ABSTRACT

This summary of forest health conditions across British Columbia (BC) in 2002 is a compilation of the annual provincial aerial overview surveys, insect population predictions, information on forest health agents not aerially detectable and special project information. Ministry of Forests forest health specialists and forest health consultants supplied this information.

The largest mountain pine beetle epidemic in recorded history in BC continued to expand, with attacked area more than doubled over 2001 to just under two million hectares. The largest increase occurred in the Prince George Forest Region, where 685,598 ha were affected, followed closely by 539,315 ha in the Cariboo Forest Region and 511,798 ha in the Prince Rupert Forest Region. Mountain pine beetle attack was lower in the southern forest regions (Vancouver, Kamloops and Nelson) but they still experienced significant rises in infested hectares. A series of mild winters and an abundance of mature lodgepole pine have contributed to the current outbreak situation. Despite aggressive control tactics, a further population expansion is expected next year if the winter weather continues to be mild.

Western balsam bark beetle and spruce beetle were two other bark beetles identified as a concern. The western balsam bark beetle attacked nearly one million hectares of sub-alpine fir stands throughout BC (particularly in the northern forest regions). The area affected by spruce beetle increased more than 2 ½ times over 2001 levels to a total of 268,995 ha, of which 94% occurred in the Prince George Forest Region.

Defoliators also had significant impact on the health of forests in BC. Western spruce budworm continued on an upward trend, defoliating a total of 487,443 ha of Douglas-fir, primarily in the Cariboo and Kamloops Forest Regions. Significant defoliation is also predicted for next year. Defoliation by the 2-year budworm affected 160,231 ha of true fir and spruce stands in the Prince George, Cariboo and Kamloops Forest Regions. The eastern spruce budworm, a chronic defoliator of true fir and spruce, continued to damage stands in the Prince George Forest Region (although aerial mapping did not occur in 2002). Western hemlock looper was predominantly in the second year of a predicted four year cycle in the southern portion of the province. In 2002, the western hemlock looper defoliated 44,277 ha. Further increases in size and severity are predicted for next year. Provincially, almost 68,000 ha of deciduous stands were also attacked by various defoliators.

Pine needle diseases affected large areas of lodgepole pine, particularly in the central and northern portions of the province. Pine needle cast infected 265,930 ha in the Cariboo Forest Region. Low level aerial surveys detected unprecedented levels of Dothistroma needle blight in the Prince Rupert Forest Region, with 19,530 ha affected.

Aspen and poplar leaf and twig blight infected aspen (and some cottonwood) stands throughout the Prince Rupert and Prince George Forest Regions. The affected hectares more than tripled to 80,156 ha this year. Various other forest health factors such as false Hemlock looper, Douglas-fir beetle, flooding, bear and porcupine damage caused localized damage in different areas throughout the province.

2002 Summary of Forest Health Conditions in British Columbia

Douglas-fir beetle

Introduction

The B.C. Ministry of Forests (BCMOF) is responsible for detecting, recording and monitoring insects, diseases, animal damage and environmental factors in the forests of British Columbia (BC). Much of this information is gathered at the regional level (Figure 1) through aerial overview surveys. Experienced personnel map forest health disturbances from fixed wing aircraft. The map scale is usually 1:100,000, which allows for efficient coverage of the province at an acceptable level of accuracy. The standards employed for overview surveys have been adopted from the Canadian Forest Service standards. Details of the survey methodology are available online at the Resources Information Standards Committee website: http://srmwww.gov.bc.ca/risc/pubs/teveg/foresthealth/index.htm.

2002 marks the fourth year that the BCMOF has conducted provincial aerial overview surveys. Methodology of data collection varied from region to region over the first three years, consisting of a mosaic of overview and detailed aerial survey data (collected specifically for directing bark beetle management activities). In 2002, all

Preparing for an aerial overview survey

Table 1. Number of flying hours required by each Region to complete the 2002 provincial aerial overview surveys.

Region	Flight hours
Vancouver	52.5
Cariboo	240.8
Kamloops	48.0
Prince Rupert	177.5
Prince George	100.8
Nelson	96.7
Total	716.3

Figure 1. Map of British Columbia outlining Ministry of Forests Regional and District boundaries in 2002.

data collected for the overview survey conformed to the current methodology, which created a consistent, cohesive picture of forest disturbances throughout British Columbia.

The 2002 provincial aerial overview surveys were conducted from mid July through the first week of September. The surveys were completed three weeks earlier than in 2001 due to favourable weather conditions and better project organization. A total of 716.3 flying hours were required to survey the province (Table 1).

The majority of all forested lands were surveyed; the main exception was Fort Nelson and the northern portion of Fort St. John Forest Districts, where eastern spruce budworm was the primary forest health agent. The window of opportunity for mapping this defoliator occurred before the aerial survey contract was awarded and heavy rains in July washed away most of the symptomatic red foliage from the defoliated trees. Consequently, the areas with budworm damage were not flown in 2002.

Forest health disturbances that kill trees (such as beetles, flooding, windthrow, porcupine, etc.) were detected during aerial surveys by observing foliage colour changes in dead trees. Only recently discoloured trees (attacked and killed within the last year) were mapped; therefore each year's survey results do not include trees that have been dead for more than one year. Small infestations of up to 50 trees were recorded as spot infestations. Larger infestations were drawn as polygons on the survey map, with the percentage of recently killed trees separated into three intensity classes (Table 2).

Table 2. Intensity classes used for recording forest health damage.

Disturbance	Intensity Class	Description
Mortality	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	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.

Visible defoliation caused by insects and foliage diseases was also recorded during the surveys. Defoliator damage tended to be widespread throughout areas, and was therefore mapped only as infested polygons, not spots. Only current defoliator damage was recorded, which was assessed as a portion of the tree defoliated (average for the polygon), rather than a percentage of trees attacked within a polygon (Table 2).

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).

Certain forest health concerns, particularly diseases such as rusts, cankers, decays and dwarf mistletoes, are not usually visible during aerial overview surveys. Therefore, these disturbances are only covered in this report when identified by other survey means such as ground surveys or special project surveys. This report is a summary of the 2002 aerial overview survey results, with additional insect population predictions and special projects information supplied by regional and district forest health specialists and consultants.

