused significant defoliation, in particular the western spruce budworm. Infestations dropped more than a third since last year, but 463,962 ha across the southern half of BC were still affected. Cascades, Central Cariboo, Chilcotin, and 100 Mile House Forest Districts contained the majority of the defoliation. The biological control agent *Bacillus thuringiensis* var. *kurstaki* (*Btk*) was successfully applied to 30,419 ha of high value Douglas-fir stands to reduce western spruce budworm damage and population levels. Infestations continued to decrease in size and intensity in the Coastal Forest Region.

After a peak in 2003 of 794,303 ha, defoliation by the large aspen tortrix declined to 132,494 ha affected in the NIFR this year. Of the 135 male gypsy moths caught in the summer of 2005, only two populations, one in Nanaimo and the other on Salt Spring Island, were identified for eradication with *Btk* and mass trapping while three other sites were massed trapped. Mass trapping at two sites in 2004 and 2005 have yielded encouraging results.

Wildfire was the most damaging abiotic agent in 2005 with 39,029 ha burned. This was approximately one-sixth the area affected over the past two years, largely due to significant rain events this summer, beginning in June. With extensive rain in August of 2005, drought conditions recovered substantially this year and only 137 ha of damage was recorded compared to 11,326 ha in 2004. Red belt damaged a total of 26,639 ha, primarily in the Peace and Fort Nelson Forest Districts.

Foliar diseases continued to be a problem, especially dothistroma needle blight in northwest BC. Effects of this disease are difficult to see during the overview surveys yet 1,690 ha were recorded in 2005, indicating increased levels of damage. Aspen and poplar leaf and twig blight damage reached a peak in 2002, when 82,376 ha were infected. Affected area has declined annually since then, and this year it was not recorded at all.

Other forest health factors such as western hemlock looper, birch leaf miner, windthrow and flooding caused localized damage in various areas throughout the province.

2005 Summary of Forest Health Conditions in British Columbia

Introduction

It is the responsibility of the British Columbia (BC) Ministry of Forests and Range (MOFR) to monitor and record damage to the forests of BC. Various agents can injure trees, including insects, diseases, animals and environmental factors. A large portion of the damage information is gathered on an annual basis by aerial overview surveys. These surveys have been conducted by the MOFR for the past nine years, and by the Canadian Forest Service (CFS) previous to that time.

Aerial overview surveys are designed to obtain data quickly and cost efficiently over large areas. The information is used for a variety of important purposes, including: monitoring of forest health issues over time, providing forest managers with current damage information and contributing input into national indicators for sustainable forest management.

Some forest health concerns, particularly diseases such as rusts, cankers and dwarf mistletoes, are not usually discernable from aerial overview surveys. Other methods such as low-level helicopter flights or ground observations are used to identify damage caused by these agents. These agents were discussed in this report if they arose as a concern and/or damage conditions changed, but were not tabulated with the overview findings.

Overview data was collected by each forest region, and was summarized by forest district (Figure 1). Forest Practices Branch then collated this information into a Provincial database. This report is a summary of the 2005 survey results. Additional insect population predictions, damage agent observations, forest health presentations, projects and publications have been provided by various sources throughout the province.

Aerial observer recording forest health damage

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

The aerial overview surveys consist of experienced personnel sketching forest health disturbances on maps from fixed wing aircraft. Maps are at a scale of 1:100,000 and use black and white (panchromatic) Landsat 5 satellite images as a base highlighted with specific features like creeks, roads and harvesting to improve spatial orientation. These maps are a great improvement over the topographic maps that were utilized in the past. 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.

Survey flights are optimally conducted during the months that the priority forest health factor's damage is most visible. This varies by type of damage and location in the province. In 2005, the flights were conducted from early July through mid September. Provincially, wildfires during the survey months were generally small and therefore smoke was not a large concern for visibility. Rain and/or fog were the primary sources of survey delays, particularly in the northern and coastal portions of the province. A total of 779.7 flying hours were required to survey the province (Table 1).

Hand-held Global Positioning Satellite (GPS) receiver units were utilized to record flight lines, ensuring adequate survey coverage (Figure 2). Flight patterns were in a grid for relatively flat topography and by drainages in mountainous terrain. Line intensity varied depending on visibility and the extent of forest damaging agents. The majority of all forested land was surveyed. The exception was the northwest corner of the province, where poor weather and time constraints interfered. Non-forested types such as alpine tundra were not surveyed. In total, 79% of the province was flown in 2005.

Forest disturbances that killed trees (bark beetles, fire, flooding, porcupine, etc.) were mapped by observing foliage colour on dead trees. Generally, dying tree foliage turns yellow to bright red, then over time colour intensity fades and foliage is shed, at which time trees are referred to as grey.

Only mortality that occurred within the previous year was mapped. Hectares damaged in past years cannot be added cumulatively, since new mortality may appear in the same areas that had a percentage of the trees killed previously.

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

Table 1. Number of flying hours required by each Region to complete the 2005 provincial aerial overview surveys.

Region	Zone	Flight hours	Survey Dates
Southern Interior Forest Region	Cariboo	184.5	July 12th – Sept 7th
	Kamloops	58.0	July 14th – 28th
	Nelson	108.5	July 25th – Aug 12th
Northern Interior Forest Region		378.2	July 7th – Sept 12th
Coast Forest Region		50.5	July 28th – Aug 20th
Total		**779.7**	**July 7th – Sept 12th**

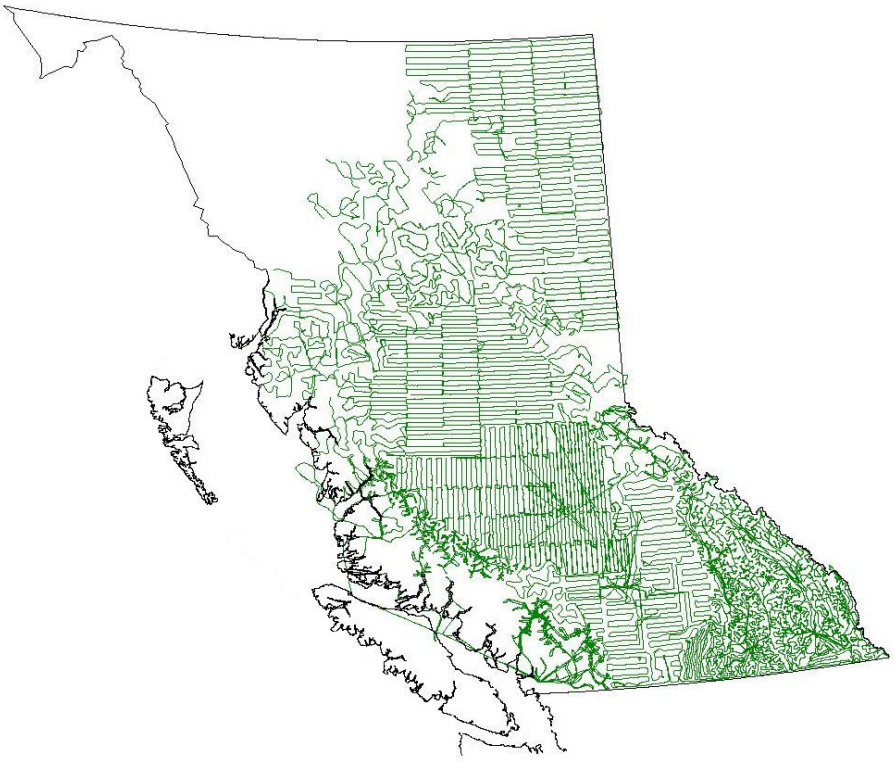


Figure 2. Flight paths flown while conducting the 2005 aerial overview surveys.

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.

damage agent was noted according to intensity classes (Table 2). Light, moderate and severe have historically been the standard provincial classes. Starting in 2004, light mortality was separated into trace and light, and severe was divided into severe and very severe. These refinements capture the behaviour of certain damaging agents to a better degree, and assist with impact analysis.

Small areas of up to 50 recently killed trees were noted as spots. To include these spots in total hectares affected, 1 – 30 trees were recorded as 0.25 ha and 31 – 50 trees as 0.5 ha of severe intensity.

Accurate mortality volume estimations have not been an expected outcome of the aerial overview survey. This is because the survey is a poor estimator of the actual number of trees killed (and consequently, volume killed), due to the broad incidence classes, known errors of omission (i.e., missed trees), and other limitations.

The other disturbance that may be visible from the air is defoliation caused by insect feeding or foliage diseases. Defoliator damage tends to be

widespread throughout areas and was therefore mapped as affected polygons only, not spots. Only current defoliation was recorded, which was assessed as a percentage of the foliage damaged, averaged for the polygon (Table 2). Hectares of defoliation cannot be added cumulatively for successive years because the same area may experience more than one year of damage.

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.

Mountain pine beetle larvae

General Conditions

Damage to BC forests as recorded during the aerial overview surveys in 2005 is summarized in table 3. Mountain pine beetle continued to cause the highest tree mortality, with a record of over 8.7 million hectares infested. Area affected by western balsam bark beetle damage rated second, with over 1.8 million hectares. Other forest health agents for which significant areas of damage were recorded included: western spruce budworm, large aspen tortrix, spruce beetle, Douglas-fir beetle, fire and redbelt. The effects of various other damaging agents were recorded at a smaller, more localized scale. Details of damage caused to specific tree species are documented in the next section of this report.

Bark beetles and defoliators have been the primary forest health factors recorded during the aerial overview surveys for the last six years. Bark beetles have been constantly increasing. This is due in part to mild winters resulting in low beetle mortality rates. The extensive mountain pine beetle outbreak is the main driver of the beetle damage expansion. In contrast, defoliator damage has fluctuated year to year, reflecting the large population changes that often occur over relatively short time periods with these insects (Table 3).

Abiotic factors continued to be the third largest grouping of damaging agents. Injuries caused by specific abiotic agents are primarily weather related, and as such can change drastically from year to year.

Damage by diseases and animals fall third and fourth respectively in hectares affected. For both these categories however, damage is often difficult to detect during the aerial overview surveys and it is therefore underestimated.

The MOFR sponsored the *Future Forest Ecosystems of BC – Exploring the Opportunities* symposium Dec. 6-7, 2005 in Prince George to examine forest management challenges such as climate change, insect infestations, wildfire events and timber species selection.

The symposium featured leading experts presenting overviews and the latest projections for ecological change agents that may significantly impact BC's forests. The agenda also included working group sessions to provide recommendations for adapting the current forest management paradigm to meet future challenges.

Table 3. Summary of hectares affected by forest damaging agents as detected in 2005 aerial overview surveys in British Columbia.

Damaging Agent	Hectares Affected
Bark Beetles:	
Mountain pine beetle[a]	8,736,068
Western balsam bark beetle	1,846,312
Spruce beetle	55,628
Douglas-fir beetle	42,752
Fir Engraver beetle	2,483
Western pine beetle	71
Total Bark Beetles:	10,683,314
Defoliators:	
Western spruce budworm	463,962
Large aspen tortrix	132,494
2-year-cycle budworm	7,455
Birch leaf miner	4,105
Western hemlock looper	3,732
Misc. defoliators	1,066
Eastern spruce budworm	703
Satin moth	394
Forest tent caterpillar	148
Douglas-fir tussock moth	56
Total Defoliators:	614,121
Abiotics:	
Fire	39,029
Redbelt	26,639
Windthrow	16,749
Flooding	2,938
Drought	137
Slide	354
Total Abiotics:	85,846
Diseases:	
Dothistroma	1,690
Misc. diseases	704
Larch needle cast	672
Pine needle cast	319
Total Diseases:	3,386
Animals:	
Bear	1,755
Total Animals:	1,755
Provincial Total	11,388,422

[a] Includes infestations in parks totalling 918,211 ha.

Logepole pine mortality due to mountain pine beetle attack

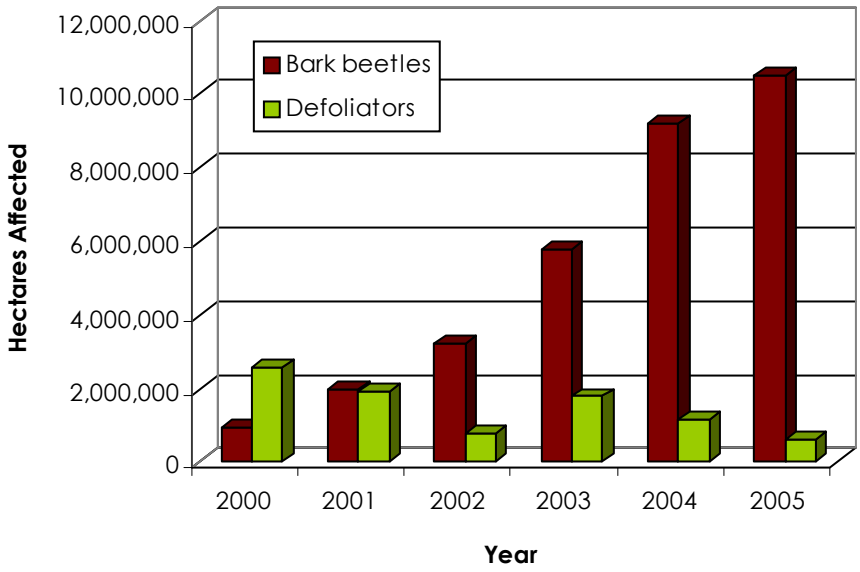


Figure 3. Hectares affected by bark beetles and defoliating insects from 2000 – 2005 in British Columbia.

Damaging Agents of Pines

Mountain pine beetle, *Dendroctonus ponderosae*

Provincial Situation

Mountain pine beetle (*Dendroctonus ponderosae*) continued to cause extensive tree mortality throughout the range of pine in the province (Figure 4). Beetle populations have been on the rise for several years, due to an abundance of mature lodgepole pine and very favourable weather conditions.

The present outbreak is the most extensive in recorded history, and it is not expected to abate in the near future. A provincial scale mountain pine beetle model was developed to assess the outbreak (http://www.for.gov.bc.ca/hre/bcmpb/) and conclusions to date are that it will last at least ten more years, and kill at least 80% of the merchantable pine volume.

Hectares infested by mountain pine beetle in BC totalled a record 8,736,068 ha in 2005 (of which 918,211 ha are located in provincial parks and protected areas). As a comparison, only 165,567 ha were damaged in 1999. Infestations rose sharply from 1999 to 2001, when 784,000 ha were recorded as affected. Since then, area of attack has approximately doubled each year. The increase slowed slightly to 80% from 2004 to 2005.

Within the stands attacked by mountain pine beetle this year, 784,039 ha (9%) sustained very severe mortality, 1,197,533 ha (14%) severe, 2,148,886 ha (24%) moderate, 2,332,551 (27%) light and 2,273,060 ha (26%) trace mortality. The percentage of severe and very severe mortality has almost doubled since 2004, while light severity went down proportionally. The other categories remained constant.

