

2004 SUMMARY OF FOREST HEALTH CONDITIONS IN BRITISH COLUMBIA



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ABSTRACT

This report, “2004 Summary of Forest Health Conditions in British Columbia”, was compiled from provincial aerial overview survey data, insect population predictions, local reports on forest health agents not aerially detectable and special project information.

The largest mountain pine beetle epidemic ever recorded in BC continued to expand to over 7 million hectares of affected lodgepole pine stands. The highest attack levels continued to occur in the Quesnel Forest District, with almost 1.4 million hectares affected. The largest increase was recorded in the 100 Mile House Forest District with a seven-fold rise over last year to 655,901 ha. Infestations in the Chilcotin and Central Cariboo Forest Districts were also substantial, with 1,138,475 ha and 706,825 ha attacked, respectively. Large infestations in the Northern Interior Forest Region (NIFR) almost doubled since last year to 2.6 million hectares, primarily in the Fort St. James, Prince George, Nadina and Vanderhoof Forest Districts. Mountain pine beetle attack was lower in the southern part of the province, though infestations still quadrupled since 2003. Factors indicate a further population expansion next year if the winter weather continues to be mild.

Western balsam bark beetle damaged 2 million hectares of subalpine fir stands, though mortality in general was very light. Areas of the province with the highest amount of mature sub-alpine fir were most affected, primarily in the NIFR. The area affected by spruce beetle dropped three fold from last year to 104,805 ha. Most of this decrease occurred in the NIFR, whereas many of the districts in the Southern Interior Forest Region (SIFR) experienced an increase in spruce beetle mortality.

Defoliation by insects was also significant. Western spruce budworm infestations increased to a high of 623,825 ha, affecting Douglas-fir from Williams Lake south to Princeton and to a lesser extent, Pemberton. Sampling predictions indicated a collapsing population in the Coastal Forest Region (CFR) but significant areas of defoliation continuing in the southern interior for 2005. The biological control agent *Bacillus thuringiensis* var. *kurstaki* (*B.t.k.*) was applied to 25,500 ha of high value Douglas-fir stands to reduce western spruce budworm damage and population levels. The large aspen tortrix damaged 429,526 ha of aspen and poplar stands in the Fort Nelson, Peace, Mackenzie and Prince George Forest Districts. Defoliation by the eastern spruce budworm and 2-year-cycle budworm, which have been very active in true fir and spruce stands for the past several years, was down sharply. Sampling indicated that the eastern spruce budworm population has collapsed. Western hemlock looper was in the declining 4th year of an outbreak in the SIFR, and is expected to be down to endemic levels in 2005. Two small populations of gypsy moth were reproducing in the lower mainland, and required eradication treatments with *B.t.k.* in the spring of 2004.

Drought damage was the most damaging abiotic factor with 11,326 ha affected, the majority of which was recorded in Kamloops, Okanagan – Shuswap and Cascades Forest Districts. Tree species affected were primarily western red cedar in the CFR, pine and Douglas-fir in the SIFR.

Wildfires burned 223,772 ha this year, which was almost as high as last year. Actual damage was far less however, since the majority of the fires were located in remote areas with low values at risk.

Dry conditions reduced the incidence of leaf and needle diseases, though foliar diseases continue to be problematic, especially on hosts that have been planted outside of their natural ranges. Aspen and poplar leaf and twig blight damaged 51,227 ha throughout the NIFR. Dothistroma needle blight continued to be the most significant forest pathogen of lodgepole pine in northwest BC. This disease was also responsible for defoliation in more isolated instances in the Prince George and Headwaters Forest Districts, though not to the same extent as that found in the western portion of the NIFR.

Other forest health factors such as Douglas-fir beetle, redbelt and flooding caused localized damage in various areas throughout the province.

2004 SUMMARY OF FOREST HEALTH CONDITIONS IN BRITISH COLUMBIA

INTRODUCTION

The BC Ministry of Forests (BCMOF) monitors and records damage to the forests of British Columbia (BC) caused by insects, diseases, animals and environmental factors. Most of the information is gathered on an annual basis through aerial overview surveys, which the BCMOF has been responsible for conducting since 1997. In 2003, several BCMOF regions and districts were amalgamated (Figure 1).

The aerial overview surveys has a variety of important purposes, including: obtaining reliable and consistent information over large areas, monitoring changes in forest health issues over time, providing forest managers with current damage information and contributing input into national indicators for sustainable forestry management.

Some forest health concerns, particularly diseases such as rusts, cankers and dwarf

mistletoes, are not usually discernable from aerial overview surveys. These concerns were primarily discussed in this report when identified by other surveys such as low-level helicopter flights or ground surveys, but were not tabulated with the overview findings. This report is a summary of the 2004 overview survey results, with additional insect population predictions and special projects information supplied 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)

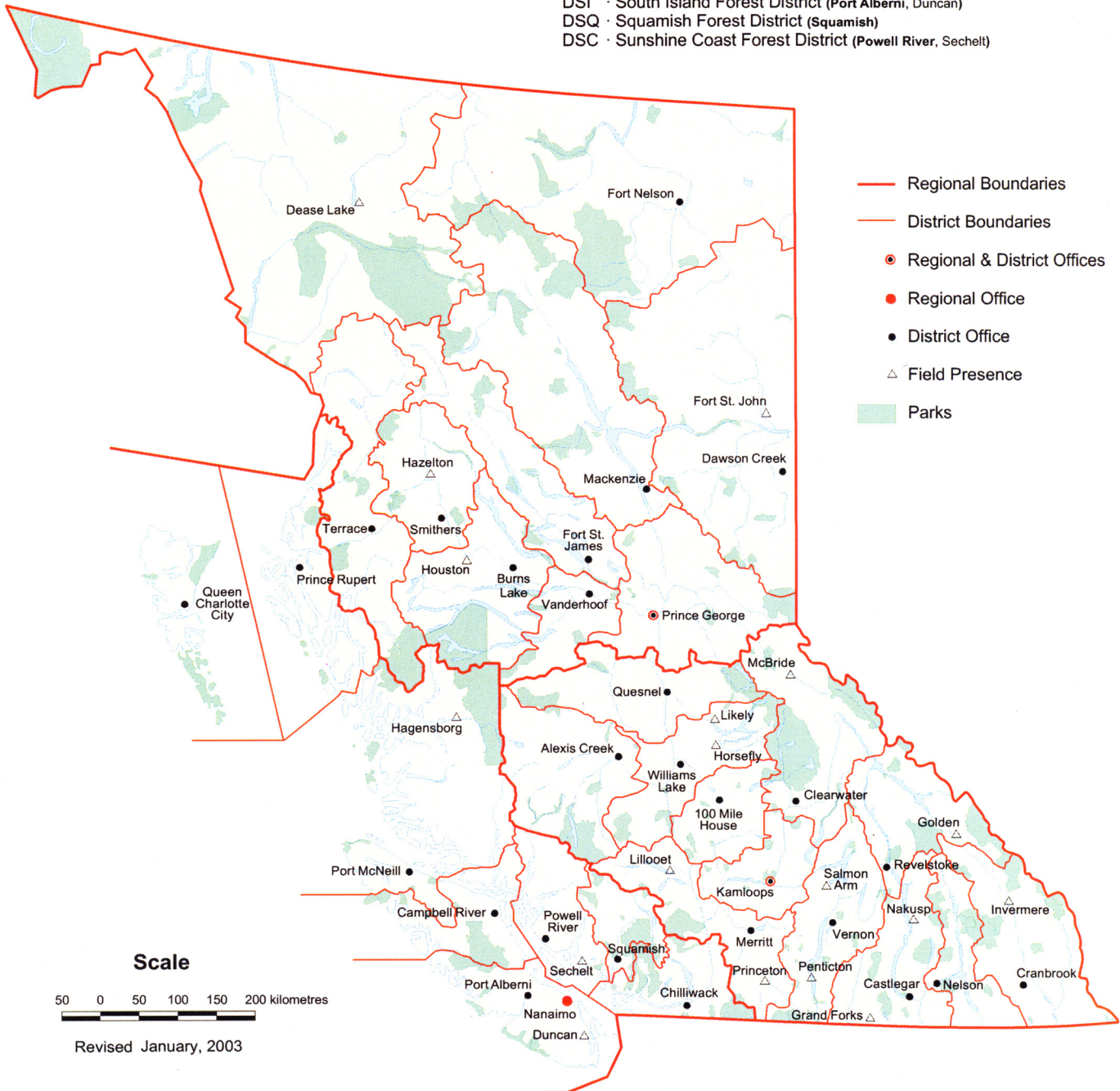


Figure 1. Map of British Columbia outlining Ministry of Forests regional and district boundaries as of April 1, 2003.

METHODS

To conduct the aerial overview surveys, experienced personnel sketch forest health disturbances on maps from fixed wing aircraft. A map scale of 1:100,000 is used to provide efficient, economical coverage of the province with an acceptable level of accuracy. The map bases that are now used provincially are satellite images with overlays of features such as creeks, roads and harvesting. This is a great improvement over the topographic maps utilized in the past. Details of survey methodology are available online at the Resources Information Standards Committee website: <http://srmwww.gov.bc.ca/risc/pubs/teveg/foresthealth/index.htm>.

The 2004 provincial aerial overview surveys were conducted from mid July through the end of September (Table 1). Surveys were completed over a shorter time frame than in 2003, due to somewhat better weather conditions. Poor visibility resulting in smoke from forest fires interfered with some flights early in the season, and then rain caused delays throughout August in 2004. At least good flying conditions were obtainable intermittently, unlike 2003 when unrelenting smoke forced flights to be conducted in less than optimal conditions. A total of 628.5 flying hours were required to survey the province (Table 1).

Hand-held Global Positioning Satellite (GPS) receiver units were utilized to record flight lines to ensure adequate survey coverage (Figure 2). Relatively flat expanses of forested land were flown in a grid pattern. Drainages were flown in more mountainous terrain. Flight line intensity varied depending on visibility and the extent of forest damaging agents. The majority of all forested land was surveyed. Non-forested types such as alpine tundra were not surveyed.

Forest health disturbances that killed trees (beetles, flooding, windthrow, porcupine, etc.) were mapped during aerial surveys 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. Only mortality that occurred within the previous year is mapped annually. Hectares damaged in past years

cannot be added cumulatively, since new mortality may appear in areas that had a portion of the trees killed before.

Large areas of damage were drawn as polygons on the survey map, with the percentage of recently killed trees separated into intensity classes. Intensity classes of light, moderate and severe (Table 2) have historically been the provincial standard. In the last two years, large areas of previously uninfested pine have developed a very unusual pattern of widely scattered, very low intensity mortality. This tends to be underestimated by recording spots and overestimated by recording light polygons. Hence, a trace category (<1% current mortality) was developed for use in 2004. This category better describes balsam bark beetle mortality as well, which often has this scattered pattern.

Table 1. Number of flying hours required by each Region to complete the 2004 provincial aerial overview surveys.

Region	Zone	Flight hours	Survey Dates
Southern Interior Forest Region	Cariboo	170.6	Aug 6 – Sept 18
	Kamloops	43.7	July 15 – July 25
	Nelson	53.4	July 21 – July 30
Northern Interior Forest Region		308.0	July 6 – Aug 25
Coast Forest Region		52.8	July 31 – Sept 26
Total		628.5	July 6 – Sept 26

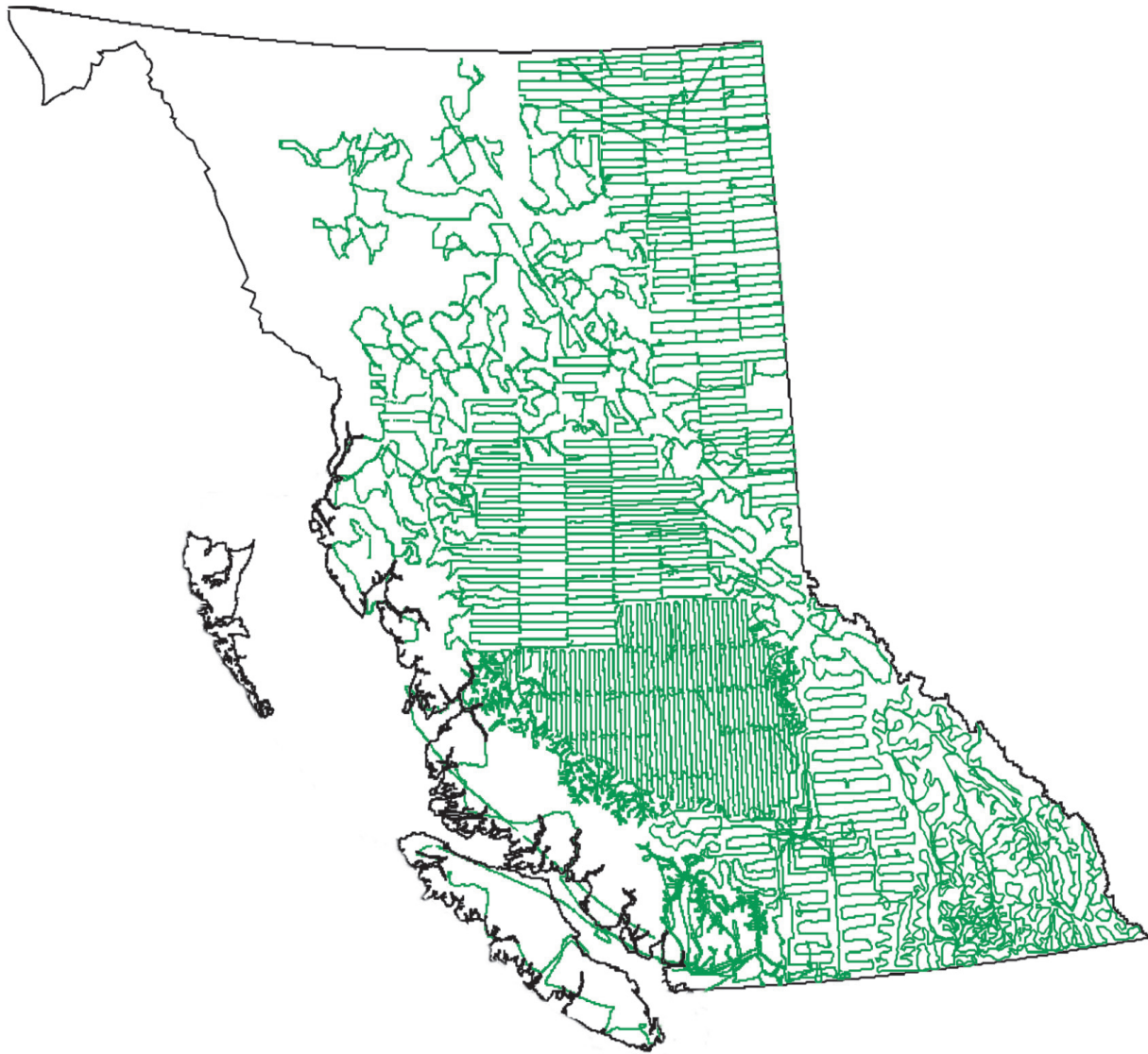


Figure 2. Flight paths flown while conducting the 2004 aerial overview surveys.

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%+ 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.

Unprecedented high levels of mountain pine beetle mortality over large areas within a single year necessitated a division of the severe mortality intensity class into 30% - 49% for severe, and 50%+ for very severe. This refinement is designed to assist in impact analysis. Since this category did not exist historically and most likely won't be required after the present outbreak, data for this report is compiled under the broader category of severe as described in table 2.

Small areas of up to 50 trees killed were recorded 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.