Mountain pine beetle continued to be the most damaging agent in the province in 2002, with over double the infested hectares recorded in 2001. Other

significant damaging agents included: western balsam bark beetle, western spruce budworm, spruce beetle, two-year cycle budworm, eastern spruce budworm, western hemlock looper, pine needle diseases, satin moth, and aspen/poplar leaf and twig blight. Several other forest health agents caused localized damage (Table 3).

Overall, bark beetles and defoliators were the most visible forest health factors to affect the forests of BC over the last four years. Bark beetle activity continued to increase significantly, due to mild winters and low beetle mortality rates. Defoliator populations tend to fluctuate widely over a relatively short time period. The total hectares defoliated in 2002 are missing an estimated 1.6 million hectares of unmapped eastern spruce budworm defoliation (Figure 2).

A *Provincial Forest Health Strategy* is being developed and will be completed in early 2003. This strategy will provide overall objectives and actions to achieve forest health goals and help to identify provincial priorities. These provincial goals and priorities will guide ministry and industry operations and research over the next few years.

The following pages report detailed observations of pest damage as noted during 2002.

Table 3. Summary of hectares affected by forest damaging agents as detected in 2002 aerial overview surveys in British Columbia.

Damaging Agent	Hectares Affected
Major Bark Beetles:	
Mountain pine beetle[a]	1,968,641
Western balsam bark beetle	990,515
Spruce beetle	268,995
Douglas-fir beetle	9,078
Lodgepole pine beetle	1,301
Defoliators: [b]	
Western spruce budworm	487,352
2-year budworm	160,231
Satin moth	45,394
Western hemlock looper	44,277
False Hemlock Looper	4,074
Forest tent caterpillar	4,127
Birch leaf miner	18,184
Unspecified/misc. defoliator	6,908
Abiotics:	
Wildfire[c]	5,179
Flooding	4,902
Windthrow	460
Slide	479
Other:	
Pine needle cast	268,314
Aspen/poplar leaf/twig blight	80,156
Porcupine	6,244
Dothistroma[d]	1,165
Larch needle blight	868
Bear	796
Miscellaneous	727
Provincial Total	4,378,367

[a] Includes infestations in parks totalling 482,426 ha.
[b] Does not include unmapped eastern spruce budworm (estimate 1.6 million ha).
[c] Does not include all large wildfires mapped by Protection Branch.
[d] Does not include areas recorded in low elevation surveys (additional 18,365 ha).

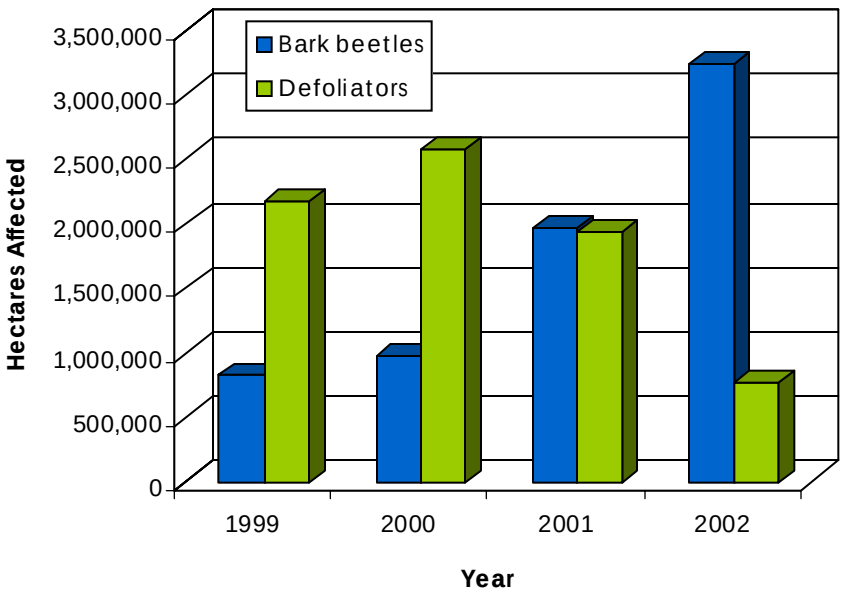

Figure 2. Hectares affected by major bark beetles and defoliators in BC.

Damaging Agents of Pine

Mountain Pine Beetle, *Dendroctonus ponderosae*

The mountain pine beetle is the most destructive pest of mature pines in British Columbia, and continues to be the largest threat to BC forests in terms of timber loss, environmental concerns and negative economic impacts. Infestations are causing extensive tree mortality throughout the province, from sea level up to the elevational limits of pine.

The most extensive mountain pine beetle epidemic in recorded history is presently underway in British Columbia (Figure 4). Beetle populations have been on the rise for several years, due to an abundance of mature lodgepole pine and very favourable weather conditions. It is believed that the province-wide drought in the summer of 1998 contributed to the increase of mountain pine beetle. Drought stressed trees were then less able to resist mass attack by mountain pine beetle. Beetle populations were further bolstered by a series of mild winters. Without the usual prolonged cold periods in the winter, beetle larval mortality has been very low. This has contributed further to the current mountain pine beetle outbreak.

Hectares under attack by the mountain pine beetle in BC have increased twelve fold from 164,567 ha in 1999 to 1,968,641 ha in 2002. Attack in all regions except Kamloops and Nelson has at least quadrupled from 2000 to 2002 (Figure 3). Of the stands affected by mountain pine beetle in 2002, 30% sustained severe mortality (up 7% over 2001), 25% moderate, and 45% light mortality.