Southern Interior Forest Region Damage

The Cariboo zone of the Southern Interior Forest Region (SIFR) continued to have the largest area affected in BC with almost half the total provincial hectares of attack. Contrary to the pattern of rising attack over the past few years however, most districts experienced a slight drop (Figure 5).

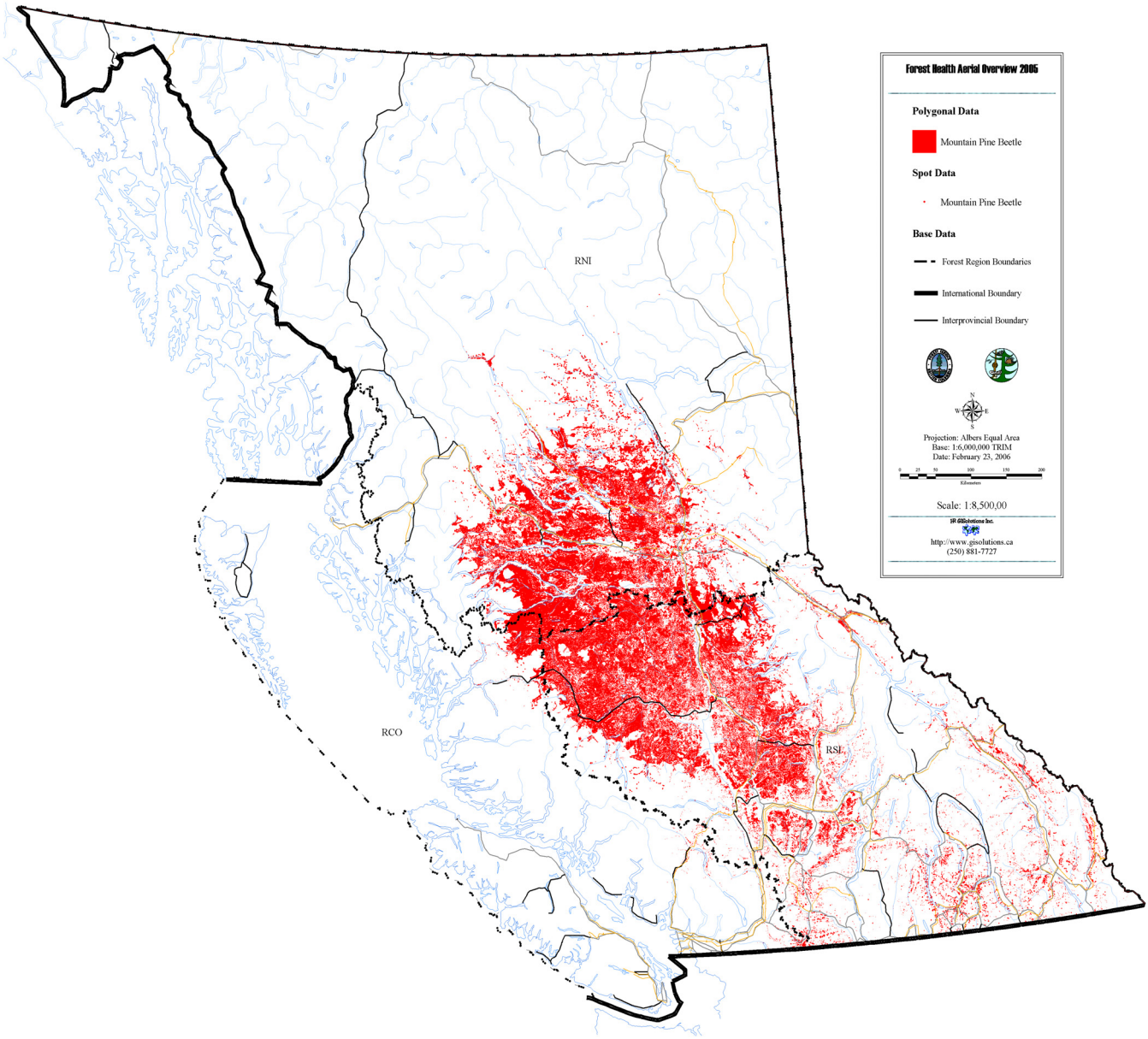


Figure 4. Mountain pine beetle infestations recorded in British Columbia in 2005.

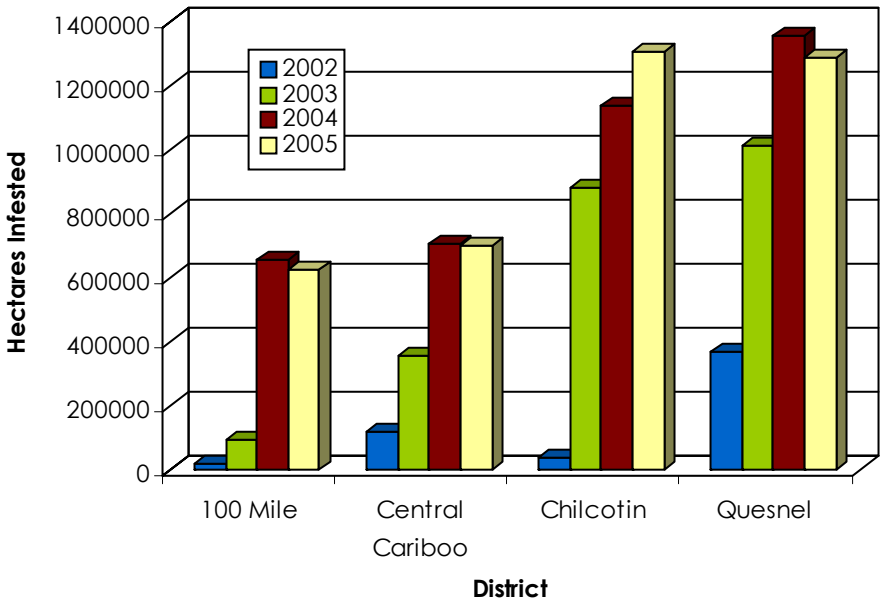


Figure 5. Hectares infested by mountain pine beetle from 2002 – 2005 in the Southern Interior Forest Region (districts with more than 600,000 ha affected in 2005).

The only district to note an increase in mountain pine beetle attack in the Cariboo was the Chilcotin Forest District, where affected hectares were reported at the highest level province wide, at 1,309,561 ha. This represented an increase of 15% over 2004 when 1,138,475 ha were recorded as damaged. In this district, large areas of new light, diffuse mortality was recorded in 2003, and only 4% of polygon intensity was greater than light. In 2004 intensity in the moderate to very severe range increased to 18%, and in 2005 it rose to 39% (510,024 ha) as mountain pine beetle populations increased.

Area affected in Quesnel Forest District dropped the most, down to 1,289,002 ha from 1,358,993 in 2004. Even with this decrease, attack levels were second highest in the province. Of this total, 134,630 ha (10%) were trace, 164,251 ha (13%) light, 400,312 ha (31%) moderate, 445,696 ha (35%) severe and 144,113 ha (11%) very severe. Compared to 2004, trace intensity remained similar, but intensity increased 27% in the severe to very severe categories, with a corresponding drop in the light to moderate range.

Area affected in the 100 Mile House Forest District dropped slightly to 623,603 ha from last year's 655,901 ha, after a seven-fold increase from 2003 to 2004. Intensity increased significantly in the moderate to severe categories, from 10% in 2004 to 41% (257,235 ha) in 2005. Trace severity fell by the same amount, and the other categories remained relatively stationary.

Attack levels in the Central Cariboo Forest District stayed almost the same as in 2004 with 700,224 ha affected. Intensity of attack increased in this district as well, with decreased light to moderate levels and a large increase from 15% to 35% from last year in the severe category.

Mountain pine beetle mortality affected 847,834 ha across the remaining districts in the SIFR (18% of the total for the region). This is a relatively small amount of attack compared to more northerly districts, but it still represents a seven-fold increase over two years. Overall, existing infestations enlarged and intensified.

The largest increase in infested hectares as well as the highest level of attack continued to occur in the Kamloops Forest District. Recorded area of attack in 2005 totalled 290,466 ha, which was double that of 2004 and ten times more than in 2003. Attack intensities were 41,567 ha (12%) trace, 126,571 ha (43%) light, 79,784 ha (27%) moderate, 27,730 ha (10%) severe and 22968 ha (8%) very severe. These severity proportions were similar to 2004.

Cascades, Arrow Boundary, Headwaters and Rocky Mountain Forest Districts had similar levels of attack in 2005 with 103,640 ha, 100,636 ha,

Mountain pine beetle pitch tubes and basal frass

99,191 ha, and 97,146 ha recorded, respectively. Infested area more than tripled over last year in all these districts, with the exception of Arrow Boundary Forest District, where damage levels doubled.

Lower levels of attack occurred in the Okanagan Shuswap, Kootenay and Columbia Forest Districts, at 78,840 ha, 42,054 ha and 35,860 ha, respectively.

In the southern portion of the SIFR, mountain pine beetle attack occurred on yellow pine as well as lodgepole pine, particularly at the higher elevational range of yellow pine. In the lower elevation yellow pine stands, attack tended to be a mix of western pine beetle (*Dendroctonus brevicomis*) and mountain pine beetle, depending on the area.

Northern Interior Forest Region Damage

In the Northern Interior Forest Region (NIFR), four of the most southerly districts continued to contain the majority of the mountain pine beetle infestations (96%). Total affected area in the NIFR rose substantially over the 2.6 million hectares recorded last year to 3.7 million hectares.

The largest increase and the highest amount of attack occurred in the Nadina Forest District, which had the third highest level of damage in BC. Recorded infestations totalled 1,226,775 ha, an increase of half over last year's total (Figure 6). Of this, 240,884 ha were in the Tweedsmuir Provincial Park and the Entiako protected area. The two-year downward trend in intensity levels reversed in 2005, with movement of the mountain pine beetle northwest towards Houston and the Bulkley valley. Stands on the west side of Babine Lake in particular showed a marked increase in attack over 2004. In total, 126,171 ha (10%) of infestations were recorded as severe and 169,702 ha (14%) as very severe, compared to only 1% of the stands in 2004. The majority of the stands (459,099 ha or 37%) were still rated at trace intensity, though this was down from 53% last year. Most of these low intensity stands were new infestations around Houston. Trace also occurred in northern Tweedsmuir Park in primarily grey stands. For the most part, the beetle had reached the western limit of interior pine from Tweedsmuir Park north to Morice Lake.

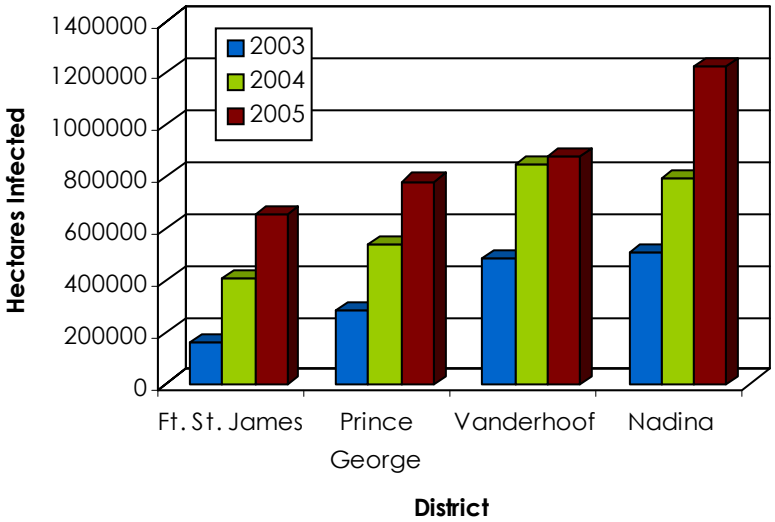


Figure 6. Hectares infested by mountain pine beetle from 2003 – 2005 in the Northern Interior Forest Region (districts with more than 600,000 ha affected in 2005).

Infested area increased only slightly in the Vanderhoof Forest District, from 846,868 ha in 2004 to 877,158 ha in 2005 (Figure 6). Attack in the Entiako protected area was up slightly as well to 77,888 ha of area affected in the district. Most of the mature pine in the southern portion of the district is now grey. This resulted in 207,121 ha (23%) of the stands being recorded at trace intensity, as opposed to only 10% last year. Younger stands including immature plantations are now being attacked and represented most of the severe to very severe rated stands in the south. Other very severe infestations were located north of Tatuk – Finger Lake and just north of Fraser Lake. Very severe intensity stands totalled 259,602 ha (30%), up sharply from only 4% in 2004.

Severe mountain pine beetle mortality southwest of Prince George

Attack in the Prince George Forest District in 2005 increased by almost half again the total recorded for last year, to 781,596 ha from 540,797 ha (Figure 6). Nearly all mature pine stands within the district were attacked, and the mountain pine beetle was rapidly invading young stands that were close to areas containing high beetle pressure. Infestations have moved further east and northeast in comparison to 2004, and previous attack west of Hwy. 97 between the Quesnel and Mackenzie Forest District boundaries have intensified. Stands rated at trace intensity were up to 358,141 ha (35%) from 24% last year, and very severe rated stands to 87,891 ha (11%) from only 1%. Correspondingly, light intensity stands were down to 186,726 ha (23%) from 43% in 2004. Moderate and severe classes stayed relatively constant at 163,741 ha (21%) and 78,497 ha (10%), respectively.

Stands affected by mountain pine beetle damage in the Fort St. James Forest District continued to rise rapidly, from 157,865 ha in 2003, 407,315 ha in 2004, to 651,372 ha in 2005 (Figure 6). The majority of the infestations are still at low attack levels (40% trace and 26% light intensity). There has been however a drop in the low intensity classes since 2004, with a corresponding 34% of the stands rated moderate to very severe, compared to only 13% last year. This reflects beetle population growth in the relatively new, large infestations mapped in 2004. Most of the attack continued to occur in the southern half of the district with some movement northward, particularly north and northwest of the Nation Lakes and the Northwest Arm of Takla Lake.

Four of the five remaining NIFR districts sustained a total of 143,267 ha of attack. Of these, the Mackenzie Forest District registered the highest level of damage, with 104,212 ha of attack in 2005, up from only 969 ha in 2003. Most of the recorded polygons were classified as trace (67%) with light at 29%, moderate at 3% and severe/very severe less than 1% intensity. Infestation movement was in a northward direction with the majority of the attack occurring between the southern

boundary of the district and the Omineca River to the north.

Affected area in the Skeena Stikine Forest District rose seven fold from last year to 23,345 ha of infested timber. Most of this (76%) was of trace intensity. In Kalum Forest District 99 ha of new infestations were recorded, primarily in two locations at 115km on Hwy 97 and in the Copper River drainage.