Visible defoliation caused by insect feeding or foliage diseases were also recorded during the surveys. Defoliator damage tended to be widespread throughout areas, and was therefore mapped as

affected polygons, not spots. Only *current* defoliator damage was recorded, which was assessed as a percentage of the foliage damaged, averaged for the polygon (Table 2). As with mortality, defoliation cannot be added cumulatively for successive years because the same area may experience several years of defoliation.

An important limitation of the aerial overview survey methodology is it is a poor estimator of the actual number of trees killed by bark beetles (and consequently, volume killed), due to the broad incidence classes and known errors of omission (i.e., missed trees). Accurate volume estimations have not been an expected goal of this survey.

Sketch mapped forest health disturbances were digitized using BCMOF Forest Practices Branch standards, available on the Ministry of Forests website (<http://www.for.gov.bc.ca/hfp/forsite/overview.htm>).



Mortality caused by mountain pine beetle

GENERAL CONDITIONS

Forest health conditions in BC as recorded during the aerial overview surveys in 2004 are summarized in table 3. Mountain pine beetle continued to be the primary cause of damage in the province, with infested hectares seven times higher than four years ago. Other significant areas recorded as affected by damaging agents included: western balsam bark beetle, western spruce budworm, large aspen tortrix and spruce beetle. Several other forest health agents caused localized damage (Table 3). Details of damage caused to specific tree species are documented in the next section of this report.

Overall, bark beetles and defoliators have been the primary forest health factors recorded during the overview aerial surveys over the last six years. Bark beetles have been constantly increasing, due to mild winters and low beetle mortality rates. In contrast, defoliator populations have tended to fluctuate widely over relatively short time periods (Figure 3).

A Provincial Forest Health Strategy is now complete. This strategy provides vision statements for the MOF's pathology and entomology programs, a mission statement, overall

Table 3. Summary of hectares affected by forest damaging agents as detected in 2004 aerial overview surveys in British Columbia.

Damaging Agent	Hectares Affected
<i>Bark Beetles:</i>	
Mountain pine beetle ^a	7,021,886
Western balsam bark beetle	2,017,595
Spruce beetle	104,810
Douglas-fir beetle	34,128
Fir Engraver beetle	1,358
Western pine beetle	351
<i>Total Bark Beetles:</i>	<i>9,180,126</i>
<i>Defoliators:</i>	
Western spruce budworm	623,735
Large aspen tortrix	429,526
2-year-cycle budworm	51,171
Eastern spruce budworm	29,648
Western hemlock looper	5,750
Satin moth	3,683
Northern tent caterpillar	872
Birch leaf miner	672
Western blackheaded budworm	229
Forest tent caterpillar	9
<i>Total Defoliators:</i>	<i>1,145,295</i>
<i>Abiotics:</i>	
Fire ^b	210,008
Flooding	4,688
Redbelt	9,926
Drought	11,326
Windthrow	5,717
Frost	1
<i>Total Abiotics:</i>	<i>241,666</i>
<i>Diseases:</i>	
Aspen/poplar leaf/twig blight	51,227
Pine needle cast	152
Dothistroma	6
<i>Total Diseases:</i>	<i>51,386</i>
<i>Animals:</i>	
Bear	140
Porcupine	24
Deer	2
<i>Total Animals:</i>	<i>165</i>
Provincial Total	10,618,639

^a Includes infestations in parks totalling 750,546 ha.

^b Provided by BCMOF Protection Branch



Damage caused by drought

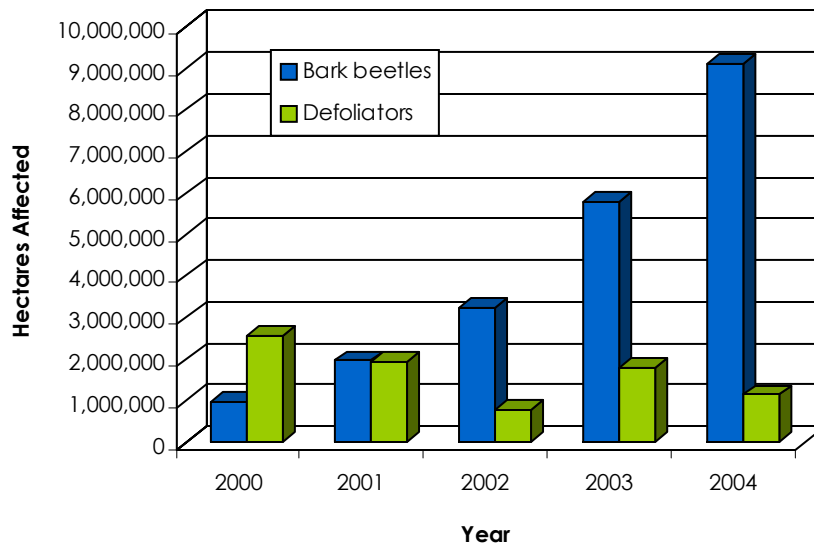


Figure 3. Hectares affected by bark beetles and defoliating insects from 2000 – 2004 in British Columbia.

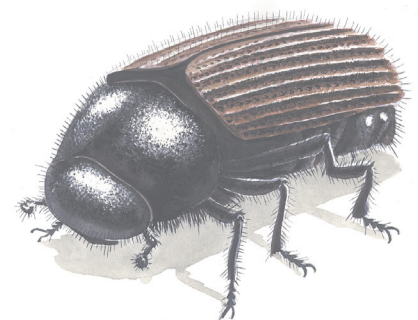
objectives and actions to achieve forest health goals and provincial priorities. These provincial goals and priorities will guide ministry and industry operations and research over the next few years. The *Provincial Bark Beetle Technical Implementation Guidelines* (2003) outline bark beetle objectives set out in the *Provincial Forest Health Strategy*.

To assist with bark beetle management, a significant portion of the Southern Interior Forest Region (SIFR) and a section of the Mackenzie Timber Supply Area (TSA) were aerially photographed in the summer of 2004. The colour photographs produced from this project were scanned, aerially triangulated and then interpreted to produce digital files showing the distribution of

recent red trees killed by spruce, Douglas-fir, and mountain pine beetles. Figures 4 and 5 depict the difference between information collected during the aerial overview surveys and the photography project, for a sample area north of Lillooet.

Both methodologies tend to have strengths and weaknesses. Recently killed individual trees can be very accurately pinpointed with the use of aerial photography. Hence, figure 5 shows many more individual trees than figure 4, where individual trees are picked up less often, or tend to be grouped into polygons. However, identification of tree species and subtleties of why they died are easier to interpret by aerial observers, who may be able to view the trees at an

oblique angle or have a better understanding of the local conditions. An example of this is the polygons coded as drought damage in figure 4, which are called beetle attack in figure 5. It is important to remember that the two surveys are conducted for different reasons, and that the data is not expected to match identically.



Douglas-fir beetle

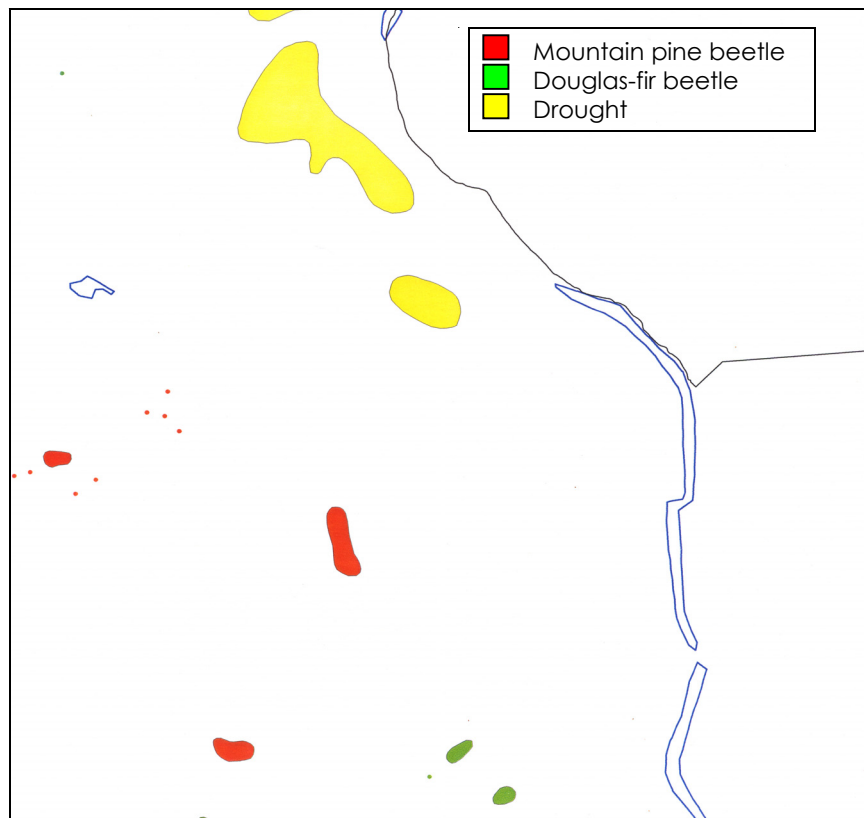


Figure 4. Aerial overview survey map of data collected in 2004 for area north of Lillooet.

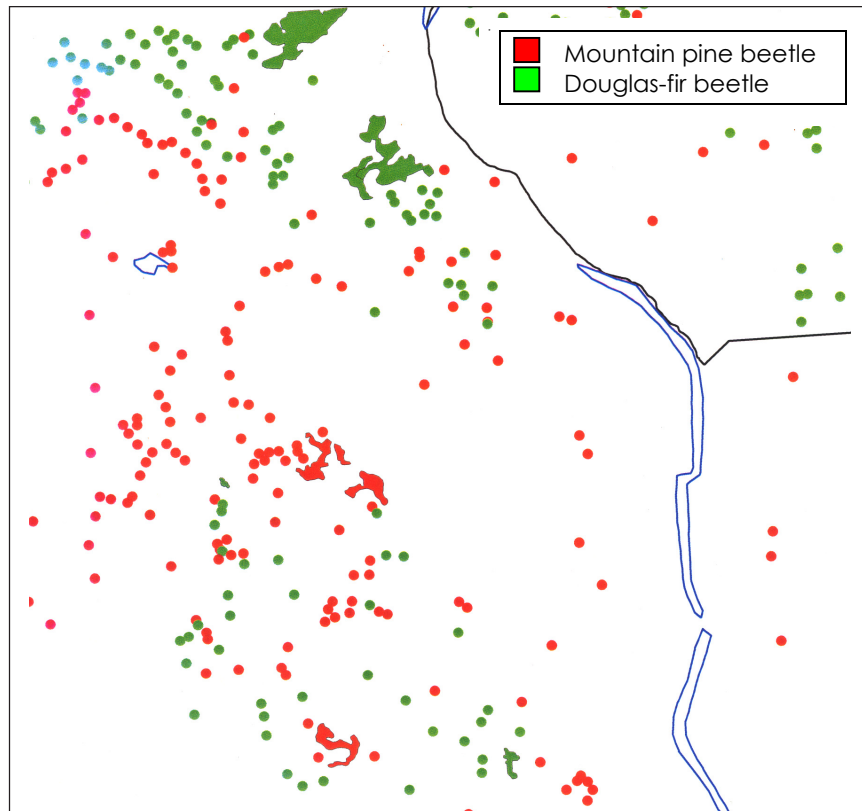


Figure 5. Mortality by mountain pine and Douglas-fir beetles as interpreted from aerial photographs in 2004 for area north of Lillooet.

DAMAGING AGENTS OF PINES

Mountain pine beetle, *Dendroctonus ponderosae*

The mountain pine beetle (*Dendroctonus ponderosae*) is the most destructive pest of mature pine (*Pinus* spp.) in BC, and continues to be the largest threat to our forests in terms of timber loss, environmental concerns and negative economic impacts. Infestations are causing extensive tree mortality throughout the range of pine in the province (Figure 6).

Beetle populations have been on the rise for several years, due

to an abundance of mature lodgepole pine (*Pinus contorta* var. *latifolia*) and very favourable weather conditions. The Canadian Forest Service (CFS) has estimated that the present amount of mature lodgepole pine is approximately three times larger than it was in 1910, due largely to fire suppression. Drought conditions over the past several years, particularly in southern BC until August 2004, have increased tree susceptibility to beetle attack. Overwintering beetle larval

mortality has been low due to a series of mild winters. The average minimum winter temperature in the south and central interior has increased by over 2°C over the last century, and climate models predict a continuation of this trend. All these factors have contributed to the current mountain pine beetle outbreak.

Hectares infested by mountain pine beetle in BC have increased over forty-two fold from the 1999 level of 164,567 ha to over seven million hectares in 2004 (of which 750,546 ha are located in provincial parks and protected areas). As a cautionary note, this total is slightly inflated. Significant harvesting has been conducted within the large infestations recently and this information was not yet available digitally for many areas. Therefore, hectares harvested could not be accurately subtracted from large infested polygons (although this amount would be small compared to the provincial total of attack).

Of the stands affected by mountain pine beetle this year, 738,592 ha (11%) sustained severe mortality, 1,852,981 ha (26%) moderate and 4,430,313 ha (63%) light (1,960,314 ha of



Lodgepole pine mortality due to mountain pine beetle attack

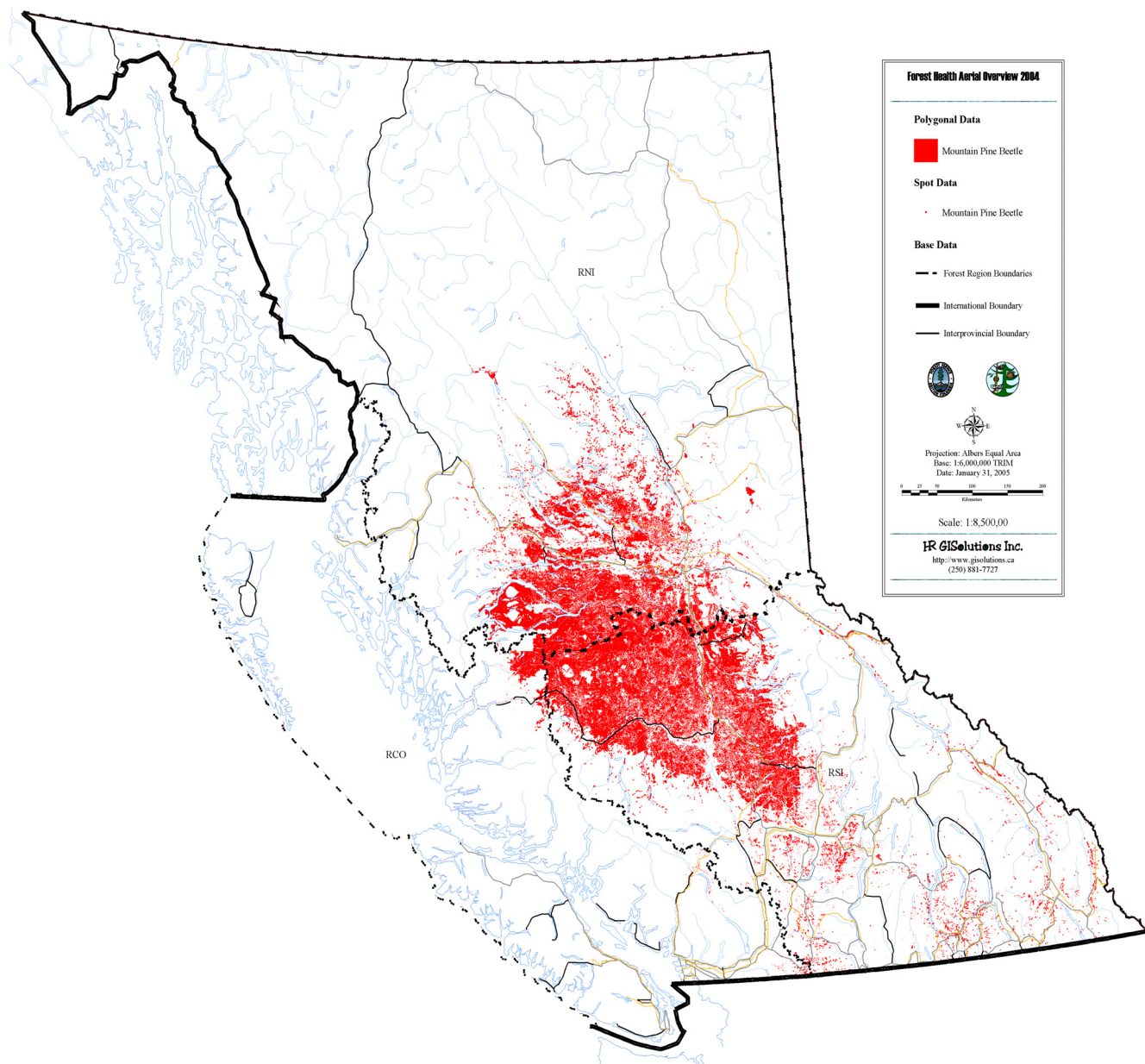


Figure 6. Mountain pine beetle infestations recorded in British Columbia in 2004.

trace and 2,469,999 ha of light were combined) mortality. The percentage of severe mortality has dropped to almost a third from the peak in 2002 (Figure 7). This may be partly attributable to the decline in current mortality within the large, pure pine infestations of the Vanderhoof, Nadina and Quesnel Forest Districts, as the beetle has depleted much of the available host material in these areas.