Prince George Forest Region experienced the greatest increase and consequently the largest affected area in BC at a total of 685,598 ha. The majority of the attack was recorded in the Vanderhoof, Prince George and Fort St. James Forest Districts at 66%, 21% and 10% of the regional total, respectively. Vanderhoof Forest District, particularly in the southwest, sustained the greatest increase in attacked hectares with

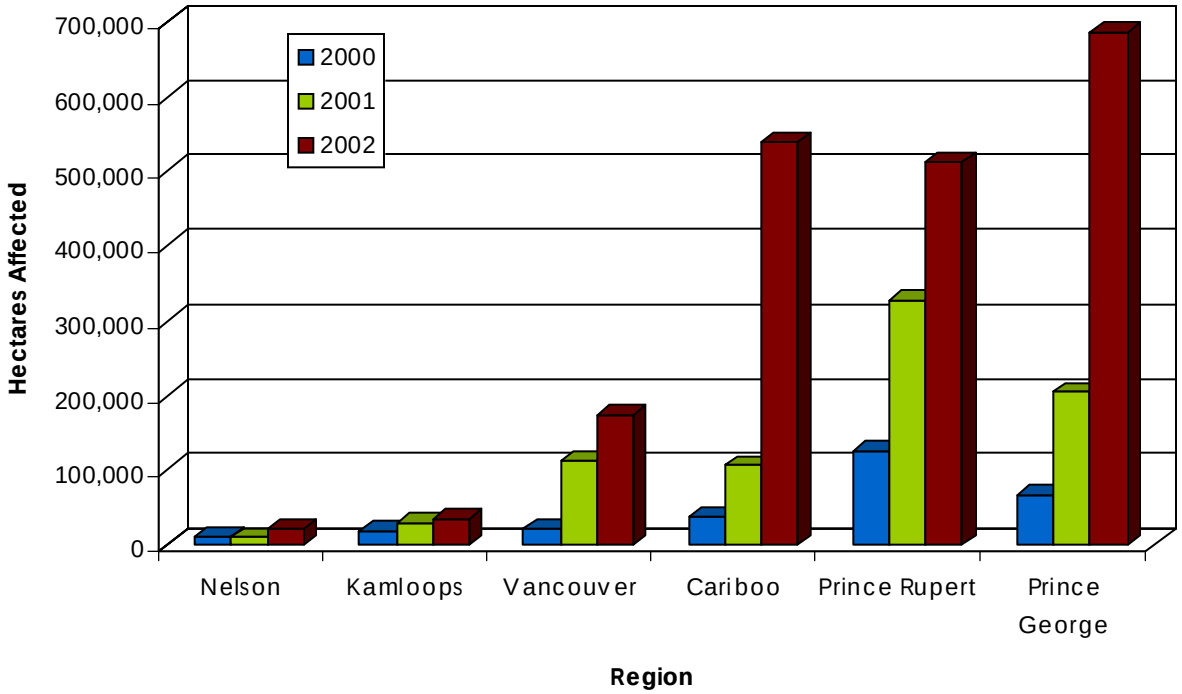

Figure 3. Change in hectares affected by mountain pine beetle from 2000 – 2002 in the six provincial forest regions.

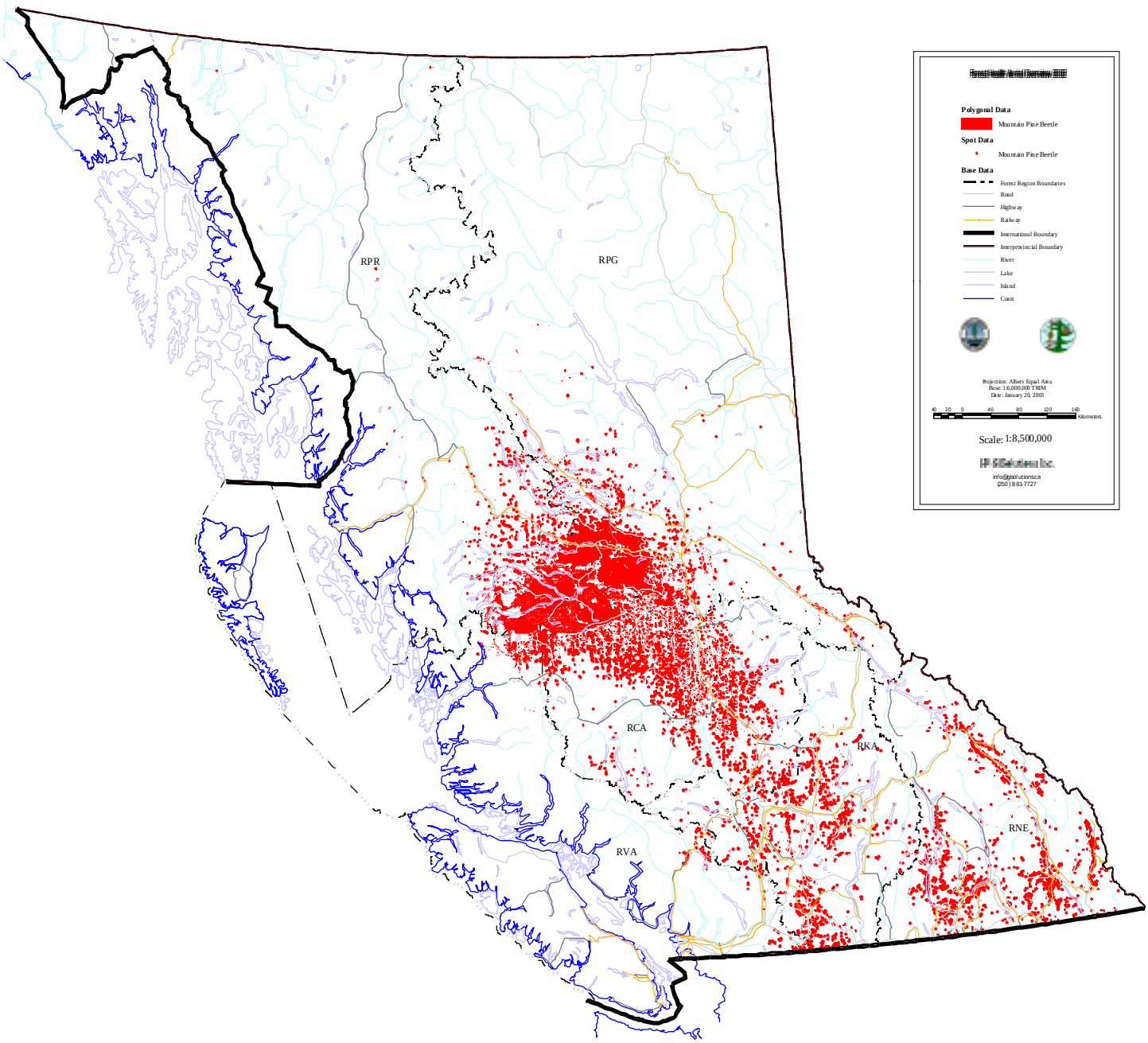

Figure 4. Mountain pine beetle infestations recorded in British Columbia in 2002.

a rise from 77,944 ha in 2001 to 450,904 ha in 2002. Roughly 56,000 ha of the infested area in the Vanderhoof Forest District are in Entiako Provincial Park. In Fort St. James and Vanderhoof Forest Districts, lodgepole pine beetle has been observed in the base of some mountain pine beetle attacked trees. To protect the urban environment in Prince George, a local forestry consulting firm is coordinating a research proposal to use anti-aggregation compounds to repel the mountain pine beetle from high value areas. Pending funding, this project could be underway in the spring of 2003.