A large portion of the provincial mountain pine beetle control efforts are now focussed in the Peace Forest District. Attack in this district rose sharply, from a few small spots observed initially in 2003 to 18,601 ha in 2004. Infestations fell to 15,611 ha in 2005. Over 90% of the infestations remained in the trace to light range, and were scattered at mid to higher elevations across the north-eastern slopes of the Rocky Mountains. Additional mortality was recorded east of Tumbler Ridge and on the plateau north and east of Chetwynd.

There is serious concern that if these infestations continue unchecked, mountain pine beetle could move across Canada in the large expanses of jack pine forests. To prevent this expansion, a mountain pine beetle Memorandum of Agreement (MOA) was reached in the spring of 2005 between the provincial governments of BC and Alberta (AB) to address the infestations in the Peace Region. Following the signing of the MOA, the federal government announced that it would contribute a grant of $100 million to aid the BC Government's efforts to mitigate the effects of the mountain pine beetle. About $21 million was allocated over three years directly to spread control efforts along the BC-AB border. In the Peace Forest District, extensive harvesting and access development are ongoing to control larger, accessible infestations. Smaller and inaccessible infestations are being controlled with a large fall and burn program (approximately $11 million dollars) consisting of traditional treatment on site and trials with helicopter extraction and burning at landings.

Ground surveys in the Peace Forest District indicate that the population is not growing quickly and is actually decreasing in some areas. Approximately 40% of the beetles were on a two year or possibly even three year cycle. Attacked trees were taking a long time to turn red (up to two and a half years), and about 20% of the attacked trees pitched out the beetle. The percentage of current attack that brood developed in before winter was only about 25%.

During ground surveys, an interesting phenomenon was discovered: the blue stain fungus that is associated with mountain pine beetle attack is not present in all the dying trees. No pattern has been determined for this. An attacked tree with blue stain is often observed adjacent to an infected tree that does not have the fungus. Dr. Colette Breuil of the University of BC and the Peace DFAM group are jointly conducting research into this unusual trend.

Weather patterns unfavourable to mountain pine beetle survival have continued in the Peace Forest District, with three extreme temperature fluctuations over a very short time period occurring in February, March and November of 2005. This resulted in larval mortality that ranged from 19% to 92%, with an average of 80%. The same weather events were noted in the Mackenzie Forest District.

As part of the strategy to minimize mountain pine beetle spread from BC to AB, beetle control activities are being implemented in the affected parks near the border. Management actions include fall and burn at Elk Lakes, Mt. Robson, Kakwa, Monkman,

Wapiti Lake and Willmore Parks. Additionally, tree removals and planning for future prescribed burns will be undertaken in Mt. Robson Park. Alberta's Willmore Park fall and burn program of approximately 6,000 trees is particularly difficult logistically, as no housing is available for crews. This project will be conducted in the spring before beetle flight with a large camp set up for the workers.

Coast Forest Region Damage

Coast Forest Region (CFR) attack levels by the mountain pine beetle increased by a third to 285,675 ha from 212,620 ha in 2004. Within the CFR, infestations range from high elevation pine down to shore pine on the ocean. The majority of the mortality continued to occur in the North Island – Central Coast Forest District (256,281 ha), with 95.3% of the attack located in Tweedsmuir Provincial Park. Most of the pine in the park is now grey, which is reflected in 78% of the stands being classified as trace to light intensity.

In Chilliwack Forest District, infestations have increased 80% in one year to 18,389 ha of damaged stands. Active areas include the Mowhokam River drainage on the border with Cascades Forest District, and off the Coquihalla Hwy. at the Portia exit. Infestations total 11,006 ha in the Squamish Forest District. Efforts to control the beetle around Whistler have been discontinued, as beetle pressure from more northerly infestations has increased beyond management capabilities.

Dead shore pine in South Moresby National Park was noted during the flight of the Queen Charlotte Islands Forest District. The mortality was suspected to be caused by a bark beetle. This area will be ground checked in the summer of 2006 to confirm causal agent.

Beetle Flights

In the SIFR, mountain pine beetle flights were fairly well synchronized. They started in late July and ran into August, with some delays due to rainy weather. Flights were finished relatively early with cool fall weather, particularly in Kootenay Lake Forest District where it snowed on September 10th. Low to mid elevation flights were most successful, with less success at higher elevations. Larval instar development heading into winter was normal.

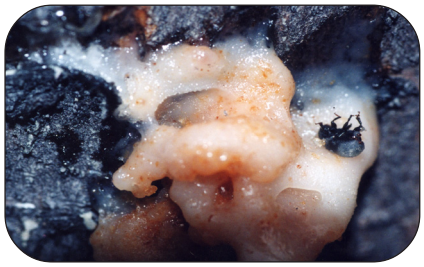
Rain was prevalent in the NIFR during regular beetle flight times but flights occurred in-between the predominantly afternoon rainy periods. Flights began in July and continued intermittently when weather permitted through August. When flights occurred beetles were plentiful, as observed by millions of beetles washing up on the shores of Frank Lake south of Vanderhoof. Larval development was variable going into winter. In general, development was good (3rd instar) in the southern portion of the region, and less advanced in the northern portion.

Mountian pine beetles on the shore of Frank Lake south of Vanderhoof

Mountain pine beetle flights were not monitored in the CFR, but it was suspected that a synchronized flight occurred at the end of July, with rain interrupting August flights.

Tree Response to Attack

With the drought conditions that much of the province experienced for several years finished in 2004, pine trees were better equipped to attempt to pitch out mountain pine beetle attack. Hence, formation of pitch tubes was relatively normal in 2005, compared to previous years. With the vigorous, synchronized attack however, trees were still quickly overwhelmed.



Mountain pine beetle pitchout

Early colour change of current "green" attacked trees in the fall instead of the following spring was also less prevalent than in the past few years, though it is still occurring province wide. The noted exception (as in 2004) was the southern portion of the Prince George Forest District and the lower elevations of the Cariboo, where up to 80% of the trees were showing chlorotic symptoms by the end of September.

Green:Red Ratios

Attacked trees usually remain undetectable from the air until the year after attack, since the foliage tends to stay green until then. Ground surveys are therefore required to determine the number of newly attacked trees for each aerially detected red tree. This statistic, called the green:red (G:R) ratio, is an important tool for projecting the growth rate of the mountain pine beetle population for a given area. Forest managers can use this projection to develop operational plans and budgets for the upcoming year.

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 neighbouring sources, and may not be truly representative. This is particularly true in many areas with the extent of the present outbreak. Therefore, not all forest districts gathered this information in 2005.

For the districts that did gather G:R ratios, the data is summarized in table 4. Overall, ratios varied greatly, even within a given district. In addition to neighbouring beetle pressure, other factors such as elevation, aspect and control measures affected G:R

Table 4. Green to red mountain pine beetle attack ratios observed in 2005.

Region / District	High	Average	Low
NIFR – Fort St. James	-	5:1	1:1
Kalum	4:1	2.5:1	1:1
Mackenzie	26:1	4:1	1.3:1
Nadina	10:1	3:1	0.5:1
Peace	3.5:1	1.6:1	0.2:1
Skeena Stikine	10:1	4:1	<1:1
SIFR – Cascades	30:1	3:1	1:1
Central Cariboo	9:1	5.6:1	0.6:1
Chilcotin	15.7:1	8.1:1	8.1:1
Columbia	8:1	2:1	1:1
Headwaters	24:1	6:1	0.8:1
Kamloops	10:1	5:1	1:1
Kootenay Lake	-	3:1	<1:1
Okanagan Shuswap	3:1	2:1	1:1
Quesnel	24:1	11.2:1	3.2:1
Rocky Mountain	4.2:1	2.4:1	0.4:1
100 Mile	24:1	7.4:1	0.52:1

ratios. For example, the highest ratios in the Cascades Forest District were located below 1,500 m and the lowest ratios at elevations over 1,600 m.

In the NIFR, ratios indicated a range from declining beetle populations (<1:1) to very active populations (26:1). For the Peace Forest District, extensive surveying was conducted as this area is of high concern. The average G:R ratio for this district has risen from 0.8:1 in 2004 to 1.6:1 this year. However, the highest ratio was down to 3.5:1 from 6:1 last year.

In the SIFR, G:R ratios were highest in the 100 Mile, Cascades, Chilcotin, Headwaters and Quesnel Forest Districts. Ratios dropped significantly since last year for all districts except Headwaters Forest District (slight rise) and Quesnel Forest District (relatively stable).

Overall, growth rate projections from the G:R ratio results indicate that the mountain pine beetle populations will continue to expand in 2006, which beetle population models concur with.

Immature Pine Issues

In heavily infested areas of the province where the beetle has been active for several years, the majority of the mature pine stands have been killed leaving only less desirable hosts to be attacked. Over the last two summers, beetles have moved progressively into younger stands. This has been reported as particularly prevalent in the Prince George, Vanderhoof, Nadina and Quesnel Forest Districts. Ground reconnaissance of young stands with less than 1% red attack have been showing up to 80% current attack.

Young lodgepole pine attacked by mountain pine beetle

Lodgepole pine trees as young as 18 years and as small as 8 cm have been recorded as mass attacked. Planted or tended stands have experienced the most attack, but unmanaged young stands have also been damaged. Brood development has been observed in these small trees, but successful emergence seems to be primarily in the larger diameter stems.

The pine engraver bark beetle (*Ips pini*) is known to breed in lodgepole pine recently killed by mountain pine beetle. When pine engraver populations build, they can attack living trees, particularly if they are stressed. This has been documented to occur in the later stages of a mountain pine beetle outbreak, and has been observed this year in the Vanderhoof Forest District. When young stands are thinned they experience stress. Therefore, it has been recommended that spacing in young pine stands near large infestations be delayed until the beetle populations have collapsed.

An unforeseen impact of the outbreak is damage to young stands by Warren's root collar weevil (*Hylobius warreni*). The larvae of this weevil feed on roots of mature lodgepole pine, and the root collar of immature pine. With areas experiencing high mortality in the mature pine, the weevils are migrating into immature stands at higher numbers than previously seen. Informal ground surveys were carried out in Nadina Forest District

this year, and some plantations had upwards of 30% mortality due to root collar girdling. The University of Northern BC is planning on conducting research into this phenomenon in the spring of 2006.

The overall impact of the current mountain pine beetle outbreak on younger stands is still uncertain, but it could negatively affect estimates of mid-term timber supply as it was previously assumed that these stands would grow with minimal damage.

Other Impacts

In the high beetle population areas, various reports have been made of young to mature interior spruce trees being attacked by mountain pine beetle. Young black spruce trees were also noted as attacked in the southwest portion of the Prince George District. In these cases, main galleries were constructed, but no eggs were laid. The spruce trees tend to wall off the attack areas, and survive.

Extensive mortality is also negatively impacting many lodgepole pine forestry research trials throughout the province.

Mitigating Beetle Impacts

The government of BC has developed a *Mountain Pine Beetle Action Plan for 2005 – 2010* to mitigate mountain pine beetle impacts to forest values, communities and the provincial economy. The objectives of the action plan are:

- Ensuring long-term economic sustainability for affected communities.
- Maintaining and protecting public health, safety and infrastructure.
- Recovering the greatest value from dead timber before it burns or decays, while respecting other forest values.
- Conserving the long-term forest values identified in land use plans.
- Preventing or reducing damage to forests in areas that are susceptible but not yet experiencing epidemic infestations.

The full action plan is available on the MOFR website (http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/actionplan/2005/).

Pursuant to the objective of the action plan to recover the greatest value from dead timber, significant allowable annual cut (AAC) increases have been made by the Chief Forester of BC. The largest recent increase in 2004 totalled 4.9 million cubic metres for the Lakes, Prince George and Quesnel Timber Supply Areas (TSAs). When this is combined with previous uplifts for beetle control, the harvest level is approximately 80% higher than if a healthy forest management scenario had prevailed. The AAC for the Okanagan TSA was also increased by 27% in 2005 to 3.4 million cubic metres per year. AACs were also raised by 52% for Tree Farm License (TFL) 49 in the Okanagan Shuswap Forest District, and by 76% for TFL 53 in the Prince George Forest District.

To reduce the environmental impacts of this increased rate of harvesting, the Chief Forester recommended an increase in the amount of retention in proportion to the size of salvage openings (up to 25% for openings greater than 1,000 ha).

Innovative uses for the timber are being encouraged through awarding short-term forest licences. For example, Ainsworth Lumber was awarded a 15 year AAC of 4.7 million cubic metres from the Prince George and Quesnel TSAs with the requirement of constructing one or more state-of-the-art oriented strandboard facilities. Four other 10-year forest licences totalling 10.5 million cubic metres were awarded to CH Anderson and Partners to manufacture industrial wood pellets for use as sustainable biofuels in European thermal power plants.

Dothistroma needle blight, *Dothistroma septosporum*[1]

Dothistroma (redband) needle blight (*Dothistroma septosporum*) continued to be the most significant disease affecting forests in northwest BC. A dry early summer followed by rain throughout August in 2004 provided ideal conditions for infection, and resulted in a pronounced increase in foliage damage, visible in the spring of 2005.

Dothistroma needle blight damage is usually underestimated during the aerial overview surveys. This is due to the difficulty of seeing damage to older foliage after current needles have flushed, which is usually the case by the time the surveys are conducted.

Infected lodgepole pine was detected during the 2005 overview flight on 1,136 ha in Kalum and 554 ha in Skeena Stikine Forest Districts. Intensity of damage was approximately equally divided between moderate, severe and very severe. Area recorded as affected was far lower in 2004 at 6 ha. Although low-level aerial surveys were not conducted in 2005, it was felt that the increase noted in the overview surveys reflected an overall increase within these two districts. Additional damage was observed over a far greater portion of the NIFR from low-level helicopter flights and ground reconnaissance. Infected stands of primarily light intensity were noted in Fort St. James, Mackenzie, Prince George and Vanderhoof Forest Districts.

Severely affected stands continued to be highest in the Interior Cedar Hemlock (ICH) biogeoclimatic zone. Damage in the Sub-boreal Spruce (SBS) zone increased, and some stands were also affected in the Coastal Western Hemlock (CWH) zone.

Heavily damaged plantations in Skeena Stikine and Kalum Forest Districts were fill-planted in 2002 and 2003. Unfortunately, snowshoe hares damaged and killed a significant portion of the seedlings under the cover of brush and dying overstory trees. It appears that the hare population is high and not following a traditional cyclical pattern at present, probably due to adequate food and warmer weather patterns. Future plans for fill-planting have therefore been put on hold.