The Cariboo zone of the SIFR continued to experience the greatest increase and the largest affected area in BC with a total of almost 3.9 million hectares (Figure 8). This is close to double the area recorded in 2003. The highest attack levels continued to occur in Quesnel Forest District, with 1,358,993 ha affected, compared to 1,010,400 ha in 2003. Of this total, 148,479 ha (11%) were trace, 326,078 ha (24%) were light, 619,519 ha (46%) were moderate and 264,919 ha (19%) were severe. The largest increase occurred in the 100 Mile House Forest District, with 655,901 ha of infested pine in 2004, which was a seven-fold increase over 2003. The majority of the increase was in trace and light intensity, with 45% of the total recorded attack in each of these categories.

Attack in the Chilcotin Forest District totaled 1,138,475 ha, a 34% increase over 2003. As expected, large areas of very light, diffuse mortality

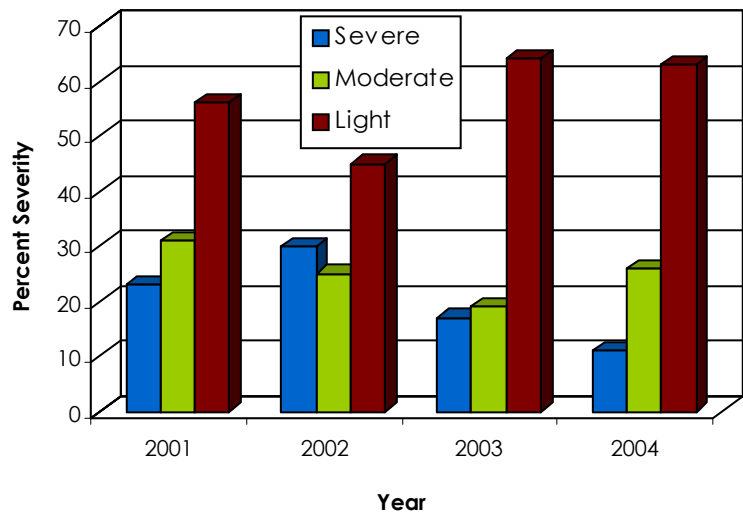


Figure 7. Changes in distribution of the proportion of attack by mountain pine beetle by severity class in BC from 2001 - 2004.

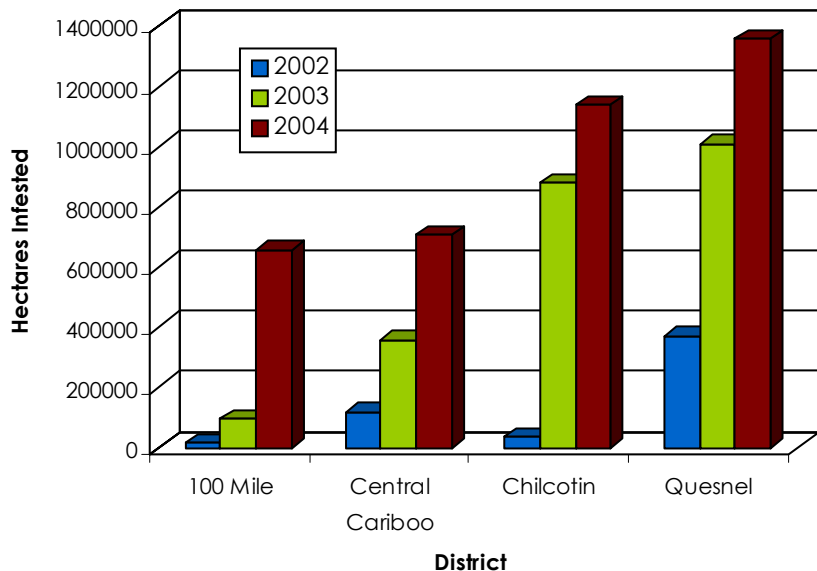


Figure 8. Hectares infested by mountain pine beetle from 2002 – 2004 in the Southern Interior Forest Region (districts with more than 600,000 ha affected in 2004).

recorded last year increased in intensity, with 18% of the attack now documented in the moderate and severe range, compared to only 4% in 2003. Mountain pine beetle infestations also grew substantially in Central Cariboo Forest District, from 357,036 ha in 2003 to 706,856 ha in 2004. Intensity of mortality increased as well, with most of the attack recorded as light in 2003 and almost half recorded as moderate in 2004.

Almost 8% of the total mountain pine beetle attack in the SIFR occurred in the remaining districts, totaling 324,817 ha of affected stands. Although this is a relatively small amount of attack compared to more northerly districts, it is still more than four times the level of attack recorded in 2003. The largest increase in infested hectares as well as the highest level of attack occurred in Kamloops Forest District, where total hectares increased more than four-fold to 117,556 ha. Attack intensities were 10,865 ha (9%) trace, 46,772 ha (40%) light, 32,147 ha (27%) moderate and 27,768 ha (24%) severe. Infestations recorded in the Arrow Boundary Forest District have been on the increase for the last four years, and totaled 51,202 ha this year, four times the level recorded in 2003. Infestations in the Okanagan Shushwap Forest District increased for the fifth year in a row to 44,054 ha affected, almost five times the

amount recorded in 2003. The Cascades and Rocky Mountain Forest Districts also experienced a sharp rise, with 33,767 ha and 30,094 ha of attack, respectively.

Mountain pine beetle infestations in the Headwater Forest District increased nine-fold over last year to a total of 30,964 ha. In August, a controlled burn was successfully conducted in Mt. Robson Park. This was a joint project involving BC Parks, Parks Canada, BCMOF and Alberta Sustainable Resource Management. The objectives of this burn were threefold: to kill mountain pine beetles in the trees, to reduce the host species, and to produce a firebreak. Interestingly, the firebreak proved its effectiveness only days later when a wildfire



Mountain pine beetle pitch tubes

started nearby and was stopped at the controlled burn site. Follow up treatment with tree removals where burning was not feasible is now underway. This treatment is being conducted primarily in campsites and areas near the Alberta border to prevent the spread of beetles eastward into Alberta. Efforts have been made to keep the effects of tree removal minimal, by conducting the treatment in winter with low impact equipment.

Of the mountain pine beetle attack recorded in the Northern Interior Forest Region (NIFR), four of the most southerly districts continued to contain the majority of the infestations (99%). Affected area almost doubled since last year to a record 2.6 million hectares.

The largest increase and the highest amount of attack occurred in Vanderhoof Forest District. Affected hectares rose to 846,868 ha, almost double that of 2003 (Figure 9). Of this total, 68,868 ha were located in the Entiako protected area. Only a few susceptible host areas along the northern edge of the district boundary remain unattacked. Severity has decreased considerably, with only 17% of the stands recorded as severe, compared to 48% in 2003. This reflects the age of many of the large infestations, where most of the trees are old (grey) attack.

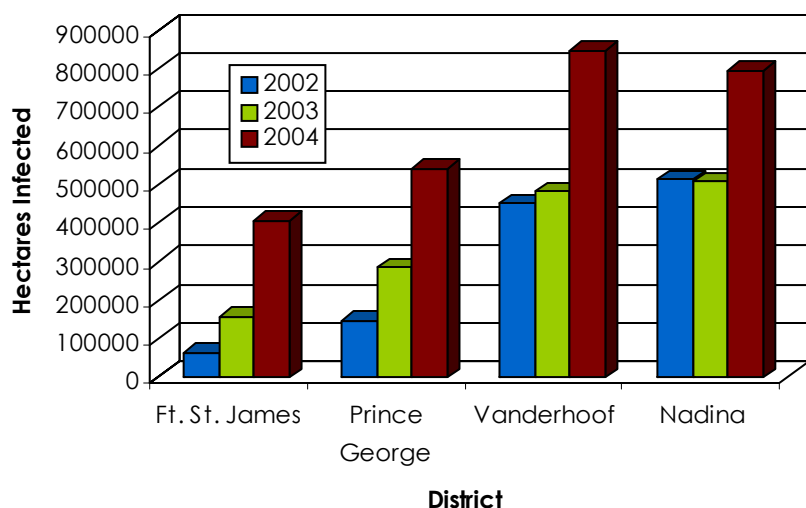


Figure 9. Change in hectares infested by mountain pine beetle from 2002 – 2004 in the Northern Interior Forest Region for districts with more than 400,000 ha affected.

The area under attack in the Nadina Forest District jumped over a third from 2003 to 793,601 ha, of which a third was located in Tweedsmuir Provincial Park and the Entiako protected area. The majority of the large infestations in the southern part of the district have high levels of grey attack, which was reflected in a continued drop of overall intensity, from 74% moderate – severe in 2002, to 54% in 2003, and only 17% in 2004. However, large expansions mapped as trace polygons were noted in the northern portion of the district this year.

In Prince George Forest District, the mountain pine beetle continued to expand, with most susceptible pine stands affected to some extent. Attack is heaviest southwest of Prince George and south of the Nechako River. Many areas of new, light infestations were

mapped southwest of McLeod Lake, right through to the Fort St. James Forest District boundary. Area infested has almost doubled since 2003 to 540,797 ha.

Area of damage in the Fort St. James Forest District rose substantially from 157,865 ha in 2003, to 407,315 ha in 2004 (Figure 9). As was the case last year, most of the beetle attack is in the southern portion of the district, with additional infested stands around the Sustat River in the northern portion. The large percentage of trace and light intensity of attack (at 61% and 23%, respectively) is indicative of relatively new infestations, with large amounts of susceptible host material still available in these areas.

Mountain pine beetle attack has risen sharply in the Peace Forest District, from a few small spots observed for the first time in

2003 to 18,601 ha in 2004. Attack in 2003 was actually higher than recorded, but the mortality was so lightly scattered that the overview surveyors could not see it with the poor visibility caused by the fires. Over 90% of the infestations are trace to light as is common in a new infestation, scattered across the northeastern slopes of the Rocky Mountains. The largest areas of attack are east of Tumbler Ridge and on the plateau north and east of Chetwynd. Vast areas of pine (lodgepole and jack pine) that stretch across Canada in the Boreal forest are potentially at risk from this infestation if weather conditions continue to permit winter brood survival.

Fortunately, ground surveys have not shown a large increase in (current) green attack. Ground surveys also indicate that the current infestation appears to have originated from one large beetle flight (likely from the outbreak East of Prince George) in the summer of 2002. Since then, these small infestations have grown very slowly with no evidence of a recurrence of similar mass migration establishing new infestation sites. An aggressive control program to treat over 3,000 infestation sites is underway in this district and has a high potential for success, given that climatic conditions east of the Rocky Mountains have historically been unfavourable to mountain pine beetle brood

success. For example, temperatures dipped to -20°C in mid April 2004 and an additional cold snap of -20°C occurred on October 20th, 2004. These late spring and mid-fall cold snaps caused some increased overall larval mortality in the Peace River Forest District.

A few recently killed lodgepole pine were identified only 8km from the Alberta border in the SE portion of Dawson Creek TSA, but ground surveys found they were aging trees that succumbed to the less aggressive lodgepole pine beetle (*Dendroctonus murrayanae*).

The Mackenzie Forest District had a large increase in mountain pine beetle infestations, from only 969 ha in 2003 to 13,700 ha in 2004. Most of the attack was either trace (58%) or light (41%) intensity, and was primarily located south and east of the town of Mackenzie. The only other attack of note in the NIFR occurred in the Skeena Stikine Forest District, which doubled since last year to 3,252 ha infested.

Mountain pine beetle attack remained relatively stable in the Coast Forest Region (CFR), with total of 212,620 ha affected. Most of the mortality continued to occur in the North Island – Central Coast District (195,194 ha), with 95% of the attack in this district located in Tweedsmuir Provincial Park. This infestation contains signifi-

cant levels of grey attack, which is reflected in the decreasing severity levels. Beetle attack has now spread westward to the ocean and down the Dean Channel. Additional areas of noteworthy beetle infestations were located in the Whistler – Pemberton corridor, on the east side of Lillooet Lake and in Manning Provincial Park where existing infestations expanded and intensified. A control program continued in the Whistler area, with efforts concentrating on preventing beetle movement south of Whistler into Brandywine Falls Provincial Park area.

Provincially, the beetle flights on average were relatively normal. The largest and best-synchronized flights generally occurred in late July and early August, at the end of a warm dry period. A cooler, wet weather pattern during the last three weeks of August halted any significant beetle flight activity. At the end of August and in early September, a warmer, drier weather pattern predominated, and smaller flights were observed throughout the province. In the NIFR, survival rates from this later flight seemed poor. In the SIFR, the survival appeared to be better.

The drought experienced for several years in the SIFR had the unusual result of current “green” attacked trees fading prematurely by the early fall,

instead of the following spring. Early fade was noticeable in 2003 in the lower elevations of the Central Cariboo Forest District, but was far more widespread in 2004. This phenomenon was also noted around the Whistler area of the CFR, and even occurred in the southern portion of the Prince George Forest District of the NIFR, where up to 75% of the attacked trees were visibly faded by the early fall.

In some areas in the SIFR, the combination of drought stress and vigorous, synchronized attack resulted in tree defenses being overcome quickly enough that pitch tubes were not formed, though this phenomenon was not as widespread as in the last few years. It was widespread in the Whistler area of the CFR where most of the pine grows on poor sites.

Attacked trees usually remain undetectable from the air until the year following attack, since the foliage usually remains green until then. Therefore, ground survey data is required to determine the average number of newly attacked trees for each aerially detected red tree. This statistic, called the green:red ratio, is an important tool for projecting the growth rate of the mountain pine beetle population in a given area. Forest managers use this projection as a guide to develop

operational plans and budgets for the following year.

Green to red ratios must be interpreted carefully. Exceptionally high ratios (usually greater than the generally accepted biological limit of 5:1) may indicate that sampling was done in areas that were being inundated by beetles from neighbouring sources, and may not be truly representative of the average reproductive rate. This is particularly true in the present outbreak, where green:red ratios as high as 50:1 have been recorded.