Mountain pine beetle populations in the Cariboo Forest Region also increased at unprecedented rates, from 103,792 ha in 2001 to 539,315 ha in 2002 (Figure 4). Almost 70% of the affected hectares were located in the Quesnel Forest District, with the largest expansion west of the Fraser River in the Kluskus, Pan and Eliguk Beetle Management Units (BMUs). All districts experienced a rise in attack; Williams Lake Forest District was second with 105,904 ha affected, particularly in the Riske, Mackin, Hawks Creek, Big Lake, Meldrum and Williams Lake BMUs. Scattered 'salt and pepper' spotting was developing along the edge of the beetle infestation in the Big Lake and Gaspard BMUs. Chilcotin Forest District had the largest proportional increase of twenty-nine fold to 34,519 ha, primarily in the Dean River corridor. This expansion was due predominantly to beetle pressure from Tweedsmuir Provincial Park and Vanderhoof Forest District, and some from Quesnel Forest District.

Mountain pine beetle infestation in Tweedsmuir Park

Hectares affected in the Prince Rupert Forest Region in 2002 were just under the total for the Cariboo Forest Region at 511,798 ha. Almost all of the attack was located in Lakes Forest District with 498,057 ha infested, of which 235,707 ha (about half of total infested area) were in Tweedsmuir Provincial Park and the portion of the Entiako protected area within the Lakes Timber Supply Area (TSA). Infestations in Morice and Bulkley Forest Districts actually decreased significantly this year.

Due to the large volume of attack in the Lakes Forest District, it was necessary to move large quantities of infested timber into the Bulkley Forest District for milling this year. To accomplish this without further spread of the beetle from the infested timber, the mills (particularly Pacific Inland Resources) in consultation with Regional Entomologist Ken White, devised a very detailed transportation and storage plan. Weather stations were closely monitored to determine temperature thresholds for possible beetle flights. Hauling plans were devised to accommodate the thresholds, including night hauling when temperatures were low enough and emergency plans for timber pick-up in case of truck breakdowns. Beetle emergence within mill yards was controlled by a variety of traps and sprinkler systems.

Mountain pine beetle attack also continued to rise in the Vancouver Forest Region with a 50% increase from 2001 to a total of 174,171 ha affected (Figure 3). Most of the mortality continued to occur in the Mid-Coast Forest District (166,959 ha), with 153,063 ha located in Tweedsmuir Provincial Park. Increases also took place in

the Dean River drainage, spreading westward from Tweedsmuir Provincial Park to the Pacific Ocean. Additional areas of significant beetle infestations were in the Whistler-Pemberton corridor, on the east side of Lillooet Lake and in Manning Provincial Park. Control activities have been initiated to the north of Whistler in an attempt to prevent the southward spread of the beetle.

Kamloops Forest Region continued to be less affected by mountain pine beetle than most other regions. Affected hectares continued to rise however, particularly in the northern portion of the Kamloops Forest District. Modest declines occurred in Merritt and Salmon Arm Forest Districts. In total, 35,903 ha were attacked in the Kamloops Forest Region.

Nelson Forest Region continued to be the least affected of all regions, though infestation levels more than doubled from 9,611 ha in 2001 to 21,856 ha in 2002. The largest increase and the majority of attack occurred in the Cranbrook Forest District with 7,785 ha affected, up from only 593 ha in 2001. Most of this attack was located along the Elk River from Fernie to Elkford. Invermere and Arrow Forest Districts also contained significant proportions of the region's attack at 22% and 17%, respectively.

The increase of mountain pine beetle attack across the province reflects a healthy beetle population. In general, large infestations from 2001 showed an alarming amount of dispersal in 2002 in the form of numerous small patches found outside of the main attack area in previously uninfected stands. This included patches of current attack only (no old attack nearby) in many areas.

Weather plays a significant role in the timing of beetle flight, beetle development, and the ability of trees to resist attack.

Province wide, the spring of 2002 was generally cool and wet, which resulted in slower beetle development and slightly later, more extended flights than normal in many areas. However, most regions reported that the beetle flight was closer to normal than it has been in the last few years.

Late, extended flight patterns in the Prince Rupert, Prince George and Cariboo Forest Regions have resulted in larvae overwintering in various instars, the majority of which are smaller than usual. Smaller larvae are generally more susceptible to cold temperatures but recent winter weather conditions have been too mild to cause significant mortality.

Following a cool wet spring most of the province experienced a dry summer and fall (with the exception of Prince George Forest Region and Invermere Forest District). The moisture stressed trees were often too weak to produce pitch tubes in response to beetle attack. This was particularly true when combined with late beetle flights when the trees were shutting down, or in areas where high beetle pressure resulted in heavy beetle attack per tree, such as in the southwest portion of Vanderhoof TSA. In contrast, the attacked trees in the rest of the Prince George Forest Region tended to have normal pitch tubes. An anomaly occurred in the Ootsa Lake and Chelaslie Arm areas of the Prince Rupert Forest Region, where mountain pine beetles attacked only high up the boles of the trees.

All recorded areas of mountain pine beetle attack are based on aerial detection of new red trees, which are actually trees attacked and killed approximately one year prior. Currently attacked trees remain green until the growing season the spring following attack. Therefore, ground surveys are required to determine the ratio of undetected "green attack" *vs.* the recorded "red attack".