Considering the wet summer conditions of 2005 in the NIFR, dothistroma needle blight damage is expected to be high next year. Low-level aerial surveys conducted by the regional specialists are planned for the spring of 2006 to assess the extent of the damage.

Pine needle cast, *Lophodermella concolor*

In contrast to the widespread dothistroma outbreak, pine needle cast (*Lophodermella concolor*) remained at low levels in the SIFR with scattered damage recorded over 319 ha. Most of this was noted in the Kootenay Lake Forest District, where ground surveys revealed that repeat infections are posing an increasing problem to post free growing young pine. Stands in the wetter ICH biogeoclimatic zones have been most affected.

Pine needle cast was predominant throughout the Cariboo from 1998 – 2002. Almost 260,000 ha of damaged stands were recorded in 2002. Subsequent dry summers reduced infection levels substantially.

[1] Most recent literature refers to Dothistroma as *Dothistroma septosporum* instead of *Mycospaerella pini*. *Mycosphaerella* refers to the sexual stage but in the vast majority of cases the asexual stage dominates.

Damaging Agents of Douglas-fir

Western spruce budworm, *Choristoneura occidentalis*

Western spruce budworm (*Choristoneura occidentalis*) defoliation recorded across the southern half of BC in 2005 (Figure 7) dropped more than a third since last year to 463,962 ha. The majority of the defoliation continued to be light (77%), with 19% moderate and 4% severe. There was a slight rise in intensity ratings over 2004.

Over 99% of the defoliation occurred in the SIFR, with expansion continuing in some districts, while significant declines were recorded in others (Figure 8). For the third year, area affected was highest in the Central Cariboo Forest District, at 193,234 ha. This was however a drop of 43% from the record 276,312 ha infested in 2004. 100 Mile House Forest District had the second highest area of defoliation of 108,119 ha, but with the largest drop of more than half since last year. Damage in these districts was still widespread across the range of Douglas-fir. Infestation decreases were primarily in the northern half of the 100 Mile House District and the southwestern portion of the Central Cariboo Forest District. It was documented that the reduction in affected area was at least partly due to control measures.

After three years of relatively stable levels of defoliation in the Cascades Forest District, area affected jumped by more than a third to 92,293 ha. Primarily, damage occurred south of Merritt in the Tulameen, Coalmont, Allison Lake and Princeton areas, and in the Lillooet TSA around Carpenter Lake, Gunn Lake, Goldbridge and Yalokum areas. An interesting anomaly was recorded along the Coquihalla Hwy. south of Merritt where defoliation occurred in subalpine fir stands, just above infestations in Douglas-fir stands, which is usually the host species.

Although the area affected in the Chilcotin Forest District was only fourth highest province-wide, the rise in defoliation was the greatest, up to 57,893 ha from 28,536 ha in 2004, and only 25 ha in 2003, when defoliation was first recorded in this district. The proportion of moderate to severe defoliation is also the highest at 63%, or 36,315 ha. Infestations follow the low elevation valleys in this district where Douglas-fir grows, all the way from the eastern district boundary to Bull Canyon past Alexis Creek.

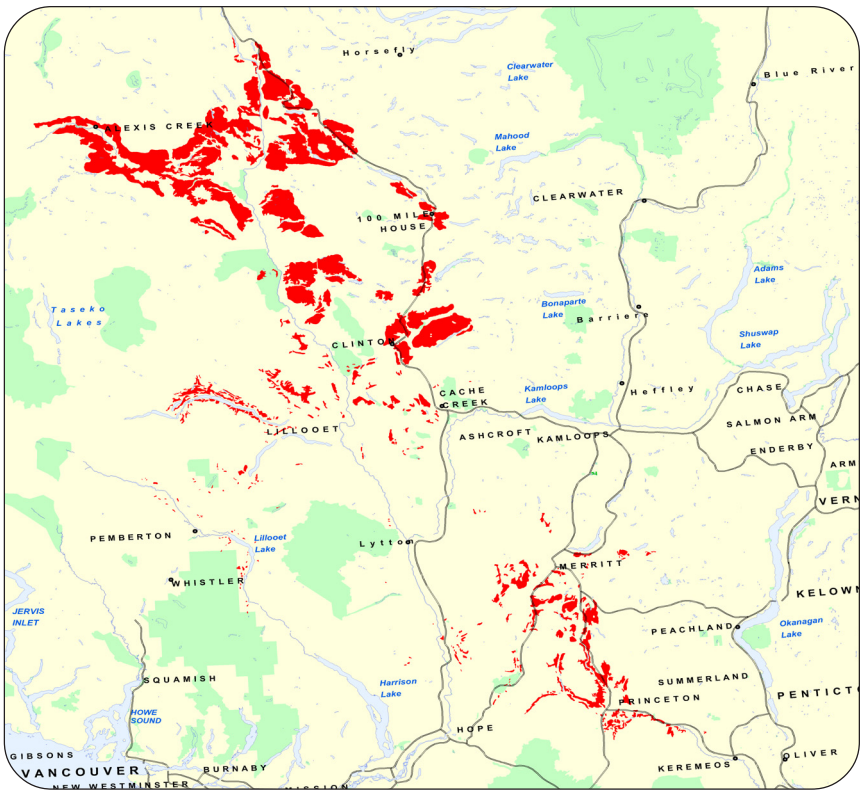


Figure 7. Areas in BC defoliated by western spruce budworm in 2005.

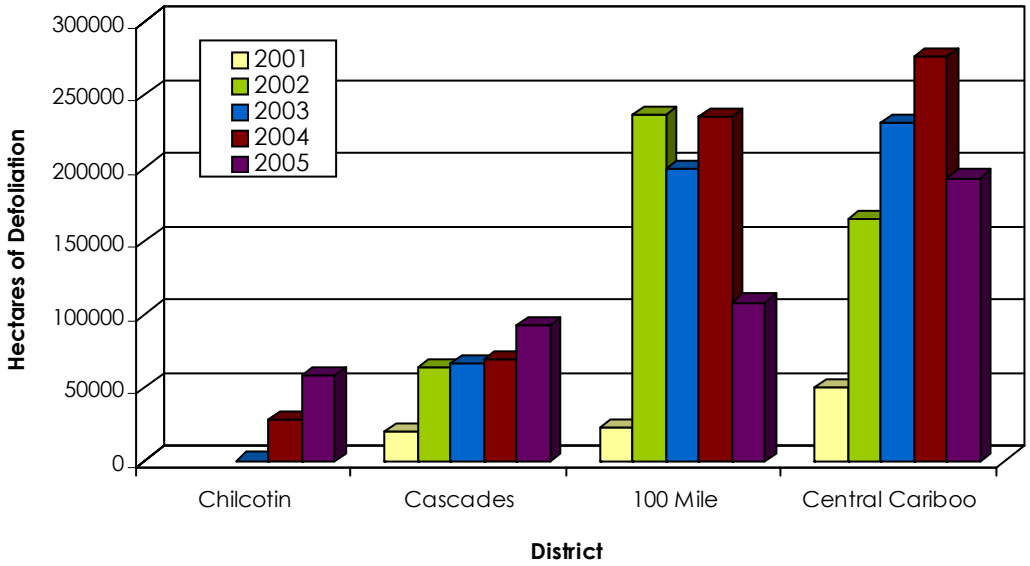


Figure 8. Hectares of western spruce budworm defoliation from 2001 – 2005, for districts with over 50,000 ha affected in 2005.

Other infestations in the SIFR are primarily light, and are mostly located in the Kamloops Forest District (6,725 ha), with small areas of 74 ha in each of the Quesnel and Okanagan Shuswap Forest Districts.

The current outbreak in the CFR is continuing a downward trend, from a peak of 16,203 ha damaged in 2003 to 5,551 ha in 2005, of which 84% was recorded as light defoliation. Affected areas in the Squamish Forest District totalled 2,539 ha and were located around Pemberton, Anderson Lake, Lillooet Lake, Birkenhead and Haylmore. In the Chilliwack Forest District, 2,643 ha were damaged, including a new infestation in the Coldwater area by the Coquihalla Hwy.

Egg mass surveys conducted in the fall predict significant (moderate to severe) defoliation for next year in various locations (Table 5). In the Lillooet TSA, areas west of Cache Creek in the Pavilion Lake, Hat Creek and Cornmall Creek are of concern. South of Merritt, areas around Voght Creek, Kane Valley Creek, Lindley Lake, Kingsvale and Kwinshatin Creek also had significant defoliation predictions. Egg mass numbers were high in some areas around Princeton, especially in the lower Tulameen River and Hayes Creek areas. In 100 Mile House Forest District sites with moderate to severe predictions were at a five year low, but areas of concern still existed west of 100 Mile House, north of Canoe Creek, and from Clinton through Loon Lake. Central Cariboo Forest District sites of concern were also down, and were located around Gaspard Creek, Meldrum Creek, Riske Creek and just west of Williams Lake. Heavy defoliation was predicted for the Chilcotin Forest District north and south of Hanceville, around Kloh Lake, east of Haines Lake and just east of Alexis Creek. With the decreasing defoliation in the CFR, no egg mass sampling was conducted this year.

Direct control with the biological control agent *Bacillus thuringiensis* var. *kurstaki* (*Btk*) is a management tool often utilized in high value stands that have sustained significant defoliation and have predictions of moderate to severe defoliation for the following year.

In the spring of 2005, a treatment program with *Btk* was

Table 5. Summary of 2005 western spruce budworm eggmass survey results.

Predicted 2006 Defoliation	Forest District				
	100 Mile	Cascades (Merritt)	Cascades (Lillooet)	Central Cariboo	Chilcotin
Nil Sites	1	1	1	3	-
Light Sites	74	74	8	49	2
Moderate Sites	18	24	23	14	1
Severe Sites	2	3	8	3	7
Total Sites	95	102	40	69	10

conducted in four forest districts. The largest area was in the Williams Lake Forest District, north and south of Williams Lake, in seven blocks totalling 15,819 ha. In 100 Mile House Forest District, a total of 7,743 ha were treated over seven blocks scattered around Dog Creek, west of Meadow Lake, and west of Chasm. Chilcotin Forest District had 4,470 ha in two blocks near Hanceville, and 2,387 ha were treated in four blocks north of Princeton in the Cascades Forest District.

Aerial application was conducted with helicopters. Two Lama AS315B's and two Hiller UH12ET's were utilized. One Lama was equipped with a Simplex spray system with four Micronaire® AU 4000 rotary nozzles, and the remaining helicopters were outfitted with a Western Aerial spray system with four Beecomist® rotary nozzles. One application of the *Btk* product Thuricide® 48L V was applied at a rate of 2.4 l/ha.

The treatments were successful, with egg mass counts predicting primarily low defoliation for 2006 within spray blocks. Areas of concern noted during the fall egg mass surveys will be evaluated in the early spring to determine if they require budworm population control. A treatment program is anticipated for late spring in various areas throughout the SIFR.

Lama helicopter at treatment staging site

Douglas-fir beetle, *Dendroctonus pseudotsugae*

Douglas-fir beetle (*Dendroctonus pseudotsugae*) attack rose provincially for the third year in a row to 42,752 ha affected, after a four-year low of 9,078 ha in 2002. The majority (86%) of the recorded damage was located in the Cariboo. Ground surveys produced a G:R ratio average of 2.5:1 for this area, which indicated a rising population. Infestations tended to correlate with areas of western spruce budworm defoliation, which is suspected to have predisposed the trees to Douglas-fir beetle attack. Root disease also seems to be a factor on some sites.

Central Cariboo Forest District showed a steady four-year climb to 20,389 ha affected. Detailed helicopter flights in the fall recorded 2,500 sites ranging from 2 to 200 attacked trees. Most of the damage was located in the Gaspard Creek area (large patches), northwest of Williams Lake (north of the military reserve), and along the Fraser River corridor in small patches. Some areas contained upwards of 100 current attack and no red attack.

The largest increase in infested area occurred in the Chilcotin Forest District, from 3,069ha in 2004 to 13,234 ha. Infestations were located from Hwy. 20 to the Chilcotin River and along its tributaries. 100 Mile House Forest District also experienced significant damage with 3,054 ha affected. Overview survey numbers have been slowly decreasing in this district over the past two years, but detailed helicopter flights still recorded 762 infestations. Areas of concern were around Canim, Horse, Deka – Bowers Sheridan, Young, Loon and Kelly Lakes, as well as Canoe Creek.

Rocky Mountain and Arrow Boundary Forest Districts had scattered infestations totalling 1,802 ha and 1,637 ha, respectively. For the remainder of the SIFR, Douglas-fir beetle infestations remained endemic, with only a few hundred hectares at most affected in each of the Cascades, Columbia, Kamloops, Kootenay, Headwaters and Okanagan Shuswap Forest Districts. Most infestations of concern resulted from trees damaged by the wildfires of 2003. Recorded attack dropped sharply in Quesnel Forest District, from 2,415 ha in 2004 (mostly trace intensity) to less than 1 ha.

In the CFR, scattered mortality due to Douglas-fir beetle decreased, with a total of 1,586 ha affected. The attack was located primarily in the Chilliwack, North Island – Central Coast and Squamish Forest Districts.

Less than 1 ha of attack was recorded in the NIFR, in the Prince George Forest District. In this district and the Vanderhoof Forest District, Douglas-fir is usually reserved on harvested blocks, and a portion of this tends to blow down and result in a beetle problem from time to time. It is suspected that more Douglas-fir beetle mortality was present in 2005 than recorded, but was likely masked by surrounding mountain pine beetle attack.

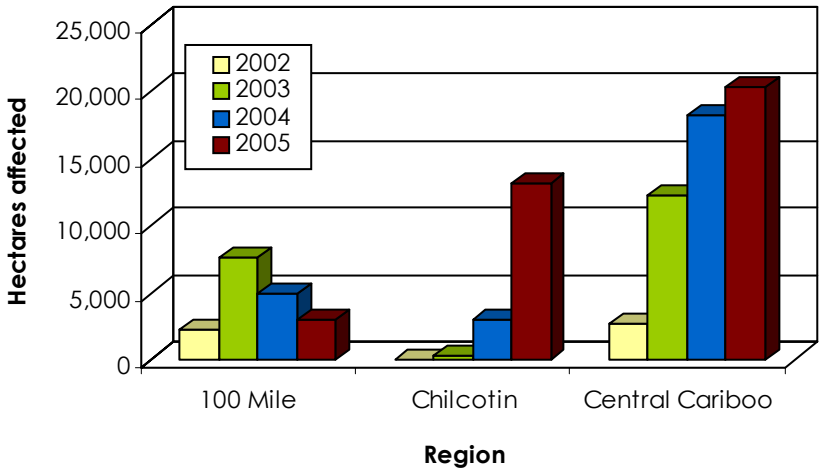


Figure 9. Hectares affected by Douglas-fir beetle in BC from 2002 – 2005, for districts with over 3,000 ha of damage in 2005.