Table 4 summarizes green to red ratios observed in various forest districts throughout the province in 2004. Overall, ratios varied greatly, even within a

district. In the NIFR, ratios indicated a range from declining beetle populations (<1:1) to very active populations (50:1). Infestations in the Peace Forest District showed an average declining population of 0.8:1. Extensive surveying was conducted to obtain this statistic as this area is of high concern. Vanderhoof Forest District had immense beetle pressure on the few remaining susceptible trees left from last year's attack, therefore green:red ratios were not felt to be a meaningful statistic, and the information was not gathered.

In the SIFR, ratios varied greatly, but averages were very high in the Cariboo zone, and decreased in the southern-most districts. Due to the low

amount of attack outside of parks in the CFR, no surveys were conducted to obtain green:red ratios.

Overall, growth rate projections from the green:red ratio results indicate that despite aggressive control tactics in leading edge infestations, the mountain pine beetle populations will continue to expand in 2005. With such a large number of mountain pine beetles, it would be difficult for even a significant cold weather event to reduce the overall population to endemic levels.

In several areas, a high number of small scattered spots appeared over large areas that were located far from any advancing infestation. In general, large infestations continued to show dispersal along the leading edges as small areas of mortality were recorded in previously uninfested stands.

In most areas with continued high infestation levels, beetle "filled in" the previously unattacked areas, often attacking smaller diameter stems. In these heavily infested areas throughout the province, reports have been made of very young lodgepole pine stands being attacked. The youngest stand was reported in Prince George Forest District with an average age of 19 years, and in several southern interior sites trees as small as 8cm were killed. This phenomenon seems

Table 4. Green to red mountain pine beetle attack ratios observed in 2004.

Region / District	High	Average	Low
NIFR – Prince George	40:1	4:1	1:1
Nadina	25:1	7:1	1:1
Skeena Stikine	15:1	3:1	<1:1
Peace	6:1	0.8:1	<0.8:1
SIFR – Chilcotin	50:1	18:1	4:1
Cascades	68:1	5:1	1:1
Central Cariboo	25:1	12:1	1:1
100 Mile	25:1	10:1	3:1
Quesnel	25:1	10:1	<1:1
Kootenay Lake	25:1	6:1	3:1
Kamloops	20:1	5:1	1:1
Headwaters	14:1	5:1	<1:1
Okanagan Shuswap	15:1	4:1	<1:1
Rocky Mountain	14:1	5:1	<1:1
Columbia	10:1	6:1	1:1

to have generally been restricted to plantations or tended stands as opposed to naturally regenerated stands. Additionally, anecdotal evidence suggests that mountain pine beetle broods have been successful in a significant number of these younger trees, which has historically not been the case.

The pine engraver bark beetle (*Ips pini*) is known to breed in lodgepole pine recently killed by mountain pine beetle. In large numbers, the pine engraver can attack living trees, especially if they are stressed. For example, mature lodgepole pine were killed along cutblock boundaries for two to three years after the collapse of the mountain pine beetle outbreak on the Chilcotin plateau in the mid 1980's. A 19-year-old lodgepole pine plantation that was thinned in October 2003 near Kluskus in Vanderhoof Forest District had been attacked and killed by *Ips pini* in 2004. It was hypothesized that the high numbers of emerging pine engraver beetles from nearby mountain pine beetle infestations, combined with thinning and drought stress, resulted in this situation. It has since been recommended that any spacing in young pine stands near large infestations be delayed until the beetle populations have collapsed. More surveys are required to determine the actual extent of this damage. Results of these surveys may impact the

estimates of mid-term timber supply as these younger stands were assumed to continue growing with minimal damage.

Another anecdotal observation of an effect that vast areas of dead pine are creating is a rising water table. Some previously mesic sites in the NIFR within the large older infestations are showing water tables at or just below the surface. These are just some examples of many possible unforeseen effects that are resulting from the current epidemic.



Ips beetle egg and larval galleries

Pine Needle Diseases

Dothistroma needle blight, *Mycosphaerella pini*

Dothistroma (red band) needle blight (*Mycosphaerella pini*) damages needles of all ages on pine trees, when mild wet weather conditions suitable for spore dispersal and infection occur during the growing season. Infected needles do not turn red until the following spring. Immature and mature stands can experience significantly reduced growth and some mortality.

The aerial overview survey often under-estimates the actual area affected by pine needle diseases due to the difficulty in accurately identifying damage to older foliage at the height flown and because the survey is conducted after the ideal time for detecting the disease (usually best in early June).

In 2002, low-level aerial surveys using helicopters were first conducted to determine the extent of the initial Dothistroma infestation in the former Kispiox Forest District. These surveys were expanded in 2003 to include Kalum Forest District. An initial management strategy was developed that included low-level aerial surveys, followed up by ground surveys with specific standards for this disease, and planting of the hardest hit plantations. In 2004, aerial surveys were conducted over

susceptible stands in Bulkley, Kispiox and Cranberry TSA's, as well as the eastern portion of Prince George Forest District and parts of Headwaters Forest District.

Dothistroma needle blight continued to be the most significant disease affecting forests in northwest BC. The incidence of disease stabilized in 2004 due to drier conditions in 2003. However, mortality resulting from previous infections continued and new growth of damaged trees was minimal in portions of the Kalum, Nass, Kispiox, Cranberry and Bulkley TSA's. The most severely affected stands were located in the Interior Cedar Hemlock (ICH) and Coastal Western Hemlock (CWH) biogeoclimatic zones with some in the Sub-boreal Spruce (SBS) zone. Of particular note was mortality in mature valley bottom pine stands in the Upper Skeena and Squingula River drainages in the Fort St. James District. In 2003, 436 ha of failed lodgepole pine plantations in

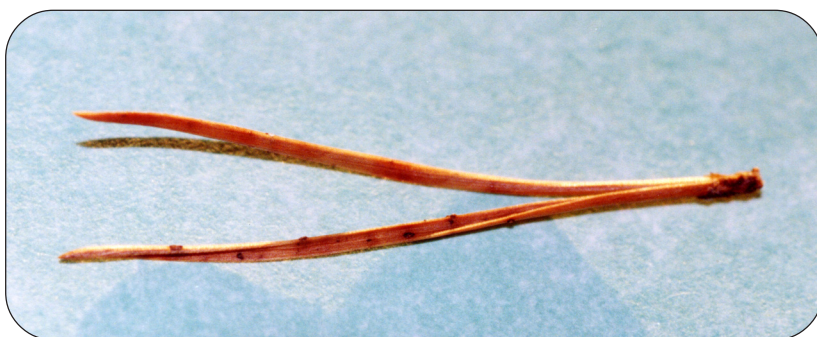
the Kispiox, Cranberry and Nass TSA's were fill-planted with a mixture of shade – tolerant species. This reforestation effort unfortunately coincided with a peak in snowshoe hare populations, who fed on the seedlings. In 2004, the hare population was down significantly, which allowed for some seedling recovery. In the fall of 2004, over 480 openings were assessed for *Dothistroma* damage using low-level aerial surveys in the Kispiox, Cranberry and Bulkley TSAs combined. Of the 12,000 ha surveyed close to 10% (1134 ha) will require follow-up ground surveys to confirm whether or



Lodgepole pine affected by Dothistroma

not adequate alternate species stocking is present or to estimate number of trees required for fill-planting.

Dothistroma was observed in many stands during a helicopter survey in the Prince George Forest District, but most of these were healthy or only very lightly affected. The few moderately and severely infected stands tended to be in low – lying topographic positions. A flight in the Headwaters Forest District in early June revealed 290 ha of severe defoliation in



Fruiting bodies of Dothistroma needle blight on lodgepole pine needles

young stands and age classes of lodgepole pine. Plantations in the Castle Creek drainage and along the Fraser River east of Kiwa Creek were the most affected. Moderate defoliation occurred on 3,600 ha in all age classes of lodgepole pine, especially in the Holmes River drainage and along the Fraser River. Dothistroma needle blight was also responsible for moderate to severe defoliation of lodgepole pine in stands near Cottonwood House east of Quesnel.

Stand damage from Dothistroma infection is anticipated to increase in 2005, due to the rain that fell for most of August. This may also be the case for pine needle cast (*Lophodermella concolor*), which heavily defoliated current foliage of pine throughout the Cariboo from 1998 – 2002. Defoliation caused by this needle cast dropped sharply in 2003 to 40,940 ha affected and to endemic levels in 2004 with only 152 ha infected, due to the previous years' drought conditions.

Phaeoseptoria contortae

A needle disease caused by the pathogen *Phaeoseptoria contortae* can affect young lodgepole pine trees. Infections occur on needles only during their first year of growth. Affected needles turn red with prominent black transverse stripes the following spring, resulting in defoliation. Growth reduction may result from this needle loss.

Infected stands were noted by ground reconnaissance in the higher elevation SBS and lower elevation Engelmann Spruce Subalpine Fir (ESSF) transition zone throughout the Bulkley and Morice TSA's, and some areas of the Lakes TSA. Affected trees were primarily found in plantations.

Elytroderma needle cast, *Elytroderma deformans*

Elytroderma needle cast caused by the pathogen *Elytroderma deformans* not only affects needles of lodgepole and pondersosa pine trees, it also causes branch and stem infections. Diseased needles turn red and display long black longitudinal fruiting bodies the summer following infection. The branch infections (brooms) and stem infections characterized by brown lesions in the inner bark were identified in numerous lodgepole pine stands in the Mackenzie and Prince George forest districts in 2004. These branch and stem infections would have occurred many years ago, but had gone undetected.



Broom caused by Elytroderma needle cast infection

Pine Stem Rusts

Comandra blister rust, *Cronartium comandrae* **Stalactiform blister rust, *Cronartium coleosporioides*** **Western gall rust, *Endocronartium harknessii***

Pine stem rusts are found in lodgepole pine stands throughout BC. Trees of all ages can be affected, but damage is greatest in young stands. Infections can reduce tree growth, lead to serious defects, and cause tree mortality. It is uncommon to be able to identify rust mortality during an aerial overview survey, as the dead trees are usually small and tend to be scattered.

Thirty 1 ha plots consisting of a total of 45,000 trees were established in susceptible pine plantations in the former Lakes Forest District in 1997 to study the incidence and impact of comandra blister rust. The trees ranged in age from 10 to 25 years at the time of plot establishment. A re-assessment of these plots in 2004 showed significant numbers of new infections and mortality, even though the trees are now 17 – 32 years of age. This adds weight to the theory that comandra blister rust infections and their damaging effects do not necessarily decline rapidly

when trees reach approximately 20 years of age.

Four lodgepole pine progeny installations established by the Kalamalka Research Centre in the mid to late 1980's in

the Vanderhoof, Prince George and Mackenzie forest districts in 2004. Of note on all three sites was a significant increase in the incidence of stalactiform blister rust. Although these same sites

were not for comandra blister rust in the past, climatic conditions for several years in the late 1990's and early 2000's have been very favorable to stalactiform blister rust. As a result there appears to have been a surge in this disease relative to the level of comandra blister rust.



Lodgepole pine stem rust infections

the Prince George and Mackenzie forest districts were assessed for pine stem rust incidence and severity. The objective of this assessment was to quantify variation in resistance to pine stem rusts. These stands were closing in on 20 years of age, and canopy closure had occurred many years ago. Very few recent stem infections were noted.

Several young lodgepole pine installations were assessed in

District staff in the Rocky Mountain Forest District has observed that new infections caused by all lodgepole pine rusts were very high in 2004. Given that stem rust infections generally take two to three years to become visible it is likely that one or more “wave years” (i.e., years when conditions are highly favourable for infection) have occurred there recently.

DAMAGING AGENTS OF DOUGLAS-FIR

Western spruce budworm, *Choristoneura occidentalis*

Western spruce budworm (*Choristoneura occidentalis*) is the most serious defoliator of interior Douglas-fir (*Pseudotsuga menziesii*) in BC. Significant damage can be caused by larvae feeding on foliage during an outbreak, such as reduced seed production due to damaged cones, growth loss, topkill, creation of stem deformities and even mortality. Understory trees are particularly vulnerable.

Defoliation by western spruce budworm continued five-year expansion trend. Area affected across BC reached a high of 623,735 ha in 2004 (Figure 10). The majority of the defoliation continued to be light (85%), with 14% moderate and only 1% severe. As in the past three years, most (82%) of the defoliation occurred in the SIFR 100 Mile House and Central Cariboo Forest Districts at 234,656 ha and 276,312 ha affected, respectively (Figure 11). Aerially visible defoliation increased sharply in the Chilcotin Forest District, from only 25 ha in 2003 to 28,536 ha in 2004. Damage was widespread in the Central Cariboo, present to some extent in most Douglas-fir stands ranging from the southern boundary of the 100 Mile House District to slightly north of Williams Lake,

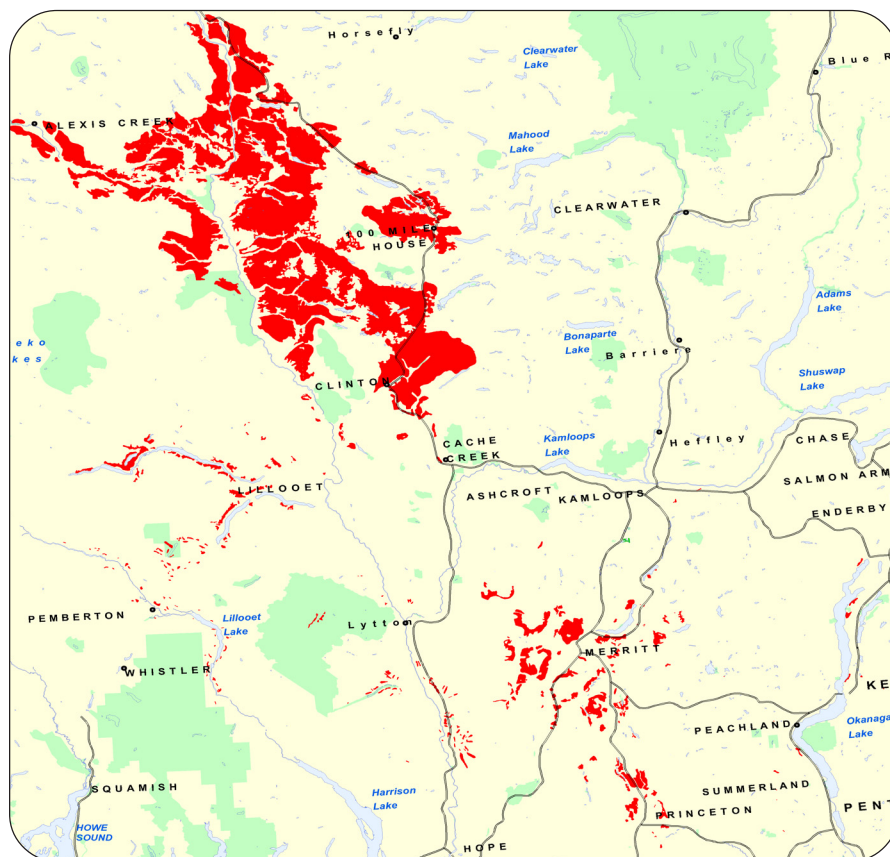


Figure 10. Areas defoliated by western spruce budworm in 2004.