Lodgepole pine killed by mountain pine beetle in the Chilcotin

Pitch tubes and frass resulting from mountain pine beetle attack

Table 4 details green to red ratios observed throughout the province in 2002. The highest ratio in the province was reported for various areas in the Cariboo Forest Region, where the ratio reached 40:1. Several new infestations in Williams Lake and Horsefly Forest Districts were reported to contain over 100 green attacked trees with no red attack in the vicinity. However, green to red ratios must be interpreted carefully. Exceptionally high ratios (usually greater than 5:1) may indicate that the sampling was done in areas that were being inundated by beetles from a neighbouring source, and may not be truly representative of the average situation. The ratios are a rough estimate of the average number of new attacks expected for each red tree.

All indications are that despite aggressive control tactics, the mountain pine beetle population will continue to expand provincially in 2003, barring a significant cold weather event during the winter.

In 2001, the province instituted, through regulation, an emergency bark beetle management area based on the *Provincial Bark Beetle Management Strategy*. Within this area, special appraisal adjustments and streamlined regulatory processes are eligible in specific situations to promote expedited small volume harvesting to treat small volumes of infested wood. Small patch removal is used as a control method on small isolated new infestations and on the leading edge of the outbreak where aggressive treatment is being applied to slow the expansion and suppress beetle populations.

Table 4. Green to red mountain pine beetle attack ratios observed in 2002.

Region	High Range	Low Range
Cariboo	27:1 to 40:1 (All districts)	3:1 to10:1 (100 Mile House and Horsefly Districts)
Kamloops	8:1 to10:1 (All districts)	1:1 (Clearwater District)
Nelson	12:1 to 20:1 (Cranbrook and Invermere Districts)	1:1 to 3:1
Prince George	5:1 to 10:1 (Prince George and Vanderhoof Districts)	1:1 to 3:1
Prince Rupert	10:1 (Morice District)	2:1 (Bulkley District)

Pine Needle Diseases

Pine needle cast, *Lophodermella concolor* Dothistroma needle blight, *Mycosphaerella pini*

Pine needle casts, such as *Lophodermella concolor*, affect lodgepole pine trees of all ages. Needles are only infected during their first year of growth during moist summers and they do not turn red until the following spring. Growth reduction and occasional mortality may result after years of repeated defoliation, particularly in younger trees.

Lodgepole pine trees affected by Dothistroma needle blight

Dothistroma (red band) needle blight attacks needles of all ages, any time conditions are suitable for spore release and germination during the growing season; hence damage to lodgepole pine can be far more devastating in a shorter period of time than that which occurs with needle casts.Immature stands can sustain significant mortality, and even mature stands can be seriously affected.

For both foliage diseases, the aerial overview survey likely under-represents the actual area affected due to the difficulty in accurately identifying damage to older foliage and because the survey is not conducted at the ideal time.

The Cariboo Forest Region was the only region in the province to have a significant number of hectares infected with pine needle cast in both 2001 and 2002. Aerial overview surveys detected 265,930 ha of infected lodgepole pine in 2002. The majority of the infected stands were found in the Williams Lake and Chilcotin Forest Districts at 42% and 34%, respectively. In 100 Mile House Forest District 35,053 ha were mapped as affected, but this district was surveyed somewhat late and it was estimated that double the identified hectares were actually infected. Pine needle cast infected 1,884 ha in the Prince George Forest Region. Infestations remained minor in the Kamloops and Nelson Forest Regions (under 500 ha) for the second consecutive year.

55 year old lodgepole pine affected by Dothistroma needle blight

Unprecedented levels of infection in immature pine stands by Dothistroma needle blight continued in the Prince Rupert Forest Region. The disease has spread considerably and impacts have intensified since 2000. The majority of affected stands were located in the Kispiox TSA, Cranberry TSA and Nass TSA in the Interior Cedar Hemlock and Coastal Western Hemlock biogeoclimatic zones.

A project was undertaken to conduct low level aerial surveys over 21,000 ha of immature lodgepole pine leading stands in the Kispiox and Cranberry TSAs to assess incidence levels and potential timber supply impacts of Dothistroma needle blight. The results showed that only 7% of the stands had no obvious symptoms of the foliar disease; 16,055 ha had 100% of the trees affected to some degree by Dothistroma, and 1219 ha had <50% maximum live crown left on the pine within the entire opening. At least some mortality has occurred on 1,350 ha and trees in 455 ha have sustained >10% mortality. This foliage disease is even causing a small amount of mortality in mature lodgepole pine.

Ground surveys of the most heavily infected stands are presently underway, and they confirm the aerial estimates. Replanting of 800 ha over the next two years with shade tolerant species (due to a well established deciduous overstory) is planned for openings with unacceptable levels of dead and dying lodgepole pine.

Pine Stem Rusts

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

Pine stem rusts are prevalent on lodgepole pine throughout BC. Trees of all ages can be infected, but damage is greatest in young pine 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.

Various studies of stem rust incidence and impact on young lodgepole pine are underway throughout the province. One project has recently been completed in the Lakes TSA in the Prince Rupert Forest Region. From 1995 to 2001, 331 cutblocks of primarily young lodgepole pine were sampled (total of 15,039 ha). Stem rusts were observed in 99.7% of the sampled stands: percentages of the stands found in each incidence class were 25.3% low (<10%), 36.4% moderate (10-20%), and 38.3% high (>20%). High incidence levels were frequently found adjacent to long straight openings where winds were frequent or persistent. High incidence areas were most often clustered, and ecosystem classification did not seem to be correlated with rust incidence. Many of the stem infections dated back to the year 1992; a year when weather conditions seemed favorable for infection.

From 1982 to 1999 in the Cariboo Forest Region, a series of permanent sample plots were established in young lodgepole pine stands across the region in various biogeoclimatic zones. Each plot was set up in an area with a specific forest health concern, to assess pest incidence and impact and the spread of specific forest health factors or pest complexes throughout a stand over time. The specific focus of eight of these plots is stem rusts. The plots have been assessed several times, most recently in the fall of 2002. Results are being analyzed over the winter.

Stalactiform blister rust infection on young lodgepole pine stem

Damaging Agents of Douglas-Fir

Western Spruce Budworm, *Choristoneura occidentalis*

The western spruce budworm is a serious defoliator of interior Douglas-fir in BC. Outbreaks of this budworm cause significant damage via larval feeding on the foliage, resulting in reduced seed production due to damaged cones, growth loss, topkill, creation of stem deformities and even mortality, particularly with the understory.