Douglas-fir tussock moth, *Orgyia pseudotsugata*

Douglas-fir tussock moth (*Orgyia pseudotsugata*) is monitored by the MOFR through the use of annual pheromone trapping sites in high hazard areas of the Cascades, Kamloops, Okanagan Shuswap and 100 Mile House Forest Districts. This system provides early warning of a rising population before significant defoliation occurs.

Trap catches of over 25 moths per trap for two to three years indicates an outbreak is likely. Over the past seven years, trap catches have varied considerably within the monitored forest districts (Table 6). Trap numbers also varied greatly within districts, as Douglas-fir tussock moth outbreaks are often localized.

Kamloops Forest District showed a steadily increasing average population for four years through 2003, followed by two years of declining numbers. Defoliation of 19 ha was mapped during the overview survey in the Scheidam Lake area.

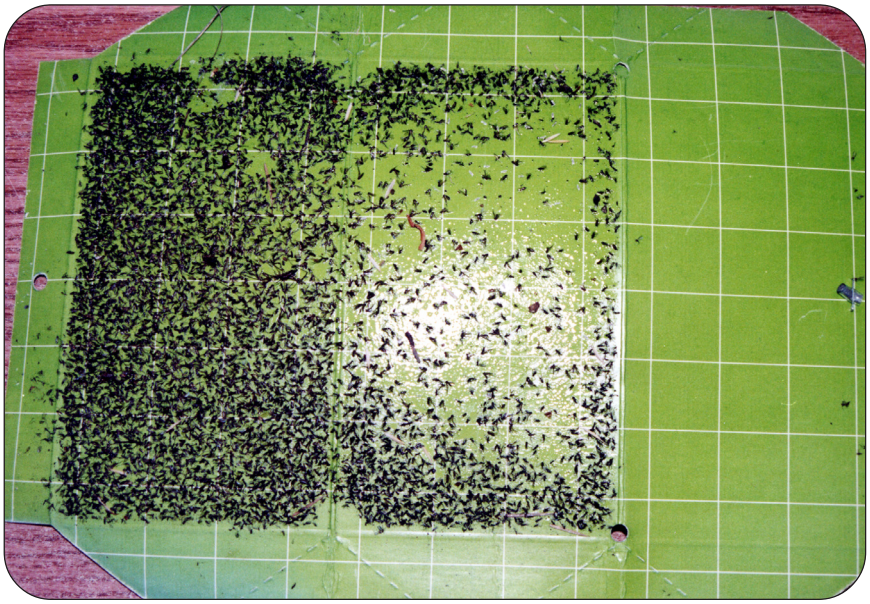
Trap catches in the Okanagan Shuswap Forest District peaked in 1998, then slowly declined. An area of 36 ha of defoliation was recorded for 2005 just outside of Vernon, adjacent to a trap site that was close to or exceeded outbreak threshold numbers for four years. Subsequent ground surveys however found very few egg masses, and it is suspected that a nucleo-polyhedrosis virus caused the population decline.

Table 6. Average number of Douglas-fir tussock male moths caught per trap, 1999 – 2005.

Year	District			
	Kamloops	Okanagan Shuswap	Cascades	100 Mile House
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

Cascades Forest District trap catches show a trend similar to the Okanagan Shuswap Forest District sites, but with no defoliation recorded. In 100 Mile House Forest District, overall trap catches were at a seven-year low. Catches may have been artificially low, as gnat populations were at epidemic levels and saturated the traps.

Douglas-fir tussock moth larva



Gnats in Douglas-fir tussock moth pheromone trap

Damaging Agents of Spruce

Spruce beetle, *Dendroctonus rufipennis*

Spruce beetle (*Dendroctonus rufipennis*) severity and hectares affected are difficult to determine accurately with the aerial overview survey. Under-estimations occur because newly killed trees appear dull yellow or purplish-red in colour at best, and often just change rapidly from green to grey. Subtle foliage colour changes can also be caused by other factors like heavy cone crops or two-year cycle budworm defoliation. Colour change is often only observable for a few weeks, and timing of the change can vary year to year. This short window may not coincide with the aerial survey dates. Drastic changes in area affected from one year to the next can be related to these observation difficulties and/or to the 2-year cycle of the spruce beetle.

These large changes in damaged area were again the norm as recorded during the 2005 overview surveys (Figure 10). Provincially, spruce beetle attack dropped for the second year in a row, from 315,953 ha in 2003 to 55,628 ha this year.

The majority of the attack (41,199 ha) was situated in the SIFR. Intensity levels were well distributed, with 18% trace, 35% light, 26% moderate, 17% severe and 4% very severe. Infestations were highest in the 100 Mile House Forest District, where 12,724 ha were affected, down from a high of 21,152 ha in 2003. The majority of the attack occurred in the Hendrix Lake, Bosk Lake and Spanish Creek areas. Sanitation harvesting is occurring in these infestations. Area damaged by spruce beetle dropped by almost three fold from 2004 in the Central Cariboo Forest District to 10,610 ha, but this still was the second highest area of attack recorded for the province. Areas of concern were around Horsefly Mountain, Bouldry Creek and Bill Minor Creek. Headwaters Forest District sustained the third highest level of damage, where infestations jumped from 3,012 ha last year to 9,996 ha. Attack near Kinbasket Lake will be salvaged in the near future.

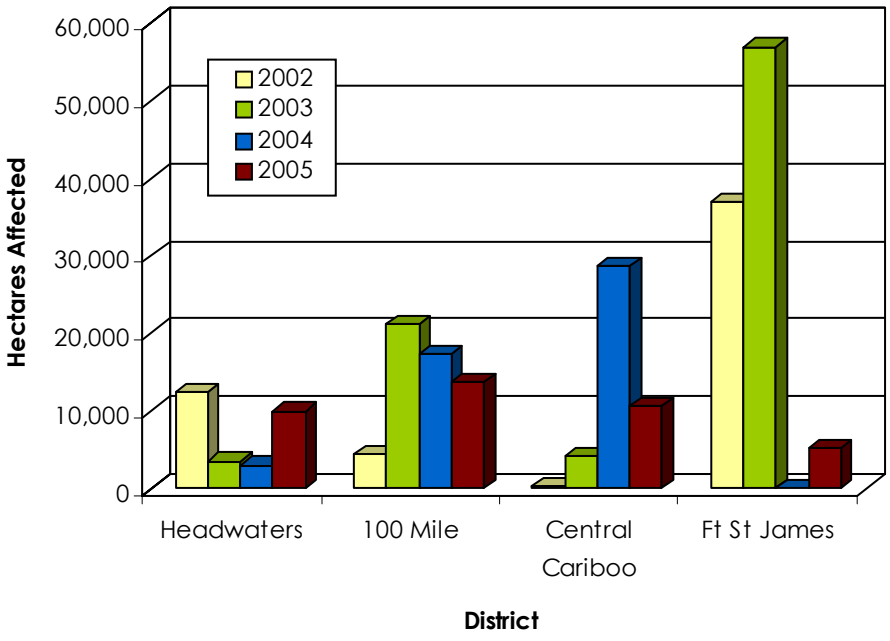


Figure 10. Hectares affected by spruce beetle in BC from 2002 – 2005, for districts with over 5,000 ha of damage in 2005.

Two other districts in the SIFR had spruce beetle attack levels of note in 2005. Area affected in the Cascades Forest District remained virtually unchanged from 2004 at 3,114 ha. Most areas of concern were in the Lillooet TSA. Infestations dropped drastically in the Quesnel Forest District to 2,613 ha from 22,551 ha last year. However, significant current attack that is still green has been reported from ground surveys in the Haoran Creek, Mount Anderson and

Benson Lakes areas. These infestations resulted from a strong windstorm that caused scattered blowdown in the area two years ago. All other districts in the SIFR reported endemic levels of spruce beetle attack, ranging from 321 ha to less than a hectare.

In the NIFR, Fort St. James Forest District had the highest level of damage from spruce beetle with 5,320 ha of attack. Recorded infestations in this district have fluctuated rapidly over the past few years (Figure 10). Primary locations of infestations were southwest of Kloch Lake and north of Stuart Lake. It was difficult to delineate between 2-year cycle budworm defoliation and spruce beetle attack in this district. The Peace and Nadina Forest Districts had 1,981 ha and 1,939 ha affected, respectively, mostly along river valleys. A large area of blowdown from 2004 at Maxan Lake in the Nadina Forest District is of concern for building spruce beetle populations. Endemic levels of attack were noted in the Fort Nelson, Mackenzie, Prince George and Skeena Stikine Forest Districts. Intensity levels of infestations in the NIFR were lower than in the SIFR, with 76% trace, 12% light and 12% moderate.

Spruce beetle in the CFR damaged a total of 4,983 ha, with very low intensity levels recorded (49% trace and 51% light). The majority of attack (84%) was found in the North Island – Central Coast Forest District, which was more than double the amount identified last year. Infestations were located in the Dean River drainage, at Owikeno Lake and scattered patches within the Coast Mountains between the Dean River and Knight Inlet. Other infestations occurred in Chilliwack and Squamish Forest Districts in the Haylmore Creek area, near Chilliwack Lake, within Manning Park and in the mountains to the east of Lillooet River.

Chip cocoons formed by white pine weevil larvae

White pine weevil, *Pissodes strobi*

Despite its' common name, the primary hosts for the white pine weevil (*Pissodes strobi*) are Sitka, white, and Englemann spruce and their hybrids. The weevil causes top kill and subsequent stem deformities, which seriously affects regenerating stands. The damage is too subtle to be seen during the overview surveys.

An interesting trend, which is being studied by Angus Shand of the CFS, has been noted in white spruce stands in the Fort Nelson Forest District. Stands in the river valley bottoms sustain plentiful white pine weevil attack at varying densities, yet up on the plateau, stands are only minimally affected. It is suspected that weather differentials may be a factor, as it is significantly warmer in the summer in the river valley bottoms but colder in the winter, as compared to the plateau. The stands in question range from 15 to 30 years in age.

Damaging Agents of True Fir

Eastern spruce budworm, *Choristoneura fumiferana*

An outbreak by the eastern spruce budworm (*Choristoneura fumiferana*) defoliated vast areas of white spruce (1.6 million hectares in 2001) in the north-eastern portion of BC for many years until 2004, when recorded defoliation dropped significantly to 25,263 ha in the Fort Nelson Forest District and 4,385 ha in the Peace Forest District. This year, defoliation was at endemic levels, recorded at light to moderate intensities over only 703 ha in the Fort Nelson Forest District.

Sampling of overwintering early instar larvae is conducted annually at six survey sites in the Fort Nelson Forest District, to predict expected defoliation levels for the following spring. Larval densities dropped sharply in 2002 and again in 2003, and no larvae were found over the past two years. Three sites this year (Liard and two at Snake River) showed trace defoliation on the samples, and the other three (Clarke Lake, Kotcho and Muskwa) showed no defoliation. These results indicate that defoliation will be negligible again in 2006.

2-year-cycle budworm, *Choristoneura biennis*

Provincially, 2-year-cycle budworm (*Choristoneura biennis*) defoliation has been low over the past four years, when compared to the peak years of 1999 to 2001. Northwest of Prince George Forest District the 2-year-cycle budworm is on an odd year cycle; hence 2005 was the second year in the budworm life cycle for this area. In Fort St. James Forest District, 5,457 ha of light defoliation were recorded. Aerial surveys were conducted in August for this district and much of the defoliation was not evident from the air, especially after a summer of multiple rain events washed off much of the damaged foliage. Ground checks confirmed a more widespread problem, particularly on understory trees. It was estimated that infested hectares were five times that aerially sketched. Main areas of damage were located towards Tchentlo Lake and in the Ominica and Ominicetla valleys. Defoliation recorded in Mackenzie Forest District in 2003 was not apparent this year.

2-year-cycle budworm defoliation

From Prince George Forest District south, the 2-year-cycle budworm is on an even year cycle. Therefore, defoliation was down significantly from 51,171 ha last year to only 1,998 ha in 2005. All recorded defoliation was located in the Headwaters Forest District, and was of light intensity.

2-year-cycle budworm pupa

Western balsam bark beetle, *Dryocoetes confusus*

Western balsam bark beetle (*Dryocoetes confusus*) damaged over 1.4 million hectares in 2005 across BC. Intensity of attack was recorded at 81% trace, 16% light, and 3% moderate. This reflected a drop from the 2 million hectares recorded in 2004, to levels very similar to those in 2003.

Since 2004, base maps included previous year's western balsam bark beetle polygons to both save time in mapping large and extensive polygons and to improve incidence estimates. Surveyors verified the existing polygon boundaries and severity classes and, in many cases, these changed very little since the previous year due to the chronic nature of the damage.

The majority of western balsam bark beetle attack occurs in districts that have the largest amount of mature sub-alpine fir. Most of these are in the NIFR. Affected area dropped slightly in the Mackenzie and Fort St. James Forest Districts, to 451,792 ha and 386,882 ha, respectively (Figure 11). Attack recorded across BC has been highest in these two districts for four consecutive years. The Skeena Stikine Forest District damage levels remained fairly constant with last year, at 183,689 ha affected. Levels of attack in the Nadina Forest District dropped 50% from 2004 to 117,087 ha. Infestations in the Peace and Prince George Forest Districts remained relatively stable and similar in size, at 110,537 ha and 93,398 ha, respectively. Area damaged in Kalum and Fort Nelson Forest Districts both dropped slightly to 45,569 ha and 40,756 ha each. Attack in Vanderhoof Forest District was lowest of the NIFR districts at only 2,643 ha, reflecting the low proportion of this species in the timber inventory.

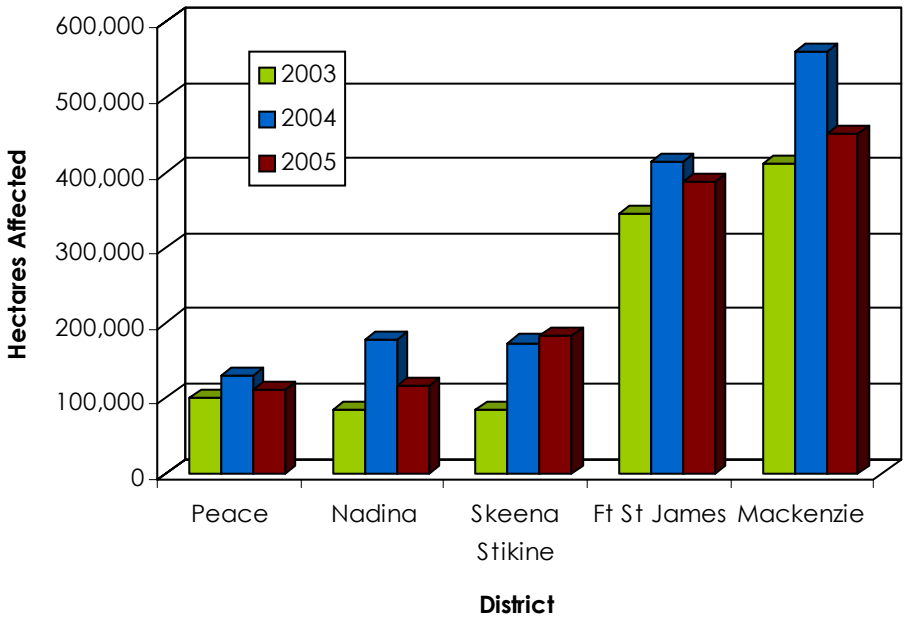


Figure 11. Hectares affected by western balsam bark beetle in BC from 2002 – 2005, for districts with over 100,000 ha of damage in 2005.