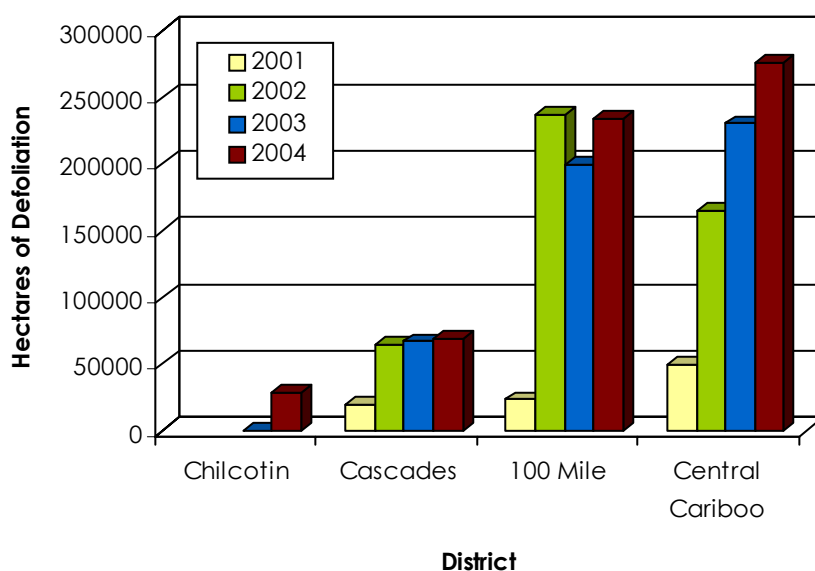


Figure 11. Hectares of western spruce budworm defoliation from 2001 – 2004, for districts with over 5,000 ha affected in 2004.

and west of Young Lake / Horse Lake near 100 Mile House all the way to just past Alexis Creek in the west.

Cascade Forest District defoliation has remained relatively constant over the past three years, with 68,845 ha affected in 2004. Most of the damage occurred south of Merritt in the Aspen Grove and Princeton area, and in the Lillooet TSA around Goldbridge, Gun Lake and Pavillion Lake. Kamloops Forest District saw a drop in defoliation area for the 2nd year

in a row, from a peak in 2002 of 15,544 ha to 4,606 ha this year. The majority of this damage was located northwest of Cache Creek, on the border with 100 Mile House District.

Infestations in the CFR dropped significantly from 2003 levels, both in size and intensity. Areas of defoliation around Pemberton, Anderson Lake, Lillooet Lake, Birkenhead and Haylmore in the Squamish Forest District totaled 4,183 ha, a drop of more than half from area affected in 2003. In

Chilliwack Forest District, recorded defoliation totaled 4,709 ha. Intensity was primarily light (93%) throughout the CFR.

Eggmass surveys conducted in the fall predict significant defoliation for some areas next year, particularly in the Central Cariboo, 100 Mile House, and Cascade Forest Districts (Table 5). Some parts of the Chilcotin Forest District are predicted to sustain moderate to severe levels of defoliation as well, with three times the average

Table 5. Summary of 2004 western spruce budworm eggmass survey results.

Predicted 2005 Defoliation	Forest District					
	Squamish	Chilliwack	Chilcotin	Cascades	100 Mile	Central Cariboo
Nil Sites	4	5	0	0	1	3
Light Sites	9	7	1	5	71	36
Moderate Sites	0	0	3	34	38	29
Severe Sites	0	0	1	22	1	3
Total Sites	13	12	5	61	111	71



Aerial application of B.t.k.

number of eggmasses/10 M2 foliage recorded over last year. The average number of eggmasses/10 M2 foliage is down in 100 Mile House Forest District, in part due to recent control measures. Eggmass results in the Chilliwack and Squamish Forest Districts confirm that the populations are in decline, with all sites predicting low to nil 2005 defoliation.

Direct control with the biological control agent *Bacillus thuringiensis* var. *kurstaki* (B.t.k.) can be utilized as a management option. In the spring of

2004, 20,946 ha were treated in the 100 Mile House Forest District south of 100 Mile House, north of Chasm, Big Bar Lake and Meadow Lake. Another 4,558 ha were sprayed in the Central Cariboo Forest District west of Williams Lake to Riske Creek and west of Brigham Lake (Figure 12). Treatment was conducted with two 802 Air Tractors utilizing a T-Jet spraying system. One application of the B.t.k. product Thuricide 48L V was applied at a rate of 2.4 l/ha. Average production was 600 ha/hr for each plane.

The treatments were successful, with eggmass counts predicting primarily low defoliation for 2005 within treated areas. This marks the 8th year of a successful budworm control program in the Central Cariboo, with only 7% of all the treatment areas ever requiring more than one application. The areas where significant western spruce budworm defoliation is expected next year will be evaluated to determine if they fall within provincial treatment criteria. Pending funding, a treatment program is anticipated for the spring in various areas throughout the SIFR.

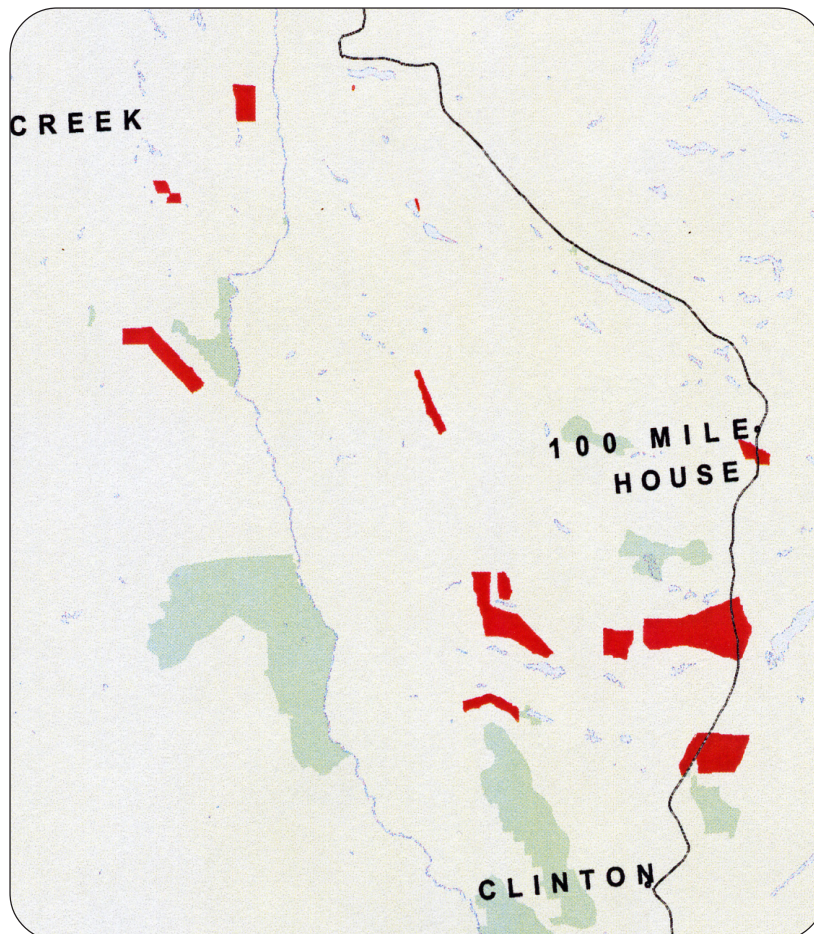


Figure 12. Western spruce budworm infestations treated with *Bacillus thuringiensis* var. *kurstaki* in 2004.

Douglas-fir beetle, *Dendroctonus pseudotsugae*

Douglas-fir beetle (*Dendroctonus pseudotsugae*) is an important pest of mature Douglas-fir in the province. At low population levels, the beetle infests scattered, weak trees. When Douglas-fir beetle populations build under favourable conditions, large numbers of healthy trees can be attacked. Events that stress trees such as drought, fire or extensive windthrow/breakage are often the precipitators of outbreaks. Although the number of trees killed by this beetle tends to be comparatively minor, they are frequently located in old growth management areas or within valuable mule deer winter range. Increased occurrence of beetle-killed trees in these habitats may reduce the suitability of these areas for their designated purpose.

Area affected by Douglas-fir beetle rose provincially for the 2nd year in a row to 34,126 ha after a four year low of 9,078 ha in 2002. This was primarily due to a large increase in the Central Cariboo Forest District, where infestations rose to 18,221 ha (Figure 13). Ground reconnaissance of some attack centers in this district showed very low new attack (approximately 0.2:1 green:red ratio), so it is expected that Douglas-fir beetle attack will decrease in 2005. Low current attack was also observed on the ground in 100 Mile

House Forest District, where aerially mapped red attack dropped by 35% from last year to 5,040 ha affected. The lack of current attack in these districts seemed unusual, considering the weakened condition of the trees due to drought. It is hypothesized that parasites and/or predators are controlling the beetle population.

The Douglas-fir beetle was thriving in the neighbouring Chilcotin Forest District however, with infested hectares rising steeply from 325 ha in 2003 to 3,069 ha this year. The beetle was very active in the Chilcotin River corridor, most notably on the steep northeast facing slopes where trees have been very drought stressed.

Ground observations confirmed a relatively high ratio of current attack, which was starting to spill out of the steep sensitive areas into the productive forests. Infestations in Quesnel Forest District also increased from only 42 ha in 2003 to 2,415 ha, although most of the attack was of trace intensity.

For the remainder of the SIFR, Douglas-fir beetle infestations remained relatively endemic, with only a few hundred hectares affected in each of the Headwaters, Okanagan, Rocky Mountain and Kamloops Forest Districts. Extensive drought mortality during the fall of 2003, and the spring of 2004, especially in the Kamloops and Okanagan Shuswap Forest Dis-

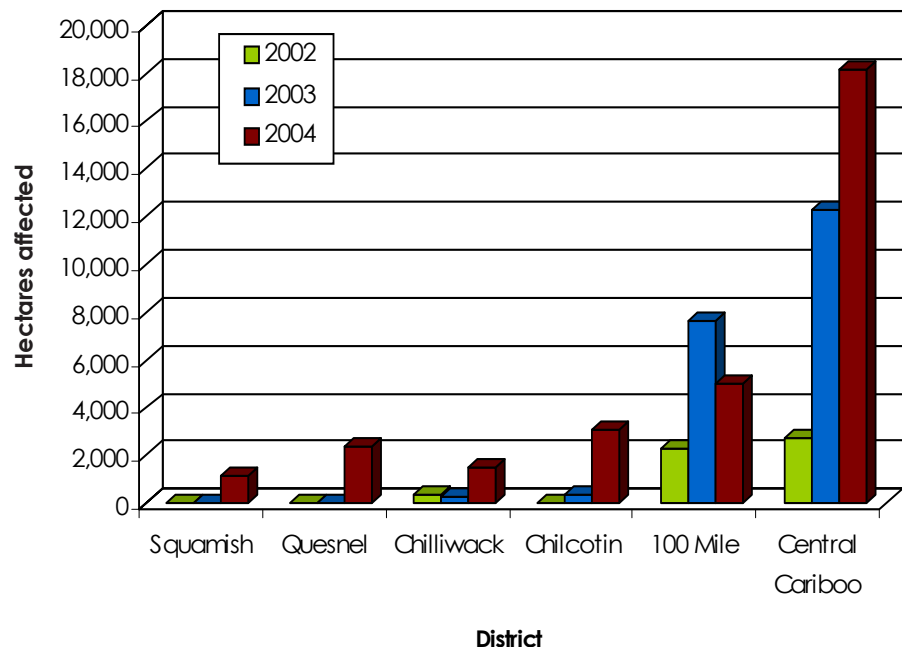


Figure 13. Hectares affected by Douglas-fir beetle in BC from 2002 – 2004, for districts with over 1,000 ha of damage in 2004.

tricts, may lead to increased Douglas-fir beetle mortality in 2005.

In the CFR, scattered mortality due to Douglas-fir beetle rose sharply in the Chilliwack and Squamish Forest Districts to 1,166 ha and 1,524 ha, respectively (Figure 13). The main areas of concern are the Nahatlach and Lillooet River north of Harrison Lake and in the Skagit area.



Mortality caused by
Douglas-fir beetle

Douglas-fir tussock moth, *Orgyia pseudotsugata*

The Douglas-fir tussock moth (*Orgyia pseudotsugata*) is a voracious defoliator of Douglas-fir of all ages. The larvae consume both old and new foliage, so even one year of defoliation can result in top kill and mortality. Populations build rapidly when an outbreak occurs and by the time defoliation is visible, stands often suffer mortality.

Pheromone trapping sites are used by the BCMOF to monitor the population in high hazard areas of the Kamloops, Cascades, Okanagan Shuswap and 100 Mile House Forest Districts. This monitoring system provides an early warning of a building population before significant defoliation occurs.

Over the past eight years, trap catches have varied considerably in the different forest

districts (Table 6). The number of moths caught in all districts except 100 Mile House was high in 1998, followed by a decline. 100 Mile House Forest District catches peaked a year later, though overall numbers were consistently lower than in the more southerly districts. Trap catches in the Kamloops Forest District in 2001 indicated a growing population that would probably reach outbreak proportions in 2002. However, extensive parasitism occurred in the fall of 2001, and no treatment was necessary. Trap catches rose again sharply at the majority of sites in 2003. Severe defoliation was recorded north of Cache Creek for three years: 49 ha in 2001, 92 ha in 2002 and 37 ha in 2003. Trap results in 2004 overall showed a significant drop in moth catches, with no current defoliation noted during the aerial surveys.

Table 6. Average number of Douglas-fir tussock moths caught per trap, 1997 – 2004.

Year	District			
	Kamloops	Okanagan Shuswap	Cascades	100 Mile
1997	17.0	3.6	11.9	1.7
1998	25.8	15.9	18.8	0.5
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

DAMAGING AGENTS OF SPRUCE

Spruce beetle, *Dendroctonus rufipennis*

The spruce beetle (*Dendroctonus rufipennis*) is the most destructive damaging agent of mature spruce (*Picea* spp.) in BC. At low population levels, the spruce beetle infests stressed trees and downed host material. If a large amount of preferred host such as windfall is available, populations can build to the point where beetles can move into healthy trees and cause widespread mortality.

Spruce beetle attack dropped by 67% from 315,953 ha in 2003 to 104,810 ha, provincially. Severity was up in the moderate – severe categories in 2004 to 35%, compared with only 9% in 2003. With the addition of the trace category however, light severity dropped to 27% and the remaining 38% was recorded as trace.

Severity and hectares affected by spruce beetle are difficult to determine accurately during the aerial overview survey. Under-estimations occur because newly killed trees only show as a dull yellowish or purplish-red colour at best, and often just change directly from green to grey. Drastic changes in area affected from one year to the next are often due to the 2-year cycle of the spruce beetle and/or the short window of opportunity to observe the subtle colour change. Often the coloured needles are only

observable for a few weeks, which may not coincide with the date of the aerial surveys.

The majority of the drop in affected hectares occurred in the NIFR, particularly in the Mackenzie, Fort St. James and Prince George Forest Districts, where total attack levels of 243,971 ha in 2003 fell to only 9,176 ha in 2004. The Skeena Stikine Forest District also experienced a significant reduction from 4,966 ha last year to 1,426 ha. Survey timing was earlier in these district this year, and may have resulted in less observable mortality. Additionally, 2-year-cycle budworm defoliation, which can predispose trees to spruce beetle attack, has been down

significantly since a peak in 1999 – 2001.