Defoliation by the western spruce budworm has expanded substantially over the last three years, particularly in the Cariboo and Kamloops Forest Regions. Total defoliation by western spruce budworm in the province has quadrupled in area from 2001 to 2002, to a total of 487,352 ha (Figure 5). As in 2001, the majority (82%) of the total defoliation occurred in the Cariboo Forest Region, primarily south of Williams Lake to Meadow Lake, and around the Clinton area. The severe defoliation experienced in the 108 Mile House area over the past several years declined significantly this year. Most of the Kamloops Forest Region defoliation occurred in the Princeton and Aspen Grove areas of the Merritt

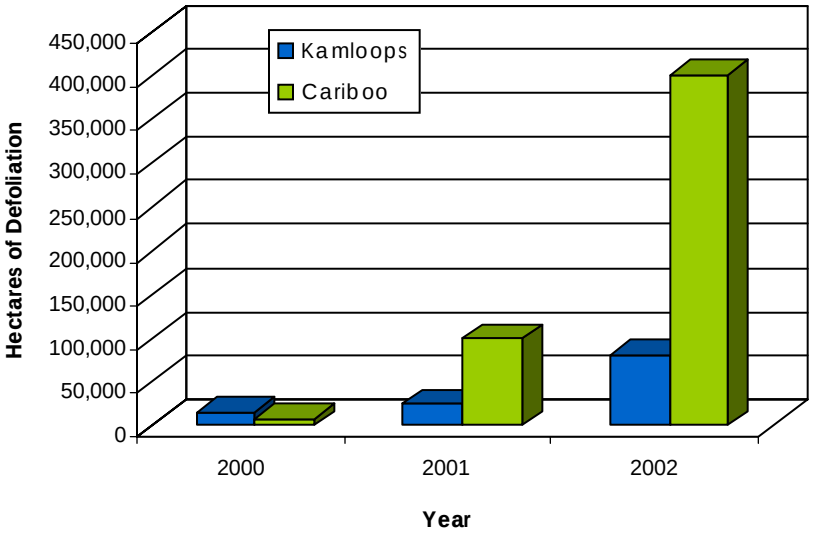

Figure 5. Change in hectares of western spruce budworm defoliation in Kamloops and Cariboo Forest Regions.

District, and in the northwestern portion of Kamloops Forest District. In the majority of the Kamloops Forest Region defoliation was light, while the defoliation in the Cariboo was approximately two-thirds light and one-third moderate.

Infestations in the Vancouver Forest Region continued to expand, up from 1,492 ha in 2001 to 3,645 ha in 2002. Defoliation was mapped in the Boston Bar and Nahatlach portions of Chilliwack Forest District, and the Birkenhead and Halymore areas of Squamish Forest District. Defoliation intensity increased from primarily light in 2001 to moderate in over half the areas this year.

Egg mass surveys conducted in the fall predict further significant defoliation for next year, particularly in the Williams Lake, 100 Mile House, Merritt and Kamloops Forest Districts (Table 5). The majority of the predicted defoliation is in previously uninfected stands.

High value stands with predicted moderate to severe defoliation can be treated with the biological control agent *Bacillus thuringiensis* var. *kurstaki* (B.t.k.). Cariboo Forest Region treated 23,111 ha and Kamloops treated 4,548 ha in the spring of 2002. Kamloops Forest Region had planned on treating a larger area, but deleted some planned sites due to population declines. The treatments were successful, with egg mass counts predicting low defoliation for 2003 in treated areas. The areas where significant western spruce budworm defoliation is expected in the Kamloops and Cariboo Forest Regions will be evaluated to determine if they fall within treatment criteria (as determined by a new provincial defoliator strategic plan which is under development). Infestations in the Vancouver Forest Region are expected to expand and intensify. No treatments are planned at this time.

Western spruce budworm larva

Table 5. Summary of fall 2002 western spruce budworm egg mass survey results for districts where moderate to severe defoliation is predicted.

	No. of sites in each defoliation category				
Forest District	**Nil**	**Light**	**Moderate**	**Severe**	**Average # egg masses/10m² foliage**
Lillooet	0	5	1	0	30.0
Williams Lake	3	23	14	0	44.4
100 Mile	4	64	23	1	44.7
Penticton	0	5	4	0	56.2
Merritt	0	47	60	1	63.2
Kamloops	1	6	14	0	63.3
Chilliwack	0	0	3	0	110.3

Douglas-fir beetle, *Dendroctonus pseudotsugae*

Douglas-fir beetle is an important pest of mature Douglas-fir in BC. At low population levels, the beetle infests scattered, stressed trees and windthrow. However, Douglas-fir beetle populations can quickly build under favourable conditions, at which time large numbers of healthy trees can be attacked and killed. Drought, fire or significant windthrow/breakage from ice are often the precipitators of outbreaks.

Hectares attacked by Douglas-fir beetle across the province declined from 14,500 ha last year to 9,078 ha (Figure 6). Although the total hectares affected by the beetle are comparatively minor, the attacked trees are frequently located in old growth management areas or within valuable mule deer winter range.

Nelson Forest Region continued to experience the largest decline in affected hectares, from 7,836 ha in 2000 to 885 ha in 2002. The most significant decline occurred in Invermere Forest District, where levels dropped from 2,522 ha last year to 55 ha. This was attributed in part to a general decline in the population, but also to aggressive control measures which included harvesting infested timber and conducting a large lethal funnel trap program (utilizing insecticide strips containing the active ingredient Dichlorvos).

Prince George Forest Region Douglas-fir beetle infestations also dropped dramatically to endemic levels throughout the region. Douglas-fir beetle attack in the Kamloops Forest Region dropped 37% from 2001, with local collapses primarily caused by heavy predation. However, new spot infestations were found to have very healthy populations. This bark beetle continues to be a problem throughout the Douglas-fir stands in the transition wet belt areas of Salmon Arm and Clearwater Forest Districts.

The largest increase in affected hectares occurred in the Cariboo Forest Region, with a 32% gain over 2001 to 5,114 ha (Figure 6). The majority of the attack occurred in small infestations along the Chilcotin and Fraser River corridors. Active areas of Douglas-fir beetle in 100 Mile House Forest District were located near Young Lake and Loon Lake.