In the SIFR, infestations in the Headwaters Forest District were the highest at 96,175 ha, virtually the same level as in 2004. Area affected in the Okanagan Shuswap Forest District rose for the third year in a row to a total of 77,086 ha. Quesnel Forest District had the third highest level of attack at 70,741 ha, down just slightly from 2004. The Central Cariboo, Rocky Mountain and Chilcotin Forest Districts experienced similar damage levels, with 25,209 ha, 21,882 ha and 21,718 ha affected, respectively. Attack in the six other SIFR districts ranged from 15,446 ha to 7,757 ha.

Western balsam bark beetle damage in the CFR primarily occurred in the North Island – Central Coast Forest District, where 28,861 ha were affected, almost half the total recorded in 2004.

Delphinella tip bight, *Delphinella balsameae* and *D. abietis*

The fungal disease Delphinella tip blight is caused by the pathogen *Delphinella balsamaea* and *D. abietis*, which damages current shoots of sub-alpine fir. The needles are only bright red for a short period in the spring, so the damage is easily missed and was not picked up during the aerial surveys.

Ground surveys over the past eleven years have recorded Delphinella tip blight in various locations. These include the Mackenzie and Central Cariboo Forest District, the ESSF biogeoclimatic zone of the Robson valley and cooler microsites of the SBS biogeoclimatic subzones in the eastern portion of the Prince George Forest District.

Infections appear to be on the rise, and an interesting damage pattern has been noted. Scattered clusters of two or three affected trees within stands have grown to four or five damaged tree clusters. Damage is very localized and can be quite high within the clusters, yet neighbouring trees are not affected at all.

Fir engraver beetle, *Scolytus ventralis*

The fir engraver beetle (*Scolytus ventralis*) is a damaging agent of true firs and occasionally Douglas-fir and spruce in southern BC. Scattered mortality of grand fir at lower elevations has been ongoing for some time, particularly in the Arrow Boundary Forest District. Mortality caused by the fir engraver beetle is difficult to determine during aerial surveys, and it is often mistaken for Douglas-fir beetle.

A total of 1,359 ha of attack were delineated during the 2004 surveys, primarily in the Arrow Boundary Forest District. This year, the total rose to 2,483 ha of mostly light intensity mortality. The increase was mainly attributed to 1,589 ha affected in the Rocky Mountain Forest District. Several of these infestations had been re-categorized from other bark beetle damage after ground confirmation checks. The remaining attack occurred in the Arrow Boundary, Kootenay Lake and Columbia Forest Districts.

Fir engraver beetle has also been active in grand fir along the east coast of Vancouver Island (from Victoria to Sayward) for the past several years, though it has not been noted in the aerial surveys. Individual and small clumps of scattered trees were attacked, primarily on private land.

Top kill and tree mortality caused by fir engraver beetle

Damaging Agents of Hemlock

Western hemlock looper, *Lambdina fiscellaria lugubrosa*

Western hemlock looper (*Lambdina fiscellario lugubrosa*) outbreaks tend to be predictable in length: populations rise in the first year but very little defoliation occurs; in the second year significant defoliation is recorded; in the third year infestations coalesce and defoliation peaks, followed by heavy egg parasitism and a collapse in the fourth year.

This cycle was illustrated in the largest recent infestation in BC which occurred in the Columbia Forest District, primarily around the Revelstoke Lake area (Figure 12). The peak year was 2003, and other infestations in the SIFR followed this pattern as well. Both hectares of defoliation and the number of moths caught at pheromone trapping sites (Table 7) reflected a population collapse in 2004. This trend has continued for most of the SIFR in 2005. Defoliation was primarily light intensity (98%), with 1,441 ha recorded for the Columbia Forest District.

The only other district in the SIFR with defoliation in 2005 was Headwaters Forest District, where affected area rose sharply from 23 ha in 2004 to 2,291 ha in 2005. Previous mortality caused by the western hemlock looper occurred along the main Robson Valley, and the new defoliation was located up side drainages in spotty infestations, particularly along the Morkill River. Moth catches rose slightly in this district, but did not indicate outbreak populations at the trap sites (Table 7). It is possible this defoliation was the result of another insect, as ground confirmation was not conducted.

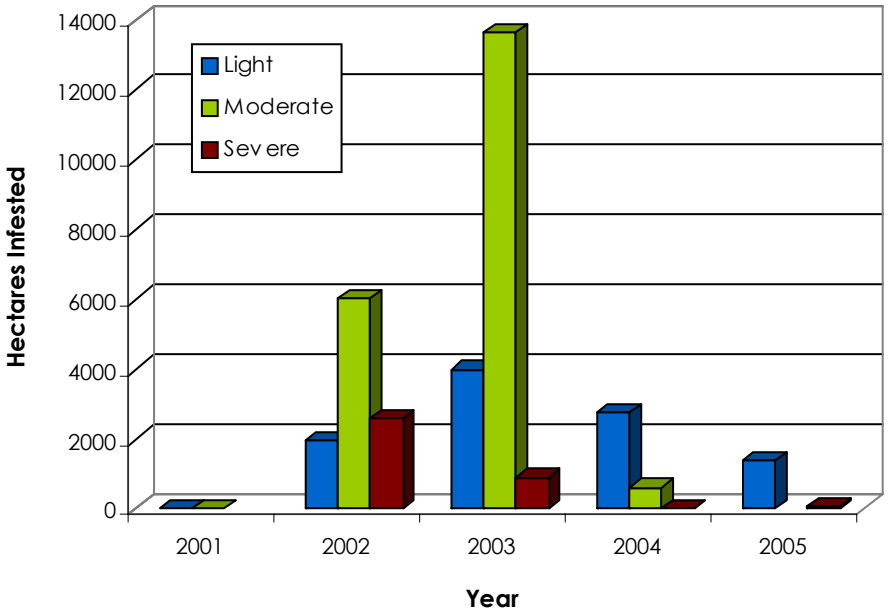


Figure 12. Hectares defoliated by western hemlock looper in the Columbia Forest District, from 2001 to 2005.

Populations in the CFR collapsed a year or more previous to the SIFR outbreak, with no defoliation reported in 2005.

Western hemlock looper larval sampling and pheromone trapping of male moths has been conducted in various hemlock stands from McBride down through the Lower Mainland in BC over the last 14 years by CFS personnel. Nicholas Conder reported on the 2005 results in comparison to previous years. As indicated by the MOFR trap results, the CFS found that overall trap catches in the interior (North Thompson, McBride, Prince George and Horsefly areas) were very low and in most cases down substantially from 2004 levels. Lower mainland collections (Coquitlam Watershed and UBC Research Forest) remained at low levels similar

to those in 2004. Only traps at Strathcona Park on Vancouver Island showed a slight increase over last year, but numbers were still well below the threshold where an outbreak appears imminent.

CFS data suggests (no statistical analysis has been done to date) that when trap catches reach 200 – 300 moths per trap, followed by a two to three fold increase the following year, an outbreak accompanied by visible defoliation will occur the next year. Their data also indicate that three-tree larval beating sampling is useful for monitoring parasitism and disease but it is not as good an indicator of outbreaks as traps baited with pheromone lures.

Table 7. Average number of western hemlock looper male moths caught per trap at various MOFR sites (6-trap clusters per site), 2002 - 2005.

	Year			
Forest District (No. sites)	**2002**	**2003**	**2004**	**2005**
Headwaters (5)	307.4	79.2	7.5	9.2
Okanagan Shuswap (10)	627.4	878.9	45.3	8.0
Columbia (10)	No traps	No traps	4.8	1.2

Hemlock looper larva

Damaging Agents of Larch

Larch needle cast (pathogen *Meria laricis*) infects needles of western larch of all ages. Needles of the lower crown sustain the greatest damage and are shed in the same year they die. In the southeastern corner of the province, a total of 703 ha were lightly affected in 2005. Most of the damage (595 ha) occurred in the Kootney Lake Forest District. The remaining affected stands were noted in the Rocky Mountain Forest District.

Larch needle diseases

No larch needle diseases were recorded last year, but in 2003 32,478 ha of larch needle blight (*Hypodermella laricis*) were mapped in four of the southern-most districts in the SIFR. Larch needle cast and needle blight often occur together. Larch needle blight differs in that black fruiting bodies are visible, and most infected needles are retained for up to two years after healthy foliage is shed in the autumn.

Larch casebearer, (*Coleophora laricella*) defoliation was also noted during ground surveys this year in the Kitchener area of the Kootenay Lake Forest District.

Damaging Agents of Deciduous Trees

Large aspen tortrix, *Choristoneura conflictana*

Large aspen tortrix (*Choristoneura conflictana*) reached an outbreak peak throughout the NIFR in 2003, when 794,303 ha were affected. Since then, area of damage has been on the decline with 429,526 ha recorded in 2004 and 132,494 ha in 2005. It was noted during ground checks this year that fresh growth of new leaves was masking earlier damage. An early spring led to earlier defoliation in June, and as surveying in affected districts did not commence until mid July, attack levels may have been higher than recorded. Attack intensity was classified as 76% light, 23% moderate 1% severe.

During the present outbreak, large aspen tortrix defoliation has affected more hectares than any other forest health agent in the Fort Nelson Forest District. Recorded damage actually rose slightly from a low for the past three years of 85,109 ha in 2004 to 89,360 ha in 2005. Previously, this district had the highest level of attack in the NIFR at 460,464 ha in 2003.

The highest level of attack last year occurred in the Peace Forest District (287,139 ha affected), but 2005 levels dropped sharply to 22,351 ha. Most of the attack occurred along Highway 97 between Chetwynd to Dawson Creek.

Large aspen tortrix defoliation rose to 24,254 ha in the Prince George Forest District last year, but dropped again this year to 15,895 ha. Most of the attack was east and west of McLeod Lake.

In the Mackenzie Forest District, defoliation declined for the 2nd year to only 4,395 ha. Attack was observed northwest of McLeod Lake. The remaining 492 ha of mapped defoliation was located at the southern end of Stuart Lake in the Fort St. James Forest District.

Defoliation caused by birch leafminer

Birch leafminer, *Fenusa pusilla*

After a high of 22,507 ha affected across BC in 2003, birch leafminer (*Fenusa pusilla*) defoliation dropped substantially to only 672 ha in the Kamloops Forest District in 2004. Populations slowly rose again in 2005, with 2,842 ha damaged in the SIFR. Primarily moderate intensity defoliation was recorded in the Kamloops and 100 Mile House Forest Districts, at 1,498 ha and 1,169 ha, respectively. The remaining 86 ha were located in the Okanagan Shuswap Forest District.

Defoliation attributed to birch leaf miner is often a complex of various insects, including the birch leaf miner. Bronze birch borer (*Agrilus anxius*) has been identified as well in trees weakened by previous defoliation and drought in the Kootenay Lakes Forest District. South of Argenta in this district, many mature birch trees have been observed to be suffering dieback and mortality.

Gypsy moth, *Lymantria dispar*

The North American strain of the European gypsy moth (*Lymantria dispar*) has been periodically intercepted in BC since 1978, but aggressive monitoring and eradication programs have so far prevented its establishment.

For the past 25 years, the federal and provincial governments have coordinated a provincial monitoring program using pheromone traps to detect incursions of gypsy moth into BC from infested areas in Eastern Canada. Movement of infested materials – usually outdoor household articles like lawn furniture, barbeques, and recreational vehicles – by people emigrating to BC is the usual source of new infestations. Where trap catches identify the location of potential infestations, egg mass surveys are conducted to determine if the population is reproducing. If evidence of a breeding population is found, eradication treatments with applications of *Btk* are usually conducted.

Egg mass surveys completed by the Canadian Food Inspection Agency in 2004 did not find any egg masses in the areas where adult male moths were caught. Therefore, no *Btk* treatment was conducted in the spring of 2005.

In the summer of 2005, 135 male moths were caught in pheromone traps at twenty-one areas across Southern Vancouver Island, the Gulf Islands and the Lower Mainland (Figure 13). At Gabriola Island, Saanich, Langley and Duncan, high density mass trapping grids were employed. The premise of mass trapping is that if enough traps are placed in an infested area, any male moth will be trapped before it has successfully mated with a female. The Duncan mass trapping grid produced encouraging results with a dramatic reduction in catches from 24 in 2004 to 2 in 2005. Similarly, the Gabriola trapping resulted in a slight decrease (from 22 to 19) in 2005 but more importantly, a non-viable (unfertilized) egg mass was recovered. Both Duncan and Gabriola mass trapping projects will continue in 2006.

Egg mass survey results at Nanaimo, Saanich and Salt Spring Island showed viable (fertilized) egg masses.

Because the high number of male moths caught in both Nanaimo (8) and Salt Spring Island (42) indicate a growing population, *Btk* applications combined with intensive egg mass searches and mass trapping are proposed for the spring to eradicate these gypsy moth populations.

In Saanich, a viable egg mass was discovered on the edge of the mass trapping grid. As a result, a small, highly accessible area in Saanich is slated for ground spraying in the spring.