Several areas of the SIFR experienced substantial expansions of area affected by spruce beetle. The largest increases occurred across the eastern half of the Quesnel and Central Cariboo Forest Districts, to 22,553 ha and 28,792 ha, respectively (Figure 14). 100 Mile House Forest District infestations declined slightly from 21,152 ha in 2003 to 17,253 ha. This still represented the 3rd highest amount of attacked hectares in the SIFR. Survey timing to see new spruce beetle was very good in these three districts this year. In the north-eastern portion of the province, modest increases were recorded for the 2nd year in a

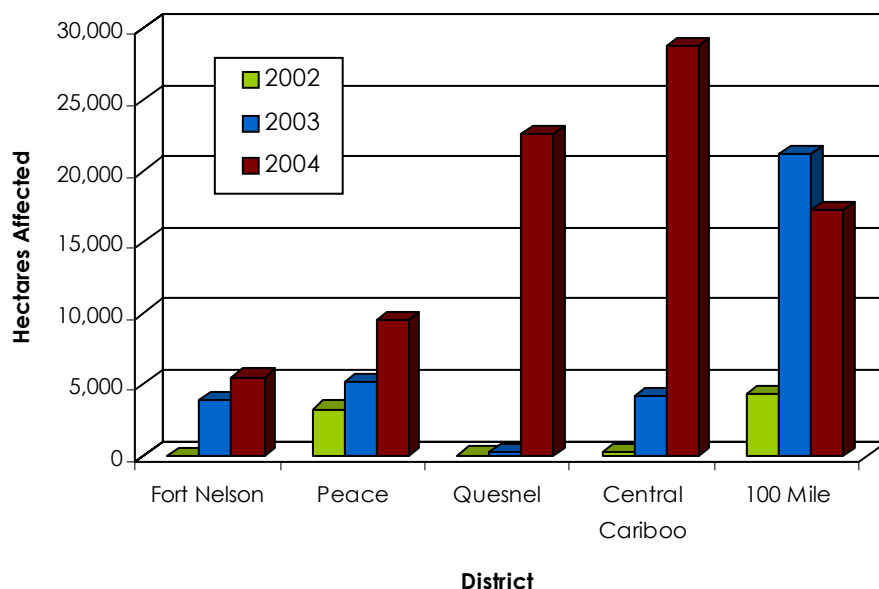


Figure 14. Hectares affected by spruce beetle in 2002 - 2004, for districts with more than 5,500 ha infested in 2004.

DAMAGING AGENTS OF TRUE FIR

Eastern spruce budworm, *Choristoneura fumiferana*



Mortality caused by spruce beetle

row for Peace Forest District (9,544 ha) and Fort Nelson Forest District (5,508 ha).

Other infestation levels of note occurred in the Cascades Forest District where 3,044 ha were infested, and Headwaters Forest District with 3,015 ha of attack. In general, the SIFR forests have lower amounts of spruce than the NIFR forests, and this is usually reflected in lower levels of spruce beetle attack. However, various windthrow events occurred over the past two falls in the vicinity of some of the present infestations in the SIFR, and populations seem to generally be on the increase.

Area affected in the CFR dropped to 2,152 ha, from 3,071 ha in 2004. The primary infestation in the Haylmore Creek area of the Squamish Forest District is beginning to deplete the available host.

The eastern spruce budworm (*Choristoneura fumiferana*) is a significant defoliator of all ages of sub-alpine fir (*Abies lasiocarpa*) and spruce in north-eastern BC. Since larvae feed on both old and new foliage, severe defoliation can occur during an outbreak. Several consecutive years of defoliation can result in growth loss, tree deformity, top-kill and tree mortality.

After many years of significant defoliation, it appears that the eastern spruce budworm population has experienced a general collapse, as recorded in both northeastern BC and Alberta. Affected hectares dropped six-fold in the Fort Nelson Forest District to 25,263 ha, and four-fold in the Peace Forest District to only 4,385 ha. Defoliation was confined to chronic areas

along major river valley bottoms, and surveyors found it difficult to ascertain if some of the damage was actually current.

As in previous years, branch samples from affected areas in the Fort Nelson Forest District were collected and early instar larvae emerging from the samples were counted in order to predict expected defoliation levels for 2005. This is the third consecutive year that larval densities have dropped sharply, and the first year since sampling began that no larvae were found. These results indicate that defoliation will be nil to trace next year all six survey sites, located at Clarke Lake, Snake River (two), Kotcho, Liard and Muskwa.



Eastern spruce budworm defoliation

2-year-cycle budworm, *Choristoneura biennis*

The 2-year-cycle budworm (*Choristoneura biennis*) is a significant defoliator of all ages of sub-alpine fir and spruce throughout the subalpine and boreal forest of the BC interior. Damage is very similar to that caused by the eastern spruce budworm.

The 2-year-cycle budworm usually completes its life cycle over two years. Most of the defoliation damage occurs in the 2nd year, when larvae are bigger and hence consume more foliage.

On a provincial basis, defoliation has been low over the past three years, when compared to the peak years of 1999 to 2001. From Prince George Forest District south the 2-year-cycle budworm is on an even year cycle, hence 2004 was the 2nd year in the life cycle for this area. Accordingly, area affected increased to 51,171 ha, from 36,144 ha in 2003. Most defoliation mapped over the last two years has been light. The amount of defoliation mapped in 2003 was quite high for the 1st year of the cycle, possibly due to the long, warm feeding season. Heavier defoliation was anticipated this year, but was not observed. Defoliation was primarily concentrated in the Central Cariboo and Quesnel Forest Districts in 2003, but in 2004 defoliation levels fell in the Central Cariboo, and the

highest level was recorded in the Headwaters Forest District at 29,466 ha. There was some speculation that the budworm may have gone off cycle, but ground reconnaissance in several areas indicated that this was not the case. The low defoliation intensity recorded may have partly been due to heavy late August rains washing off affected needles, as many of the aerial surveys in these areas occurred after the rain. Eggmass sampling conducted at sixteen sites on TFL 52 east of Quesnel indicated that defoliation would likely be light in 2005/06.



2-year-cycle budworm defoliation

The portion of the province northwest of Prince George Forest District is on an odd year cycle; hence 2004 was the 1st year in the budworm life cycle for this area. No defoliation was recorded during the aerial surveys this year.

A study by the Canadian Forest Service with the support of the

NIFR was launched in 1999 to determine the economic and ecological impacts of the 2-year-cycle budworm. Permanent sample plots were established, with 32 plots in the Fort St. James and 7 in the Mackenzie Forest Districts. These plots were re-assessed in 2000, and additional plots were established in Robson Valley Forest District (10) and Prince George Forest District (5). Plots were again re-assessed in 2001, 2002 and a subset of the plots in 2003 (17 in Fort St. James, 4 in Mackenzie and 4 in Prince George Forest Districts). The same subset was re-assessed in 2004.

The 2004 results have not been tabulated to date, but various trends were discovered in previous assessments. All sites showed a higher level of defoliation in subalpine fir than spruce. In general, topkill and mortality related to defoliation was also higher in subalpine fir than spruce to date. However, spruce damage and mortality may catch up to that of subalpine fir as the outbreak progresses. Mortality can be expected to continue for up to ten years after the end of the outbreak. Stands that experienced defoliation were predominantly in the SBS and ESSF biogeoclimatic zones. Within susceptible ecosystems, the risk of damage increased in stands with a higher component of host trees.

Western balsam bark beetle, *Dryocoetes confusus*

The western balsam bark beetle (*Dryocoetes confusus*) is the most significant damaging agent of mature sub-alpine fir in BC. This bark beetle in association with a pathogenic fungus can cause extensive tree mortality in high elevation ecosystems.

Area affected by mortality due to western balsam bark beetle continued to climb to over 2 million hectares, from 1.3 million hectares in 2003. The annual impact of western balsam bark beetle is usually less than most bark beetles, because the mortality rate per year is very low. This was far better reflected this year with the addition of the intensity category of trace. Compared to last year's 94% light, this year only 20% of the hectares were categorized as

light, and 78% were called trace (total of 98% of the attack). It is suspected that the addition of trace as a severity level contributed to the overall increase in area affected, as a surveyor would be more likely to draw a polygon of trace rather than identify scattered individual trees over large areas.

Western balsam bark beetle mortality tends to occur at a chronic low level in susceptible stands, often resulting in extensive cumulative damage over time. Implementing control measures for this beetle is very difficult due to the scattered nature of attack, merchantability and accessibility issues, and harvesting restrictions in caribou habitat.

Generally, the districts with the greatest amount of area affected by western balsam bark beetle have the highest areas of mature sub-alpine fir, and are mainly in the NIFR. The largest areas attacked by western balsam bark beetle for the second consecutive year occurred in the Mackenzie and Fort St. James Forest Districts, where 559,429 ha and 407,313 ha were infested, respectively (Figure 15). Levels of attack rose to 177,988 ha in Nadina Forest District and to a similar level (173,607 ha) in Skeena Stikine Forest District. This was almost a 50% increase over 2003 for both districts. Peace Forest District experienced a slight increase to 128,985 ha, and Prince George Forest District remained relatively stable at 82,963 ha. Infes-

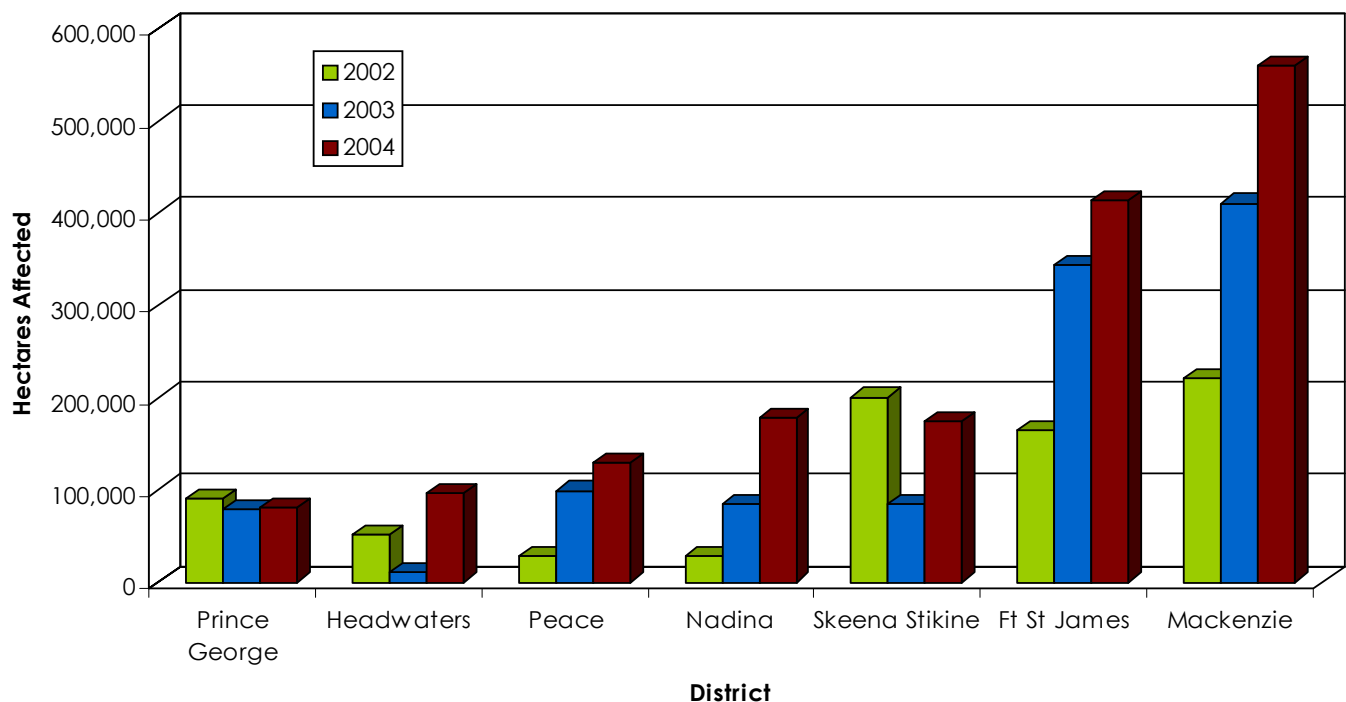


Figure 15. Hectares affected by western balsam bark beetle in BC from 2002 - 2004, for districts with more than 80,000 ha infested in 2004.

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

tations in the Fort Nelson and Kalum Forest Districts rose to 66,972 ha and 59,751 ha, respectively. Attack in Vanderhoof Forest District remained relatively low with 6,965 ha affected.

The highest amount of western balsam bark beetle attack in the SIFR in 2004 was in the Headwaters Forest District, where infestations rose nine-fold from 2003 levels to 97,060 ha affected. Area affected in the Quesnel Forest District, which had the highest levels of attack in the SIFR in 2003, dropped 13% to 73,800 ha. Area affected in the Okanagan Shuswap Forest District rose for the 2nd year in a row to a total of 33,486 ha. Infestations in the Central Cariboo Forest District dropped to 30,730 ha, while area in the 100 Mile House and Chilcotin Forest Districts rose to 26,717 ha and 14,065 ha, respectively. All other districts in the SIFR had attack levels under 4,000 ha.

Mortality rates in most areas of the CFR were very low, with the exception of North Island – Central Coast Forest District, where recorded attack increased for the 3rd year in a row to 55,549 ha.

Delphinella tip blight is a fungal disease caused by the pathogen *Delphinella balsameae* and *D. abietis* that affects current year's sub-alpine fir shoots. Infections cause the new shoots to droop and turn red in the spring. All ages of trees can be affected, and damage tends to be worst on the outside portion of the tree in the lower crown. The impact of this disease tends to be minor, though repeated defoliation can result in reduced tree growth. Damage caused by this fungal disease can sometimes be mistaken for frost damage or budworm defoliation, as it can be quite widespread.

The needles are only bright red for a short period, so it is easy to miss the damage, particularly from aerial surveys. Delphinella tip blight has been noted in ground surveys over the past ten years in various areas, including the Mackenzie and Central Cariboo Forest



Lower crown damage due to
Delphinella tip blight

Districts, the ESSF biogeoclimatic zone of the Robson Valley and cooler microsites of the SBS biogeoclimatic zone in the eastern portion of the Prince George Forest District.



Shoot damage caused by *Delphinella* tip blight

DAMAGING AGENTS OF HEMLOCK

Western hemlock looper, *Lambdina fiscellaria lugubrosa*

The western hemlock looper (*Lambdina fiscellaria lugubrosa*) is one of the most destructive defoliators of conifers in BC. Western hemlock (*Tsuga heterophylla*) is the preferred host, but the looper will feed on a large variety of coniferous, deciduous and shrub species during an outbreak. The larvae are wasteful feeders of both new and old foliage, which can lead to top-kill and mortality in only one year.

Outbreaks by this defoliator are usually predictable in length: populations rise in the 1st year but very little defoliation occurs; in the 2nd year significant defoliation is recorded; in the 3rd year infestations coalesce and defoliation is at the peak, followed by heavy egg parasitism and a collapse in the 4th year.

Infestations in the SIFR were primarily in the last year of the outbreak cycle in 2004, with defoliation down sharply from 39,398 ha in 2003 to only 5,509 ha. As would be expected at

this point, the majority of the defoliation (79%) was recorded as light intensity. Most of the defoliation was mapped around the Revelstoke Lake area. Eggmass samples collected this fall in the SIFR confirmed the population drop, with 20 of 23 sites predicting nil defoliation for 2005, and light defoliation predicted for the remaining 3 sites.

Pheromone trapping sites have also been used by the MOF in the SIFR to assist with population predictions over the past three years (Table 7). Sites in Headwaters and Okanagan Shuswap Forest District followed the outbreak trend, with relatively high numbers of moths caught in 2002 and 2003 and a sharp dip in numbers in 2004. Low trap catches were also reflected in 2004 at ten Columbia Forest District sites, though they are new sites with no previous data comparisons available.

Most populations in the CFR have collapsed, and only 241 ha of light defoliation were recorded this year, mostly in the Bella Coola area of the North Island Central Coast Forest District. Mortality is still continuing due to previous severe defoliation in the Rainy River drainage of the Sunshine Coast Forest District, where salvage harvesting is underway.