Vancouver Forest Region had the lowest level of Douglas-fir beetle attack, though hectares affected did rise from 93 ha to 372 ha. The majority of the attack centers were located in the Skagit Valley.

The Canadian Forest Service and a UBC Faculty of Forestry graduate student have been working with the Kootenay Lake Forest District on the development of a susceptibility rating system for stands in the West Arm that are being attacked by Douglas-fir beetle. The study first focussed on tree variables that influenced susceptibility. Age, diameter, height, phloem thickness, bark thickness and growth rate were found to be significant variables.

Figure 6. Change in hectares affected by Douglas-fir beetle in BC from 2000 to 2002.

Douglas-fir beetle gallery

A more recent addition to the study measured water use efficiency by analyzing the amount of carbon 13 relative to carbon 12 in trees. The results suggested that infected trees had been subjected to higher drought stress than non-infected trees.

The study also looked at stand variables. Preliminary results suggest that live crown ratio is an important variable. This may indicate that the hazard rating for Douglas-fir beetle is more complicated than for other bark beetle species and should take into account several other stand variables not included in current hazard rating methods.

Douglas-fir tussock moth, *Orgyia pseudotsugata*

The Douglas-fir tussock moth is a destructive defoliator of Douglas-fir of all ages. Since the larvae consume both old and new foliage, one year's defoliation can result in top kill and mortality. Historically, infestations have occurred in the driest parts of the southern interior, primarily in the Kamloops Forest Region.

Douglas-fir tussock moth larva

Pheromone trapping sites are used to monitor the population in high hazard areas in Kamloops Forest Region and the southern part of 100 Mile House Forest District. Trap catches in 100 Mile House District have not reached the threshold where significant defoliation is expected, though trap catches have slowly climbed again from a sharp drop in 2000. The highest trap catches were in the areas of Clinton Creek, Bonaparte River and Loon Lake. Trap catches in the Kamloops Forest Region in 2001 indicated a building population that would probably reach outbreak proportions in 2002. However, extensive parasitism occurred in the fall of 2001, and no treatment was necessary in 2002 (only 92 ha of visible defoliation was mapped during the overview surveys).

Defoliation of a Douglas-fir stand north of Cache Creek by Douglas-fir Tussock Moth

Western False Hemlock Looper, *Nepytia freemani*

The western false hemlock looper is found primarily in the drier portions of southern BC. Its primary host is Douglas-fir, though other conifers are sometimes attacked. The larvae consume both old and new foliage, and defoliation can be severe, resulting in top-kill and mortality.

Western false hemlock looper defoliation in Cranbrook District

Hectares defoliated by the western false hemlock looper expanded substantially in the Nelson Forest Region in 2002. The main infestation was located in the Eager Hills outside of Cranbrook, where 2,558 ha of Douglas-fir stands of all age classes were defoliated. The majority of the defoliation was severe but buds were surviving; therefore, significant mortality is not expected. The remainder of the defoliation in the region occurred in the Invermere Forest District near Radium Hot Springs, Invermere, and Fairmont. The severity of defoliation was evenly split between light and moderate in these areas. Most of the infested areas in Invermere Forest District coincided with areas being set up for ecosystem maintenance burning by the Kootenay National Park to restore open range for bighorn sheep habitat. Sampling across the region showed an expected population decline next year.

The only other noted defoliation by the western false hemlock looper was 512 ha of light and moderate defoliation in the Kamloops Forest District at Inks and Mowich Lakes, where it was combined with western hemlock looper defoliation.

Damaging Agents of Spruce

Spruce beetle, *Dendroctonus rufipennis*

The spruce beetle is the most destructive damaging agent of mature spruce in British Columbia. At low population levels, the spruce beetle prefers to infest weakened trees and downed host material. If a significant amount of a food source such as windfall is available, populations can build to the point of outbreak, where beetles will then move into healthy trees and cause widespread mortality.

Recorded incidence of spruce beetle attack totaled 268,995 ha across the province in 2002, up more than 2 ½ times over 2001. Of this total 61% of the hectares affected sustained light mortality, 35% moderate mortality, and only 4% severe mortality. Severity and hectares affected by spruce beetle tend to be underestimated from the air, as newly killed trees only show as a dull yellowish or red colour at best, and sometimes just change directly from green to grey. The transition period for colour change is also very short, and can be missed during an overview survey. This may in part explain the large drop in the spruce beetle in Prince Rupert Forest Region which was surveyed relatively early in the season, versus the large increase in spruce beetle in the Prince George Forest Region, which was surveyed later.

Hectares affected by spruce beetle in the Prince George Forest Region

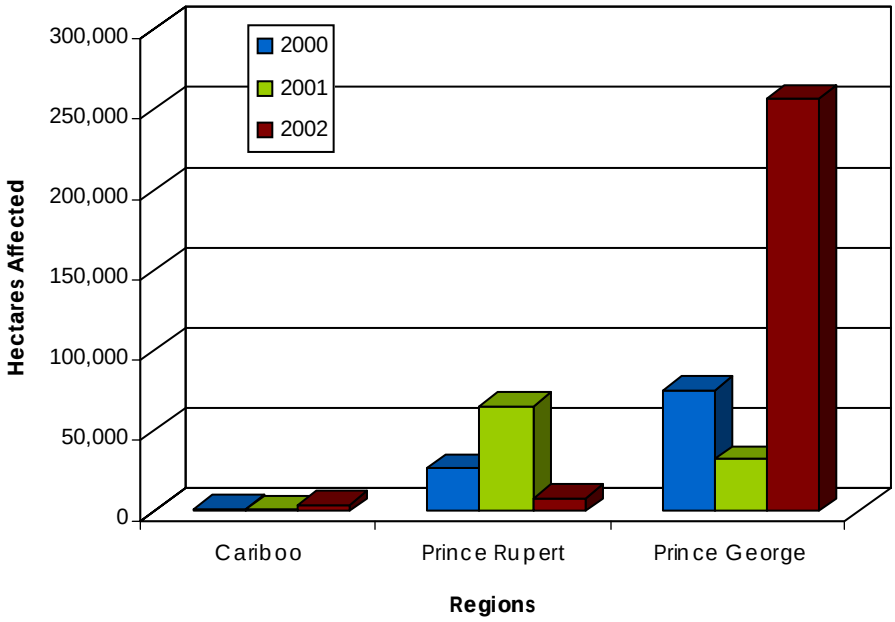

Figure 7. Hectares affected by spruce beetle, for regions with more than 4000 ha infested.

increased almost eight fold from 2001 to 2002 (Figure 7). Over 253,159 ha of attack were detected this year across the region. Infestations were up substantially in all the districts with the exception of Fort St. John, where populations dropped to endemic levels (note that not all of the district was flown). The highest level of attack was recorded in the Prince George Forest District, where 65% of the total hectares for the region were located.