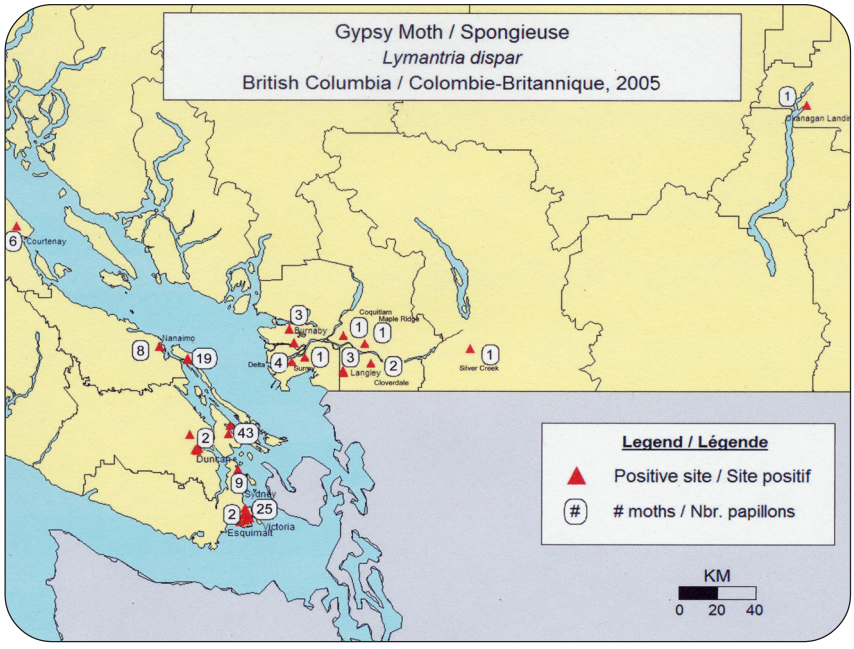


Figure 13. Gypsy moth trap locations with positive catches in 2005.

Other locations where male gypsy moth adults were located in the summer of 2005 will be trapped and monitored next summer.

A full history of the occurrence and successful eradication of gypsy moth in BC is available on the MOFR web site at http://www. for. gov.bc.ca/hfp/gypsymoth.

Satin moth, *Leucoma salicis*

An outbreak by satin moth (*Leucoma salicis*) in the SIFR peaked in 2002 at 45,394 ha of defoliation, followed by a small drop to 37,819 ha in 2003. The majority of the damage occurred in the Chilcotin, Quesnel and Columbia Forest Districts.

In 2004 the satin moth population dropped sharply, with 3,683 ha of primarily light defoliation recorded. Almost all of the affected hectares were in the Chilcotin Forest District. This year the satin moth appeared to be down to endemic levels throughout the SIFR, with only scattered small pockets of mainly light defoliation totalling 394 ha noted.

No defoliation was mapped during the overview surveys in the CFR, but ground observations picked up some damage in hybrid poplar plantations north of Powell River.

Miscellaneous damaging agents

Recorded aspen and poplar leaf and twig blight (casual fungi *Venturia* spp.) damage reached its height over the past few years across the NIFR in 2002, when 82,376 ha were affected. Last year, a total of 51,227 ha were still noted, but no damage was obvious enough to see during the 2005 overview surveys. Ground observations confirmed that damage was minimal. Infected stands were most visible in the Kispiox area of the Skeena Stikine Forest District.

Serpentine leaf miner (*Phyllocnistic populiella*) damage was widespread throughout all aspen stands in the 100 Mile House Forest District in 2002 and 2003. Defoliation decreased in 2004, and was still present but even lighter in 2005. Infested stands were becoming visible in the Williams Lake Forest District this year. Damage caused by the serpentine leaf miner is not easy to see during the aerial overview surveys, and has not been mapped to date.

Serpentine leaf miner damage

Ground observations were made of damage to poplar trees along the Fraser River Valley from Chilliwack to Hope this summer. The lower canopies of plantations were particularly affected, though the tops of the trees remained primarily healthy. Damage was not observed during the aerial surveys for this reason. Linospora leaf blotch (*Linospora tetraspora*) was the suspected, but not confirmed, cause of damage.

Alder clumps were defoliated in the Fraser Valley in 2005, and most of the damage was attributed to the alder flea beetle (*Atica ambien*).

In the Skeena Stikine Forest District, damage resulting from leaf rusts appeared late in the summer and early fall on black cottonwood and aspen stands in the Bulkley Valley. This damage was not apparent during the aerial surveys.

Damaging Agents of Multiple Host Species

Abiotic Injury and associated forest health factors

Wildfire continued to be the most significant abiotic agent, with 39,029 ha of damage recorded during the 2005 overview surveys. This was approximately one-sixth the area affected in 2003 and 2004. Weather played a large factor in this reduction. Early spring was unusually dry and warm, but most of the province experienced significant rain events starting in June, which greatly reduced the fire hazard. As with windthrow, wildfire events can occur after the surveys, hence the yearly records are from flight to flight, and are not necessarily a reflection of the calendar year.

Fires in the NIFR totalled 20,649 ha of mostly moderate intensity, and were scattered throughout the region. Area damaged by fire in the SIFR was close behind at 17,246 ha, primarily located in the southeastern portion of the region. As is common in the wetter CFR, only 1,134 ha were affected by small, scattered wildfires.

Drought damage tends to be underestimated during the overview surveys because affected foliage fades quickly, and small, scattered trees on the edge of open range are hard to detect. Recorded drought damage peaked in 2003 in the SIFR at 11,326 ha, after several very dry growing seasons. Extensive rain in August of 2004 allowed for recovery of stressed trees, and this year only 137 ha in total were noted as damaged in the Central Cariboo, Prince George, and Fort Nelson Forest Districts.

Fire scar

However, the effects from the previous drought were still causing repercussions in 2005. For example, the MOFR BC Timber Sales planted 400,000 seedlings in the Cascades Forest District this year to replace drought killed (primarily lodgepole pine) regeneration. MOFR and forest licensees in the district plan more planting for the coming year. It has also been observed (though not quantified) that drought conditions in the SIFR have led to greater tree mortality due to several major root diseases than was noted previous to the drought.

Western pine beetle infestations have also resulted from a combination of the drought and fire damage. These beetles continued to attack weakened trees along the edge of the Okanagan Mountain Fire in the Okanagan Shuswap Forest District, where 24 ha of affected stands were recorded during the overview surveys. An additional 47 ha of attack was noted in small infestations in the Rocky Mountain Forest District. In the Kamloops Forest District, mortality was not seen from the air but has been observed on the ground at low elevations up the North Thompson River, and along the Thompson River from west of Kamloops to Savona. Directly around Kamloops, stands are being affected by a combination of western pine beetle and mountain pine beetle attack (recorded under mountain pine beetle in the aerial surveys).

Red belt, a relatively rare weather driven phenomenon, damaged a total of 26,639 ha this year. Affected area was up substantially from 9,926 ha recorded in 2004. Although red belt can affect a variety of tree species, most of the 2005 damage was to lodgepole pine. The main areas were located in the mountains and foothills of the eastern portions of the Peace and Fort Nelson Forest Districts, with 19,999 ha and 4,134 ha affected, respectively. Most of the damage was recorded as moderate to severe intensity. In the Chilcotin Forest District, 2,314 ha of primarily trace to light intensity damage was mapped at the north end of Chilko Lake and in the Charlotte Lake area. It was suspected that more damage was present, but mountain pine beetle attack in the district made detection difficult.

Windthrow damaged 16,749 ha across the province in 2005, up three fold from 2004. Affected area tends to be underestimated in aerial surveys, as it is very difficult to see scattered windthrow damage under overtopping canopy trees. Slightly more than half the recorded damage was of light intensity, with the remainder in higher severity classes.

Most of the windthrow damage was located in NIFR districts (14,181 ha). The Peace Forest District had the majority of affected area at 9,393 ha. Many of the damaged trees were aspen. Minor scattered damage occurred throughout the other NIFR districts. The large blowdown event in the Maxan Lake area in the Nadina Forest District last year has been partially salvaged. The area will be watched for bark beetle mortality, as the stands had a high spruce component. The rest of the observed damage was scattered throughout the SIFR, totalling 2,567 ha. In the early winter of 2005 (post overview survey) an estimated 4,000 ha of tree breakage occurred in the Elk Valley of the Rocky Mountain Forest District due to heavy snow. Damage was scattered throughout all age classes.

Aspen windthrow

Mortality due to flooding affected 2,938 ha in 2005, and was located primarily in the NIFR (2,430 ha). Severity of damage was split between moderate and severe. Most of the flooding occurred in the Peace and Fort Nelson Forest Districts, at 1,157 ha and 654 ha affected, respectively. The bulk of the mortality occurred in small patches of spruce and was widely scattered. An additional 397 ha of damage were noted in the Chilcotin and Rocky Mountain Forest Districts of the SIFR.

Slides damaged small localized areas in the North Island – Central Coast, Columbia, Kootenay Lake, Kalum, Mackenzie and Fort Nelson Forest Districts. Total area affected was 354 ha of primarily severe intensity mortality.

In the Kootenay Lake Forest District, damage to regenerating trees by snowmobiles and helicopter skiers is an increasing problem. The tops of the trees stick out of the snow, and are being wounded and snapped off. This is particularly a problem in the Crawford and Gold Creek drainages.

Slide on highway Mackenzie Forest District

Animal damage

Various animals cause ongoing damage to a wide range of trees species throughout BC, particularly in regenerating stands. Damage is usually underestimated in the overview surveys, primarily because most forms of animal damage are not conspicuous enough to be visible from the air. For the past several years, mountain pine beetle mortality has also masked scattered mortality caused by animals.

The most visible damage is the result of bark girdling which is expressed in dead tops or mortality. Black bear (*Ursus americanus*) and porcupine (*Erethizon dorsatum*) are most often responsible. Recorded black bear mortality was up sharply from last year (140 ha) to a total of 1,755 ha affected, provincially. The main reason for the increase was a few changes to overview survey calls of mountain pine beetle mortality in the Rocky Mountain Forest District to bear damage, after ground surveys were conducted. This resulted in 1,337 ha of bear mortality to be recorded for this district. The remaining affected hectares were noted in the Mackenzie Forest District. Bear mortality to regenerating, spaced Douglas-fir and cedar stands from Bute to Toba inlet continued, but was not assessed this year. No porcupine damage was noted in 2005, but it was still known to be occurring in dispersed locations throughout the province, with the exception of Queen Charlotte and Vancouver Islands.

Elk and deer damage (through browsing and trampling) was ongoing near Sechelt and TFL 39 in the Sunshine Coast Forest District. Where Sinocast® deer protectors were used in elk areas, they seemed to be deliberately targeted for trampling by the elk.

Bear damage on young pine

Forest Health Projects

Are free growing stands meeting timber productivity expectations?

Alex Woods, Regional Forest Pathologist, NIFR (with input from Hadrian Merler)

The current administrative milestone that ensures good forest management is the Free Growing declaration. A Free Growing declaration contributes specific information to forest estate models. In order to be confident in timber supply projections it is essential that the expectations associated with Free Growing stands are met. When the 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 objective of this project is to test if the Free Growing declaration point in time assessment is an accurate predictor of future stand productivity and if the assumptions of stand performance are valid.

Evaluating the effectiveness of Free Growing as a milestone will be done by comparing the expectations placed on stands at the time of declaration to volume estimates for the same stands 5 years or more following declaration. Using the MOFR's standard growth model called the *Table Interprolation Program for Stand Yields* (TIPSY), a yield projection will be conducted on the stand characteristics documented in the original Free Growing declaration. The same characteristics will be reassessed in a survey conducted to current MOF standards. These stand characteristics will be used to determine current actual volumes using volume equations for young stands. The current volume and projected volumes from declaration values will be compared. Finally, a second TIPSY run will be used to project any changes in stand growth trajectory.

A randomly selected sample of 60 stands (30 declared Free Growing in 1987-1994, 30 declared Free Growing in 1995-2001) were surveyed in the Lakes TSA in the late summer and fall of 2005. Analysis of the data was still underway at the time this report was being written. Depending on the results of the 2005 pilot study a more continuous provincial monitoring protocol could be developed that would automatically review all Free Growing stands 10 years post declaration throughout the province.

Some of the possible outcomes of this Effectiveness Evaluation investigation could be:
1) Revision of the provincial Forest Health damage criteria
2) Adjustment of stand projection variables (Operational Adjustment Factors),
3) Contribution of information to the Chief Foresters' determination of AAC,
4) Protocol for monitoring post-Free Growing stands.

A positive result from the review of the Free Growing declaration will provide confidence in the current policy framework.

Presentation of results will take place at the winter 2006 *Southern Interior Silviculture Committee* meeting.

Forest health aerial photography update

Tim Ebata, Forest Health Project Specialist, Forest Practices Branch

In 2004 and 2005, Forest Practices Branch and the Integrated Land Management Bureau's Base Mapping and Geomatics Service co-ordinated a multi-district detailed aerial survey for bark beetle detection using conventional photography. The 1:30,000 normal colour photographs were suitable for multiple base mapping uses and could accurately capture the number and location of individual red attacked trees following interpretation. In 2004, an area of 7,359,100 ha (529 1:20,000 mapsheets; 9,749 frames) covering most of Southern B.C. and a small portion of the Mackenzie TSA were photographed starting in July 12, 2004 and ending in September 24, 2004. The film was developed and each negative was scanned at high resolution and then transferred by portable hard drives to the aerial triangulation/ photo-interpretation contractors. Interpretation was done by Vegetation Resource Inventory certified interpreters whose task was simply to identify the species of red mature spruce, Douglas-fir, lodgepole pine and subalpine fir. The first "measlemaps" were delivered by August 25, 2004 and immediately distributed to the districts for use in planning ground surveys and treatments. Due to missing flight lines caused by poor weather and smoke, some mapsheets did not get flown or were photographed very late thereby pushing the delivery of completed or partially completed measlemaps into mid-December, 2004. Despite the delivery issues, the product was considered to be excellent in defining the precise location of red trees although species identification in mixed species stands was not as good as anticipated.

In 2005, a much smaller area that was concentrated in the high priority districts along the Alberta border for mountain pine beetle spread control were included in the measlemapping project. A total of 341 mapsheets (approximately 4.7 million ha, 4,174 frames) were flown from July 18, 2005 to August 25, 2005. The contractors were able to complete delivery of all mapsheets by November 18, 2005. Once the optimal photography window closed, areas not photographed and high priority areas photographed in late August (whose map delivery time would be too late for execution of ground surveys) were flown with heli-GPS with efforts made to minimize the overlap between the two surveys. In 2005, western balsam bark beetle damage, along with mountain pine beetle, spruce beetle and Douglas-fir beetle, was mapped. Map products were very good with the exception of a large error in species identification between Douglas-fir beetle and mountain pine beetle in southeast B.C.

Please contact Tim Ebata if you wish to get copies of the spatial files or JPEG versions of the 1:30,000 photographs from both 2004 and 2005 projects.

Due to the high risks involved in obtaining the map products in a timely manner, particularly in mountainous areas of the province, photo-based detailed aerial surveys will not be conducted unless the delivery times can be shortened significantly.

Douglas-fir beetle mortality

Forest health assessments in the Central Interior of BC

Richard Reich, Regional Forest Pathologist, NIFR

EP671, a 38 year old lodgepole pine espacement trial near Fraser Lake was heavily attacked (>60%) by mountain pine beetle in 2005. In response, a final remeasurement of all forest health factors, and mensurational variables (height, height to live crown, and DBH; and crown area using high resolution digital aerial color photography) was conducted in the fall of 2005. This trial has approximately 50% incidence of stem rust infection and was being monitored for rust incidence, rust-caused mortality and impact as a function of espacement.