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

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



Western hemlock looper defoliation

DAMAGING AGENTS OF DECIDUOUS TREES

Large aspen tortrix, *Choristoneura conflictana*

Trembling aspen (*Populus tremuloides*) and balsam poplar (*Populus balsamifera* ssp. *balsamifera*) of all ages are susceptible to defoliation by the large aspen tortrix (*Choristoneura conflictana*). Severe defoliation can result in reduced radial growth, but mortality is rare.

Defoliation was recorded throughout aspen stands in four of the NIFR districts. From the air, it was at times difficult to determine if the defoliation was due to tortrix or aspen and poplar leaf and twig blight. Ground checks were conducted in all the districts, and geographic extrapolations were made based on these checks. Of the recorded damage, a total of 429,526 ha were attributed to defoliation by the large aspen

tortrix, which is half the level recorded last year. Defoliation intensity was rated as 72% light, 20% moderate and 6% severe.

A large decline was noted in the Fort Nelson Forest District, where defoliation decreased from 460,464 ha in 2003, to only 85,109 in 2004. This may in part be attributed to earlier survey timing this year, when feeding may have been less visible. The highest level of attack occurred in the Peace Forest District, with 287,139 ha affected, up slightly over 2003. Most of the defoliation was concentrated around Moberly Lake and Chetwynd. In the Mackenzie Forest District, area affected dropped by half since last year to 33,023 ha, but rose by 44% to 24,254 ha in the Prince George Forest District.



Severe defoliation of aspen stands by large aspen tortrix

Satin moth, *Leucoma salicis*

Satin moth (*Leucoma salicis*) is an important defoliator of all poplars. Periodic outbreaks often cause total defoliation of the host, which can result in top-kill, growth reduction and occasional tree mortality.

For the past three years satin moth has been observed throughout the SIFR. Area affected and intensity of attack indicated a peak in 2002, followed by a slight decrease in 2003. This year, ground observations showed that satin moth larvae were active and defoliation began in the spring; however, most populations appeared to crash by mid summer, and the majority of trees recovered. This observation was reflected in the area affected as recorded during the surveys, with a drop from 37,819 ha in 2003 to only 3,683 ha. Nearly all of the area in 2004 was in the Chilcotin Forest District, with 92% of the attack rated as light.

The past three years of defoliation in Chilcotin Forest District resulted in patches of mortality totaling 1,154 ha. As this mortality was the result of past damage, it was not included in the 2004 database.

Gypsy moth, *Lymantria dispar*

Where it is established in eastern North America, the North American strain of the European gypsy moth (*Lymantria dispar*) is a serious defoliator that causes reduced growth and mortality on a wide range of deciduous trees and shrubs, as well as some coniferous trees. This insect has been periodically intercepted in BC since 1978, but aggressive monitoring and eradication programs have thus far prevented its establishment in BC. All previous occurrences of gypsy moth in BC have either been successfully eradicated by aerial or ground spray applications of *B.t.k.*, or have died out on their own.

During the past 24 years, a province-wide monitoring program using pheromone-baited traps has been conducted to detect incursions of gypsy moth in BC. Where trap catches identify the precise location of potential infestations, eggmass and larval surveys are conducted to determine if the population is reproducing. If evidence of a breeding population is found, and enough information is available to adequately define the infested area, eradication treatments are usually conducted.

The results of the 2003 eggmass surveys indicated that the gypsy moth populations in Saanich (Mt. Douglas Park/

Gordon Head) and North Delta were reproducing and required eradication efforts. Treatments were conducted in the spring of 2004, consisting of three aerial *B.t.k.* applications, covering 570 ha in Saanich and 23 ha in Delta.

In 2004, 89 male gypsy moths were caught in pheromone traps in several locations in the Lower Mainland (Figure 16). Some of these locations were new while others were located in areas where moths were caught in 2003 or earlier. High density mass trapping grids were used on Gabriola Island, Abbotsford and Duncan. Although 21 moths were trapped in both the Duncan and Gabriola mass trapping grids,

no moths were caught in the Abbotsford traps which indicate that this population has likely died out on its own.

Surveys by the Canadian Food Inspection Agency failed to find any eggmasses in the areas where adult male moths were caught. No treatments are planned for 2005. Mass trapping and delimiting trapping will continue in the summer of 2005.

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

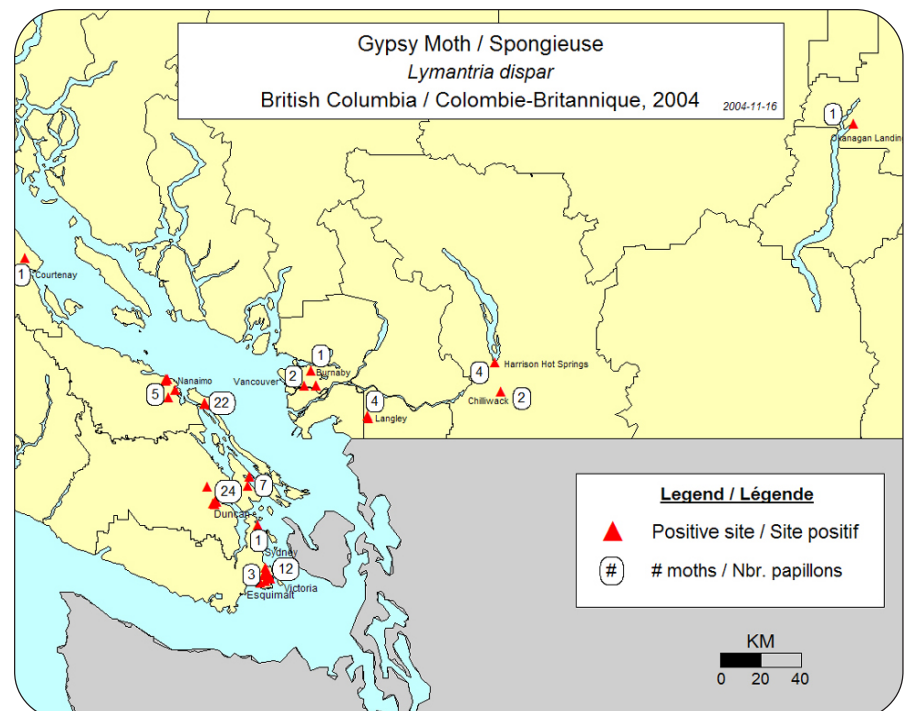


Figure 16. Gypsy moth trap locations with positive catches in 2004.

Serpentine leaf miner, *Phyllocnistic populiella*

Serpentine leaf miner (*Phyllocnistic populiella*), another defoliator of aspen, was present to an extensive degree throughout all aspen stands in 100 Mile House Forest District in 2002 and 2003. As with other deciduous defoliators in the SIFR, defoliation was not as severe or widespread in 2004. In the NIFR, serpentine leaf miner caused widespread defoliation in the Stewart – Cassiar area. It was not practical to aerially map this defoliation as it was so widespread in the aspen and would have detracted from accurate mapping of more important forest health factors.



Damage to aspen caused by
serpentine leaf miner

Miscellaneous shrub damage

Two interesting forest health agents caused significant damage to shrubs in the NIFR in 2004. The European alder leafminer (*Funusa dohrnii*) infested alder throughout the region. The most visible damage seen during the aerial surveys was severe defoliation of alder clumps in moist areas of cutblocks. MOF specialists later confirmed this damage with ground observations. Larvae mine the upper leaf surface, causing the epidermis over the mines to become brownish and hardened. Generally, the defoliation does not result in permanent damage to the alder.



European alder leafminer damage

Apiosporina collinsii is a fungus that caused damage to saskatoon bushes throughout the ICH and SBS biogeoclimatic zones in the NIFR this year. This damage was not aerially observable, but was confirmed by the regional pathologist. A black fungal mat covers the undersides of infected leaves, and dead blackened leaves remain on the bush during the winter. Infected shoots form witches' brooms that enlarge each year. The growth of infected plants is greatly reduced and heavy infections can cause mortality.



Saskatoon bush damage

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

Aspen and poplar leaf and twig blight damages trembling aspen and poplars. The causal fungi (*Venturia* spp.) are widely distributed throughout BC. Infected young shoots and terminal leaves are killed. Repeated infections can result in growth reduction and stem deformities, particularly in young stands. In some areas, the present outbreak is even resulting in mortality, including mature trees.

The unseasonably cool and wet spring weather experienced in the NIFR between 1999-2003 has provided optimum conditions for the build-up of infections by aspen and poplar leaf and twig blight. During this time, damage continued to increase, particularly in

cottonwood stands in the ICH biogeoclimatic zone and in aspen stands in the SBS biogeoclimatic zone. The drier conditions during the early part of the growing season in 2004 resulted in a slight reduction in stands affected and severity of damage in some areas.

The ongoing outbreak was better represented in the 2004 aerial overview surveys than in 2003 due to a higher level of survey intensity over the agricultural belt areas. Ground checks were conducted to confirm areas of aspen and poplar leaf and twig blight damage *vs.* large aspen tortrix defoliation, as the two are sometimes difficult to tell apart from the air during the overview survey. A total of 51,227 ha were



Aspen shoots affected by Venturia

recorded as affected in the NIFR in 2004. Defoliation intensity was classified as 52% light, 40% moderate and 8% severe. The majority of the infections occurred in the Fort St. James (17,725 ha), Nadina (14,817 ha) and MacKenzie (11,478 ha) Forest Districts, with smaller areas in the Vanderhoof (4,381 ha) and Skeena Stikine (2,792 ha) Forest Districts. Minor amounts of damage were also observed in the Prince George and Peace Forest Districts. A high percentage of the damaged stands were located along Highway 16 and in agricultural areas, such as in the Francois Lake area.



Aspen stand defoliated by Venturia

DAMAGING AGENTS OF MULTIPLE HOST SPECIES

Abiotic Injury and Associated Forest Health Factors

All tree species of all ages can be injured by a variety of abiotic agents, including drought, fire, flooding, windthrow, frost and snow. Damage can include slight to severe growth reduction, chronic tree deformities and mortality. Additionally, trees stressed by abiotic factors are often more susceptible to attack by insects and disease.

Wildfire was the most significant abiotic agent to cause visible mortality in 2003, with 248,131 ha burned, primarily in the SIFR. Several of these were large, urban interface fires that caused unprecedented damage to buildings as well as burning valuable forested land. In the spring and early summer of 2004, drought codes were extremely high and fire experts anticipated a repeat of last year. Large fires early in the season, primarily located in the NIFR, accounted for the majority

(161,153 ha) of the 210,008 ha burned in 2004. The Skeena Stikine and Fort Nelson Forest Districts sustained the most damage, with 85,746 ha and 56,178 ha burned, respectively. The SIFR experienced the second highest total area affected by wildfire in the last 10 years (after 2003), with 45,099 ha burned. Most fires (91% by count) were contained at fewer than 5 ha. In August, extensive rain occurred throughout most of BC, which greatly reduced the forest fire threat.

Although the total hectares affected by wildfire in 2004 was almost as high as in 2003, actual damage to timber resources was far less since many of the larger fires were located in remote areas with low values at risk. Approximately half of the area burned was estimated to be unproductive forest (e.g. brush and alpine tundra) in

preliminary findings from MOF protection fire reports.

Post fire insect damage resulting from last year's fires occurred in some areas. The western pine beetle (*Dendroctonus brevicomis*) attacked weakened pine trees along the edge of the large Okanagan Mountain Fire, presenting a large threat to the trees in Mission Creek Park in Kelowna. To combat this problem, 1,000 to 1,500 infested trees were removed.

After several very dry growing seasons in many parts of the SIFR, weakened trees sustained high levels of drought damage across the region. This damage became apparent earlier in the year than in 2003, with a total of 11,326 ha visible during the 2004 aerial overview surveys. This was actually an underestimation, due to several factors. By the time the aerial surveys were completed, drought damaged foliage was faded and difficult to see. As well, a lot of the mortality occurred to small, scattered trees that are hard to detect during overview surveys. In some areas, mountain pine beetle attack mixed with drought mortality masked the effects of drought. It is estimated that around 250,000 ha sustained some drought damage, although much of it



Douglas-fir and ponderosa pine damaged by drought

would have been at low levels. For recorded damage, intensity was 82% light, 13% moderate and 5% severe. A large percentage (91%) of the affected areas occurred in the Kamloops, Okanagan Shuswap and Cascades Forest Districts at 5,582 ha, 3,849 ha, and 846 ha respectively. The remainder was scattered throughout the other districts in the SIFR.

Drought damage, which consisted of flagging, stem die-back (from the top down) and mortality affected all tree species of all ages. Most of the damage occurred at low elevations in the ponderosa pine and interior Douglas-fir biogeoclimatic zones. On the edge of open range, Douglas-fir and yellow pine were particularly injured, with mortality in all age classes. The heaviest damage occurred on rocky, thin-soiled outcroppings or steep slopes, particularly on south aspects. Mortality was also quite significant in regenerating stands, particularly for lodgepole pine, Douglas-fir and larch species in openings without site preparation. Young stand mortality was exacerbated by insect attack on the drought weakened trees. In the southern portion of the CFR, drought effects were most noticeable in western red cedar, particularly on the east coast of Vancouver Island. Western red cedar appears to be dropping out of stands within the Coastal



Distinct elevational banding typical of red belt damage

Douglas-fir biogeoclimatic zone. On the positive side, the warm and dry weather has helped to reduce the occurrence of pathogens such as needle diseases throughout the province.

Although not quantified, the drought conditions over the last five years in the SIFR has led to greater tree mortality due to several major root diseases than has been observed in the two previous five year periods. These diseases include laminated root rot (*Phellinus weirii*), tomentosus root rot (*Inonotus tomentosus*), black stain root disease (*Leptographium wagneri*), armillaria root disease (*Armillaria ostoyae*) and annosus root disease (*Heterobasidion annosum*).

Red belt, a rare weather driven phenomenon, affected 9,926 ha provincially in 2004. The unseasonable occurrence of warm winds by day, followed by cold air drainage at night, led

to desiccation injury. Foliage and occasionally buds are killed, and mortality may result from severe damage. Affected areas are usually in distinct elevational bands. In the NIFR, 1,420 ha of severe red belt damage was recorded northeast of Fort Nelson on the Liard Plateau. The rest of the damage was light and located in the SIFR along the eastern slope of the coast range with large bands at the north end of the Taseko Lakes system, in the Chilcotin and Central Cariboo Forest Districts. Though red belt can affect a variety of tree species, most of this damage was in lodgepole pine stands.

Across the province, 5,717 ha of windthrow damage was recorded during the 2004 aerial overview survey. This is much higher than last year, and includes some of the late fall 2003 windthrow events. The actual amount of damage tends to be underestimated, as it is very difficult to see scattered

windthrow damage from an aerial overview survey, as the overtopping canopy often masks it. Windthrow damage that was observed aerially was primarily (81%) of severe intensity. The majority of the recorded areas were in the eastern portions of the SIFR forest districts of Quesnel, 100 Mile House and Central Cariboo. Several late fall windthrow events have occurred again in 2004, which will be mapped during the 2005 overview surveys. One of the most significant events resulted in approximately 550,000 m³ of blowdown in the Nadina Forest District in the Francois and Maxan drainages. Many of the stands affected by windthrow damage across BC had high components of either spruce or Douglas-fir. This may result in increased bark beetle mortality in the future, especially if

populations are already active in these locations.

An early, heavy wet snowfall northwest of Fort St. John in early September caused widespread breakage damage in aspen stands, particularly to younger stems. Leaves were still intact on the trees, and acted as a net to capture the snow.

Mortality caused by flooding affected 4,688 ha in 2004. Almost all of the damage was recorded in the NIFR. As in 2003, the bulk of the damage occurred in the Peace and Fort Nelson Forest Districts with 2,443 ha and 1,260 ha affected, respectively. Most of this mortality occurred in small patches of primarily spruce and was widely scattered. It is possible that this may result in increased spruce beetle mortality in the future.

Animal damage

A variety of animals cause damage to various tree species throughout B.C., particularly at the seedling to sapling stages. Feeding activity is responsible for the majority of the damage, which can range from foliage browsing to tree girdling, through bark stripping. Damage can also occur from rubbing and trampling. 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. Very little damage was recorded in the 2004 aerial surveys, mainly because most forms of animal damage are not conspicuous enough to be visible during aerial overview surveys, and because of the high levels of mountain pine beetle mortality in many areas most likely masked scattered mortality caused by animals.

Black bear mortality was recorded over 140 ha, primarily in the Chilcotin Forest District. Most of this damage occurred in mature lodgepole pine in mountainous areas at the south end of Tatlayoko Lake east to Chilko Lake. In the CFR, no bear damage was mapped aerially this year, but mortality continued, particularly in Bute Inlet to Toba Inlet. One 15-year-old plantation sustained over 50% mortality.



Blowdown at Maxan Lake

Porcupine damage was recorded on only 24 ha, mostly in the Nadina and Fort Nelson Forest Districts. Although it is difficult to accurately detect chronic porcupine damage using the overview survey method, particularly in hemlock stands, it is still known to be occurring in dispersed locations throughout the province (except Vancouver and Queen Charlotte islands where porcupine have not become established). Damage is particularly bad in immature western hemlock/Sitka spruce forests in the north-coastal areas of BC, such as the Khutzeymateen Inlet, Fords Cove, Tuck Inlet, Hayward Creek and Scotia River areas. Chronic areas affected by porcupine damage have also been noted in the Kalum TSA of the NIFR, though this has been declining over the last decade.

Scattered reports from ground surveys in the Princeton area noted mortality caused by voles in young pine plantations, up to three years after planting. Voles clip shoots of small seedlings, and gnaw on the bark of larger seedlings.



Squirrel feeding on lodgepole pine

FOREST HEALTH PROJECTS

Yellow-cedar decline

Stefan Zeglen, Ministry of Forests, Coast Forest Region

Although recognized as a damaging agent of yellow-cedar (*Chamaecyparis nootkensis*), the phenomenon of yellow-cedar decline has not been extensively investigated in BC. The decline is most commonly associated with Southeast Alaska where it has been mapped on over 200,000 ha in a broad band along the panhandle of Alaska to the international boundary along Portland Canal. The problem is specific to yellow-cedar and is characterized on the landscape as a progressive and intensifying process that results in fading trees with thin or off-color crowns, recently killed trees, and those killed 80 to 100 years ago. Following death, slow deterioration due to yellow-cedar's unique heartwood chemistry allows snags to remain standing for up to a century. As these standing dead trees accumulate, 70% or more of yellow-cedar basal area is typically found dead in these forests. The occurrence of the decline, however, can be masked by the abundant presence of western redcedar within the range of yellow-cedar. The common "spiked top" trait exhibited by redcedar can cause dead yellow-cedar

snags to become difficult to distinguish in a sea of dead tops.

The primary cause of the decline is not understood, although work in Alaska has indicated that no biotic factor appears to be causal. Site characteristics including wet soils, open canopy conditions, and elevation appear to be related to yellow-cedar decline. Current research emphasis in Alaska is on the contributing role of hydrology, soil chemistry, air and soil temperature, snowpack, freezing injury, and climate. The susceptibility of yellow-cedar to spring freezing injury in areas of low snowpack is a leading hypothesis for this forest decline. Yellow-cedar is thought to be susceptible to frost injury, particularly in areas where soil is not protected from freezing by snow. Information on the entire distribution of yellow-cedar decline, including the southern limits, is needed in order to determine how climate is involved in this forest decline.

In British Columbia, yellow-cedar commonly occurs in the windward portion of higher elevation Mountain Hemlock (MHmm1 and MHwh1) subzones. It is also widely distributed throughout the Coastal Western Hemlock zone at low elevations in the very wet

hypermaritime (CWHvh2) and very wet maritime (CWHvm1) subzones and at higher levels in the CWHvm2 subzone. These areas encompass much of the outer coast of British Columbia including the Queen Charlotte Islands, the western side of the Coast Mountains, and the Hecate Depression.

As part of a co-operative initiative, in late September Paul Hennon, a research forest pathologist who has worked extensively on yellow-cedar decline, and research soil scientist Dave D'Amore from the USDA Forest Service office in Juneau were invited to Prince Rupert to survey areas in the North Coast Forest District. Joined by regional forest pathologist Stefan Zeglen and stewardship forester Mike Grainger, the group spent two days examining sites from the air and on the ground. Observations indicate that yellow-cedar decline is indeed widespread throughout the range of yellow-cedar from the south side of the Portland Canal to the furthest observed location on Banks Island (about 100 km south of Prince Rupert).

Dense patches of dying and standing dead trees were observed, often in proximity to bogs. The snags consistently

represented mixtures of trees that died at different times; some recent mortality had fine or secondary branches retained, other older mortality had intact tops but no attached limbs. From the air, dead yellow-cedar trees can often be distinguished from all species other than western redcedar because their tops do not break as they deteriorate. Upon ground inspection, we confirmed that the majority of the completely dead snags were yellow-cedar by visually inspecting and smelling exposed wood after chopping



A patch of yellow-cedar exhibiting some of the stages of decline near Hayward Creek in the North Coast Forest District

with a hatchet, or, for snags with bark retained, by the presence of resin ducts in bark. Dying yellow-cedar trees with thin or off-color crowns were present in each of the declining stands that we mapped from the air. On the ground, we observed necrotic lesions emerging from dead roots and extending up the bole of dying trees, a symptom of yellow-cedar decline that we have reported in Alaska. Western hemlock,

western redcedar, Sitka spruce (*Picea sitchensis*), shore pine (*Pinus contorta*), and some yellow-cedar, the latter usually present as understory trees, comprised the remaining live forest.

Most of the areas with concentrations of dead trees were located between 300 and 400 m elevation, locations that favour forests with high components of yellow-cedar. As yellow-cedar is the species affected by this decline only scattered mortality occurs at lower elevations

where yellow-cedar is often present as a minor component. We speculate that yellow-cedar growing at higher elevations may be protected by snow in early spring, either directly by snow covering shallow fine roots or indirectly by snow delaying the dehardening proc-

ess (i.e., loss of cold tolerance), and thereby avoids spring freezing.

Plans for the future include continuing to examine the extent of yellow-cedar decline within its range in BC and determining the impact of the decline on forest inventory and traditional native use of yellow-cedar.

Hemlock dwarf mistletoe tree growth model

Dr. John Muir

Hemlock dwarf mistletoe (*Arceuthobium tsugense*) is a common parasitic seed plant of western hemlock in coastal BC. The mistletoe spreads by seeds dispersed from residual to nearby young trees. Over time, infestations significantly reduce growth of trees, but in some instances, spread and impacts appear negligible.

Variable retention silviculture regimes recently implemented in coastal forests create conditions that could exacerbate spread, intensification and impacts of hemlock dwarf mistletoe (HDM). However, data are lacking to quantify and substantiate effects under various regimes and environmental conditions.

HDM spread into and within young stands can be highly

variable, depending on factors such as distribution of residual infected trees, stand density, site index, latitude and elevation. Given the variety of BC coastal conditions and variability of HDM impacts, a tree growth model that could predict HDM spread, impacts, and the effects of forest practices would be a useful management tool.

Funding provided by Forest Renewal BC supported initial development towards a detailed model of spread for HDM. To date, eighteen trees have been sampled and measured on western Vancouver Island to determine the effects of dwarf mistletoe infection, including wood densitometry. Further funding is required for more sampling and analyses before the model can be completed.



Aerial shoots of hemlock dwarf mistletoe

FOREST HEALTH PRESENTATIONS

Spatial and temporal patterns of western spruce budworm, *Choristoneura occidentalis*, outbreaks in Southern British Columbia.

Dr. Lorraine Maclauchlan,
Regional Entomologist, SIFR

Venue: Entomological Society of Canada Annual Meeting, Kelowna BC, October 2003.

Abstract

Over 1,600 Douglas-fir and non-host cores were collected and analysed to determine historic outbreak patterns of the western spruce budworm, *Choristoneura occidentalis*, throughout southern British Columbia. Combined with historic overlay analysis from overview mapping, eight outbreak periods were identified in tree ring chronologies over a number of sites. Outbreak duration was between 5 to 8 years and the number of years between outbreak periods ranged from 10 to 48 years.

Outbreak history of western spruce budworm, *Choristoneura occidentalis*, in the central interior of British Columbia - overlay analysis and dendrochronology

Dr. Lorraine Maclauchlan,
Regional Entomologist, SIFR

Venue: Alberta / British Columbia Intermountain Forest Health Workshop Valemount, April 20-21, 2004.

Abstract

Using historic overview records (CFS, FIDS and MOF) coupled with dendrochronology, the outbreak history of the western spruce budworm was determined for south central British Columbia. An overlay analysis using historic and recent annual aerial overview information was completed to describe population fluctuations of the western spruce budworm in the south central portion of BC. The overlay analysis defined areas of chronic, intermittent and no budworm defoliation between 1916-2003 in potentially susceptible forest types. The majority of the defoliation records from south central BC during this time period occurred within the Kamloops Forest Region, where we identified five outbreak sub-regions that were geographically distinct. Stands within the Interior Douglas-fir bio-

geoclimatic zone (IDF) were most susceptible and suffered the greatest amount of chronic, sustained budworm activity. Over 45% of the Interior Douglas-fir zone had recorded defoliation, with some outbreaks lasting over 9 years. Within the IDF, the dry cool (IDFdk) and very dry, hot (IDFhxh) subzones were most prone to sustained outbreak events. The moister ecosystems, such as the Interior Cedar Hemlock (ICH) zone, had over 30% of its area defoliated. However, these outbreaks were less frequent and rarely lasted more than 3 years. Over 1,600 Douglas-fir and non-host cores were collected and analysed to determine historic outbreak patterns of the western spruce budworm throughout southern BC. Combined with the historic overlay analysis, eight outbreak periods were identified in tree ring chronologies over a number of sites. Outbreak duration was between 5 to 8 years and the number of years between outbreak periods ranged from 10 to 48 years.

The life and times of a Regional Entomologist - putting "practice" into pest management

Dr. Lorraine Maclauchlan,
Regional Entomologist, SIFR

Venue: UBC Faculty of Forestry, Vancouver BC, November 2004.

Abstract

This presentation focused on the various challenges and issues that entomologists are faced with in British Columbia. The numerous insects that impact the interior forests such as mountain pine beetle, western spruce budworm and others were discussed in some detail. Emphasis was put on the recurring cycle and learning from past research and operational programs. Current research projects on *Dryocoetes* and mountain pine beetle were presented.



Defoliation caused by western spruce budworm

**Footprints in our forests:
defoliators & bark beetles,
the agents of succession.**

*Dr. Lorraine Maclauchlan,
Regional Entomologist, SIFR*

Venue: Pro-D Day, Revelstoke,
November 2004

Abstract

Insects, disease and climate cause the most noticeable “footprints” in our forests and are major factors in the natural succession of most interior forests. Insect outbreaks both large scale like the current mountain pine beetle epidemic, and small point source tree mortality as caused by the western balsam bark beetle play equally important roles in forcing stands into the continued cycle of mortality and regeneration. Each group of insects causes a unique type of damage and when coupled with climatic events such as drought or fire will cause dramatic changes on the landscape.

**2004 Forest health and
mountain pine beetle
update: a NEW challenge.**

*Dr. Lorraine Maclauchlan,
Regional Entomologist, SIFR*

Venues: TSA Meetings
(Okanagan, Merritt, Kamloops,
Cranbrook-Invermere)
throughout the fall and winter
2004, and the SIR Stewardship
Meeting.

Abstract

Presented the current status of forest health in the Southern Interior Region as compiled by the Aerial Overview Survey. Emphasis was put on the expansion and intensification of the mountain pine beetle throughout the region and its presence now in young second growth stand. New directions for addressing the MPB were discussed.

**Pine stem rust hazard
rating surveys**

*Richard Reich, Regional Forest
Pathologist, NIFR*

Venue: Northern Silviculture
Committee & Northern Interior
Vegetation Management
Association Summer Field
Tour, Burns Lake, June 14-16,
2004.

Abstract

A study of 64 young lodgepole pine stands in the Vanderhoof Forest District was undertaken to determine if biogeoclimatic factors and alternate host abundance could be used to predict rust hazard at the landscape or site level. The eventual goal is to create a hazard/risk rating procedure to guide planting density and species composition in order to reduce the impact of mortality caused by pine stem rusts in plantations. Variables were collected at the stand, plot and tree level. Results seemed to show some differences at the individual factor level, including elevation and mesoslope position.

For more information: [http://
resweb.res.unbc.ca/
continuingeducation/
nscprogram2004.pdf](http://resweb.res.unbc.ca/continuingeducation/nscprogram2004.pdf)



Mortality caused by western balsam bark beetle

Comandra rust screening of Bulkley Valley seed orchard lodgepole pine

Alistair Schroff, Forester, Burns Lake Community Forest

Venue: Northern Silviculture Committee & Northern Interior Vegetation Management Association Summer Field Tour, Burns Lake, June 14-16, 2004.

Abstract

Previous studies have demonstrated that variation in susceptibility of lodgepole pine to comandra blister rust has a genetic basis. It is estimated that a 40% decrease in comandra incidence may be possible through use of seedlots based on family selections for rust resistance. Progeny tests previously established in the Bulkley Valley provided an opportunity for obtaining preliminary estimates of disease resistance. The objective of this research is to identify and accurately rank rust resistant seed orchard parents so that custom seedlots can be produced for disease-prone areas. Three primary test sites have been established at the Vernon Seed Orchard Company, and two secondary sites in Morice and MacKenzie TSA's. Trial assessments could allow collection of resistant seedlots as early as 2007.

For more information: <http://resweb.res.unbc.ca/continuingeducation/nscprogram2004.pdf>



Comandra blister rust infection on young lodgepole pine tree

Dothistroma in Northwest British Columbia, Why there? Why now?

Alex Woods, Regional Forest Pathologist, NIFR

Venue: Canadian Tree Improvement Association Conference, Kelowna, July 26-29th, 2004.

Abstract

Dothistroma needle blight caused by the fungus *Mycosphaerella pini* is causing severe damage to managed and natural stands of lodgepole pine in northwest BC. There appears to be two principle causes behind the damage occurring in this specific area, at this time. First, forest management policy and practice has head to an unprecedented amount of young lodgepole pine hosts on the landscape. Second, the weather of the past decade appears to be changing resulting in more frequent consistent days of warm rain during summer months. The weather events coinciding with a previous outbreak of Dothistroma in the study area were investigated. The weather events that possibly lead to the decline in this previous Dothistroma outbreak, two consecutive years of dry conditions, have not reoccurred during the current epidemic.

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- Maclauchlan, L.E. and J.E. Brooks. 2005. Influence of western spruce budworm on silviculture systems in southern British Columbia. *Forest Ecology and Management*. *Submitted*.
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- White, J., Wulder, M., Brooks, D., Reich, R. and Wheate, D. 2004. Mapping mountain pine beetle infestation with high spatial resolution satellite imagery. *The Forestry Chronicle* Vol. 80, No. 6, 743-745.



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