Two pine stem rust rehabilitation plots, established in 2000 near Prince George and MacKenzie, were reassessed in 2005. Early results confirm that pine stem rust (western gall rust, stalactiform blister rust and comandra blister rust) stem infections can be excised successfully. The following was recorded for this treatment efficacy test: year of infection for stem infections, the rate of treatment success, rate of reinfection, and the rate of additional infection. Although there are very limited operational treatment opportunities due to treatment cost, this work has demonstrated that these hard pine stem rusts can be successfully treated, albeit under circumstances where the value of trees is high enough.

A very detailed forest health assessment was conducted on a lodgepole pine progeny test site established in 1986 at the Willow Canyon site near Prince George. The assessment was conducted on the Central Plateau test. This detailed evaluation dovetails with a previous assessment of the same site in 2004. The original purpose of the assessment was to refine procedures for evaluating rust resistance. Additional objectives included evaluating *Elytroderma deformans* stem infection incidence (25%), an infection history study of western gall rust peak infection years, the period of susceptibility to western gall rust, and the infection height relationship of stem galls.

Elytroderma deformans stem infection on 18 yr old lodgepole pine near Prince George

Mountain pine beetle models

Through the initiative of staff at the Pacific Forestry Centre, twenty-four six-inch scale models of an adult mountain pine beetle were created by the Royal BC Museum for MOFR's public education projects. The models are about 1/4th the size of the large beetle model that the MOFR has used successfully for over 10 years. The larger model's size prevented it from being transported easily but it was still heavily sought after by districts, particularly during National Forestry Week. By having more models available to districts, public communication will be greatly enhanced. The models will be distributed to regions and districts in the spring of 2006.

Royal BC Museum mountain pine beetle models

Forest health in BC under climate change

Alex Woods, Regional Forest Pathologist, NIFR

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

Short-lived insects and fungi will be able to adapt to new environmental conditions under climate change much more quickly than their long-lived hosts. In some cases these new relationships could be positive for some forest resources. In others there is a high probability that these new relationships will be negative, particularly in terms of timber productivity.

In the case of Dothistroma in the ICH zone of northwest BC, a relatively small increase in the frequency of warm-rain events coupled with a general increase in mean summer precipitation tipped the scales in favour of a pest that in turn has had devastating consequences for lodgepole pine dominated plantations. This change in the weather for northwest BC has been attributed to possible climate change (Woods et al 2005).

The indirect impacts of climate change on BC's forests orchestrated by forest pests will present varying opportunities for management intervention. In mature unmanaged forests options for interventions will be confined to being reactive rather than proactive as the forests, their species mixes and genetic diversity are set. In contrast, the establishment of new forests can be managed proactively. This can be accomplished through increased diversity both in terms of genetics and species, as well as adjustment of establishment densities to increase the resiliency of managed stands and to reduce the risk associated with climate change and its indirect affects on pest/host interactions.

The Climate Change Task Team of the BC Ministry of Forests and Range is considering these management options among others in their report to the Chief Forester, due in the spring of 2006.

Status of mountain pine beetle attack in young lodgepole pine stands in central BC

Dr. Lorraine Maclauchlan, Regional Entomologist, SIFR

This project was supported in part by the Forest Investment Account, Forest Science Program Project Y072003, the Forests for Tomorrow Program and MOFR Forest Health Program.

Of the approximately 1.96 million ha of young, lodgepole pine leading stands between the ages of 20-55 years in B.C., 490,236 ha (25%) occur within the six districts where this study was conducted: Prince George, Quesnel, Vanderhoof, 100 Mile House, Central Cariboo and Nadina. Approximately 10% of these stands were surveyed by air to quantify mountain pine beetle (MPB)-caused mortality. The highest frequency and intensity of MPB attack was observed in polygons over the age of 40, yet stands as young as 20 years sustained high levels of attack in areas of extreme beetle pressure outside what is considered the core (older) outbreak area. The MPB did not discriminate between mature stands ($\geq$60 years) and stands 40 to 60 years; therefore these stands should be first priority for future surveys and rehabilita-

tion. 49.2% of young stands aerially assessed and 48.2% of those ground surveyed contained some level of MPB attack. Aerially observed mortality ranged from 0 to 95% red attack (2004 attack) with only trace amounts of older (grey) attack. 4.3% of the total number of polygons evaluated contained greater than 50% mortality. 23% of polygons ground surveyed had greater than 50% MPB-caused mortality within the stand.

The most severely impacted district was Quesnel with 72.8% of all polygons assessed by air having some level of MPB mortality. 60.5% of the total number of stands assessed in the 20-25 year age class had evidence of MPB attack ranging from 1% to 61% attack. Nearly 100% of stands surveyed in Quesnel over 31 years old had some level of MPB attack. In the Central Cariboo District, the percent of stands affected ranged from 45.1% to 93.3%, in 20-25 year old stands and 51-55 year old stands respectively. Approximately one third of all stands surveyed in Prince George between the ages of 20 to 40 years were attacked, with almost 100% of older stands sustaining some degree of attack. 100 Mile House and Nadina Districts had a lower frequency of attack in young stands, however, over one third of all stands aerially assessed in these two districts showed evidence of MPB-caused mortality. Green attack (2005 attack) levels in the 100 Mile House District ranged from no attack to 81%. The risk to young stands is

Young lodgepole pine mass attacked by mountain pine beetle

declining in the oldest parts of the outbreak. For example, the 2005 aerial overview survey of Quesnel showed a decline in hectares affected from 2004 (BCMOFR 2005). Attack will continue until the outbreak collapses, however, the highest future risk will be in peripheral districts, where the outbreak has gained momentum in the past two years. We anticipate future losses in young pine to be highest in the Central Cariboo, 100 Mile House, and Nadina Districts. Young pine stands in more northern and southern districts are at risk, where MPB populations are building in adjacent mature stands and the mature host resource is limited. In the south (e.g. Kamloops, Okanagan Shuswap, Cascades), there are localized areas of very high beetle attack where young pine is already under attack (personal observations). The impact may be even higher outside the core outbreak area as the beetle runs out of mature host material and more beetles disperse in from surrounding geographic areas.

Forest Health Presentations

BC conditions report

Tim Ebata, Forest Health Project Specialist, Forest Practices Branch

Venue: National Pest Forum, Ottawa, December 6 – 8th 2005.

Abstract:
A summary of the highlights of BC's annual overview survey and other interesting forest health activities was presented to a National audience of pest management specialists from the provinces, Canadian Forest Service, Canadian Food Inspection Agency, Pest Management Regulatory Agency and other disciplines.

Forest health legislation

Robert Hodgkinson, Forest Entomologist, NIFR

Venues: Association of B.C. Forest Professionals Policy Seminar, Prince George Civic Centre, September 17, 2005: University of Northern B.C., 3rd year undergraduate course in Forest Health, Nov. 24, 2005.

Abstract:
Topics covered were:
- The Bark Beetle Regulation
- The Forest and Range Practices Act
- The development of Defined Forest Area Management
- Provincial and Timber Supply Area Forest Health Strategic Plans

Hauling and milling guidelines for infested logs in the Northern Interior Forest Region of BC

Robert Hodgkinson, Forest Entomologist, NIFR

Venue: AB /BC Intermountain Forest Health Workshop, Lake Louise, April 20th, 2005.

Abstract:
Topics covered were:
- Purpose and Advantages
- Risk Assessment Procedures
- The "Monitored Temperature Approach"
- Mitigation Options

Mountain pine beetle attack moving from mature to immature logepole pine south of Prince George

Impacts of mountain pine beetle and *Ips pini* on young managed lodgepole pine stands within a salvage area of the Vanderhoof Forest District in 2004

Robert Hodgkinson, Forest Entomologist, NIFR

Venues: Western Forest Insect Work Conference, Victoria, B.C., March 2005: AB / BC Intermountain Forest Health Workshop, Lake Louise, April 20, 2005: FORREX MPB Research Workshop, Prince George, May 12, 2005: B.C. Chief Forester's field tour, Vanderhoof, July 7, 2005.

Abstract:
Vanderhoof District wished to assess the impact of mountain pine beetle (MPB) on young lodgepole pine stands within a salvage area of their district. Age class 1 & 2 lodgepole pine stands were mapped within 1 km of existing roads near the Kenney Dam area. Plots were located via random bearings in mostly the SBSmc3 05 or 01 biogeoclimatic zones. Plots were installed at least 30 m from the edge of polygons and spaced at least 100 m apart. A total of 58 plots (3.99 m or 5.64 m fixed radius) containing a minimum of 8 lodgepole pine per plot were established. All trees 7.5 cm dbh and greater were examined and plot centers were recorded by global positioning equipment. A total of 637 lodgepole pine were examined and 58% were age class 1 and 42% were age class 2. A total of 59.6% were healthy; 1.4 % had been attacked and killed by Ips pini only; 25.1 % had been attacked and killed by MPB only; and 13.8% had been attacked and killed by both MPB and Ips pini. Recommendations were made to the Forest Practices Branch to: 1) postpone any thinning and/or pruning in young Pl stands in areas moderately or heavily attacked by MPB, 2) wait until MPB and Ips pini populations have collapsed before conducting any intensive forestry activities, and 3) thin in newly-attacked areas at your own risk.

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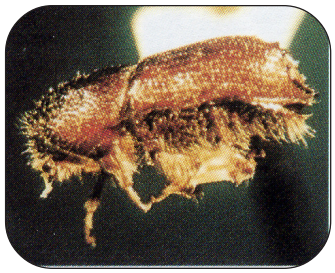

Adult Ips beetle

Impacts of mountain pine beetle on wood and paper quality

T.M. Ebata1, T. Byrne2, and P. Watson3.
1 Forest Practices Branch, B.C. Ministry of Forests and Range, Victoria, B.C. 2 Forintek Canada Corp, Vancouver, B.C. 3 Paprican, Vancouver, B.C

Venue: National Pest Forum, Ottawa, December 6 – 8th 2005.

Abstract:
The "shelf life" of beetle-killed timber is dependent on the change in wood and eventually chip quality over time. This presentation summarized two MPBi funded research areas that attempted to address the impacts of the beetle on wood and pulp quality and the economic impacts this may have. The first research area looked at the various factors that impact the quality of lumber produced from beetle killed timber. The two main issues are: 1) blue-stain – leading to degrade and unacceptability in appearance grade markets like Japan while also improving permeability of stains and preservatives; and 2) dryness – that leads to lower lumber volume and grade recovery. Other issues being examined involve the optimization of logs with large checks, sorting dry wood in the millyard to optimize kiln

drying regimes, examining methods of improving yield for plywood veneers; and addressing issues faced by the used of dry pine chips to make OSB. The overall message is that you can still make quality solid wood products out of standing dead trees but at some point in time, it becomes uneconomic. For the pulp and paper industry, the news isn't as encouraging. Chips made from standing dead trees tend to be very dry and do not absorb the chemicals used to digest them into pulp as readily as chips from freshly cut trees. The blue-stain also presents a challenge by increasing the efforts to bleach the pulp thereby increasing production costs. Overall, impacts of increased pine chip proportions will result in reductions in paper strength and quality and ultimately have an impact on the competitiveness of the industry on the world market. The challenges to the industry are to minimize these impacts and maintain market share.

Mountain pine beetle updates

Robert Hodgkinson, Forest Entomologist, NIFR

Venues: Prince George Rotary Club, Prince George, April 12, 2005: Chinese Foresters, Prince George, July 6, 2005: Pacific Streamkeepers Federation Meeting, Prince George, October 15, 2005. North Peace Cultural Center in Ft. St. John on October 17, 2005

Abstract:
Mountain pine beetle biology, life cycle, hosts, outbreak dynamics, limiting factors, control tactics and strategies were presented to various audiences.

Lodgepole pine mortality caused by mountain pine beetle in mixed species stand

What has the beetle taught us this time

Robert Hodgkinson, Forest Entomologist, NIFR

Venue: University of Northern B.C., Mountain Pine Beetle Epidemic and the Future of Communities and Ecosystems Conference, November 10, 2005.

Abstract:
New observations on mountain pine beetle were grouped around 4 themes: attacking, killing, and occasionally breeding in very young Pl; dispersing up to approximately 60 km per year; spreading to new non-historic ranges; and, overwhelming preventative measures and attacking non-hosts.

The complete PowerPoint presentation is available at: http://www.forrex.org/programs/Ecosystems_Stand_Management/MPB%20Conference/UNBC%20presentations/Robert%20Hodgkinson.ppt

Forest Health Publications

Bleiker, K.P., B.S. Lindgren and L.E. Maclauchlan. 2005. Defense response of fast- and slow-growing subalpine fir to pheromone-induced attack by western balsam bark beetle (Coleoptera: Scolytidae). Agricultural and Forest Entomology 7:1-8.

Hennon, P.E., D'Amore, D.V., Zeglen, S. and Grainger, M. 2005. Yellow-cedar decline in the North Coast Forest District of British Columbia. USDA For. Serv., Res. Note PNW-RN-549.

Maclauchlan, L.E. 2006. Status of mountain pine beetle attack in young lodgepole pine stands in central British Columbia. Min. of Forests and Range Internal Report.

Maclauchlan, L.E., J.E. Brooks and J. Hodge. 2006. Analysis of historic western spruce budworm defoliation in south central British Columbia. *In press* J. For. Ecol. and Manage.

Woods, A., Coates, D. and Hamann, A. 2005. Is an unprecedented dothistroma needle blight epidemic related to climate change? BioScience Vol. 55 No. 9, 761-769.

Wulder, M., J. White, B. Bentz, T. Ebata. 2006; Augmenting the existing survey hierarchy for mountain pine beetle red-attack damage with satellite remotely sensed data, The Forestry Chronicle, *In Press*.

Ministry of Forests and Range, Forest Practices Branch

Prepared by:
Joan Westfall
EntoPath Management Ltd.
"For the Health of our Forests"

Many thanks to the contributors to this document:

Data and specialized project information:

Forest Practices Branch -	Tim Ebata, Forest Health Project Specialist
Southern Interior Forest Region -	Lorraine Maclauchlan, Forest Entomologist
	Leo Rankin, Forest Entomologist
	Kevin Buxton, Forest Health Technician
Northern Interior Forest Region -	Ken White, Forest Entomologist
	Robert Hodgkinson, Forest Entomologist
	Alex Woods, Forest Pathologist
	Richard Reich, Forest Pathologist
Coast Forest Region -	Don Heppner, Forest Entomologist
	Stefan Zeglen, Forest Pathologist

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Resource Tenures and Engineering Branch

Editing:

Tim Ebata - Forest Practices Branch, Forest Health Project Specialist