Spruce beetle infestation

Infested hectares in the Prince Rupert Forest Region dropped from 65,226 ha in 2001 to 8,631 ha in 2002. Ground surveys confirm that spruce beetle is generally on the decline in the region, in part due to aggressive trap tree programs. Infestations dropped in all districts. The Lakes Forest District showed 5,556 ha still affected, which represents 64% of the regional total.

In the Cariboo Forest Region, total hectares infested by spruce beetle rose modestly from 1,197 ha in 2001 to 4,692 ha in 2002 (Figure 7). The majority (93%) of the attack occurred in 100 Mile House Forest District in the Hendrix Lake and Spanish Creek area, adjacent to an active infestation in Wells Gray Provincial Park. Some areas, up to 150 ha in size, had 98% of the trees attacked.

The remaining three southern regions experienced low levels of spruce beetle infestation. In Kamloops Forest Region, 1,024 ha of spruce beetle were recorded, primarily in the Lillooet Forest District, near Carpenter Lake and south of Anderson Lake.

Hectares affected in Vancouver Forest Region increased to 1,423 in 2002, with infestations primarily located in the Haylmore Creek area of the Squamish Forest District. In Nelson, small scattered spots totaled only 74 ha across the region.

Spruce foliar disease, *Rhizosphaera kaukhoffii*

An unusual foliar disease, *Rhizosphaera* (identified in samples sent to Brenda Callan, Canadian Forest Service) was noted in the Morice Forest District of Prince Rupert Forest Region. At least ten openings with juvenile spruce (<10 yrs. old) were found to be 100% affected by this foliar disease. All foliage below 1.5 meters was affected, but buds were unaffected. Infected foliage became visible in the spring, and remained on the trees throughout the summer.

Damaging Agents of True Fir

Eastern spruce budworm, *Choristoneura fumiferana*
2-year budworm, *Choristoneura biennis*

Both the eastern spruce budworm and 2-year budworm are significant defoliators of all ages of true firs and spruce. Severe defoliation can occur due to late instar larvae feeding on old and new foliage. Several consecutive years of defoliation can result in growth loss, tree deformity, topkill and tree mortality. 2-year budworm is common in the subalpine and boreal forests of the BC interior, and eastern spruce budworm is found in northeastern British Columbia.

Eastern spruce budworm continued to be a chronic problem in the Prince George Forest Region, primarily in the Fort Nelson Forest District and some areas in the Fort St. John Forest District. Unfortunately, conditions did not allow for aerial survey of the defoliation in 2002, so it is not known if there has been a change from the 1.6 million hectares of affected forests reported in 2001. Based on local observations, defoliation levels seemed to be lower than last year with the exception of plantations, where defoliation was estimated to be moderate to severe. 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 2003. The sample results indicated moderate defoliation next year at four of the six survey sites (Clarke Lake, Snake River P-2, Kotcho and Muskwa) and light defoliation at the other two sites. Neighbouring infestations in Alberta have also been sampled and results indicated increases in eastern spruce budworm populations for 2003.

The 2-year budworm requires two years to complete its life cycle. Most defoliation damage occurs in the 2nd year, when larvae are bigger and hence consume large amounts of foliage. In the Prince George Forest Region, 24,080 ha of mainly light defoliation were observed. Prince George Forest District contained 73% of the affected hectares, and the remainder was located in Robson Valley Forest District (particularly around Valemount). This is the 2nd year in the budworm life cycle for these districts. Infestations were present in the Fort St. James Forest District, but since the budworm was in the 1st year of its life cycle, defoliation was not visible from the air. The Canadian Forest Service, led by Dr. Vince Nealis, conducted defoliation assessments on a number of permanent sample plots in the region. They are working to develop a method of predicting 2nd year defoliation from 1st year defoliation. The results have not been tabulated to date, but there appears to be a general trend towards decreasing populations in the surveyed plots.

2-year budworm defoliation on balsam fir tree

In the Cariboo and Kamloops Forest Regions, the 2-year budworm is in its 2nd year. Consequently, mapped defoliation was up substantially. A total of 71,885 ha were affected in the upper elevation wet belt areas of the Cariboo, with 78% recorded as light defoliation. Two-thirds of the defoliation occurred in the Horsefly Forest District, with the rest roughly split between Quesnel and 100 Mile House Forest Districts. In Kamloops, 64,203 ha of defoliation was recorded, the majority being of light intensity and located mostly in the wetter subalpine areas of the Clearwater Forest District. Eggmass sampling conducted in the fall of 2002 generally predicted moderate defoliation for 2004.

Western balsam bark beetle, *Dryocoetes confusus*

The western balsam bark beetle is the most important damaging agent of its primary host, mature sub-alpine fir, in British Columbia. This bark beetle and an associated pathogenic fungus can be responsible for extensive tree mortality in high elevation ecosystems.

In 2002, just under one million hectares sustained mortality due to western balsam bark beetle. 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 year, 92% of the hectares affected were light attack, 7% moderate, and only 1% was severe. This reflects the typically low percentage of western balsam bark beetle attack per hectare, as compared to the spruce beetle or the mountain pine beetle (Figure 8). However, western balsam bark beetle attack tends to occur year after year in a susceptible stand, resulting in extensive cumulative damage.

The greatest increases in hectares affected by western balsam bark beetle in 2002 occurred in the Prince George Forest Region, where 566,350 ha were attacked (Figure 9). This is over double the area noted as infested in 2001. The majority of the attack occurred in Mackenzie and Fort St. James Forest Districts, at 39% and 29% of the regional total, respectively. Infestations have increased significantly in all the districts, except in Dawson Creek Forest District where levels dropped by almost half, and Fort St. John Forest District where reported levels dropped from 5,002 ha to only 67 ha (note that not all of the district was flown).

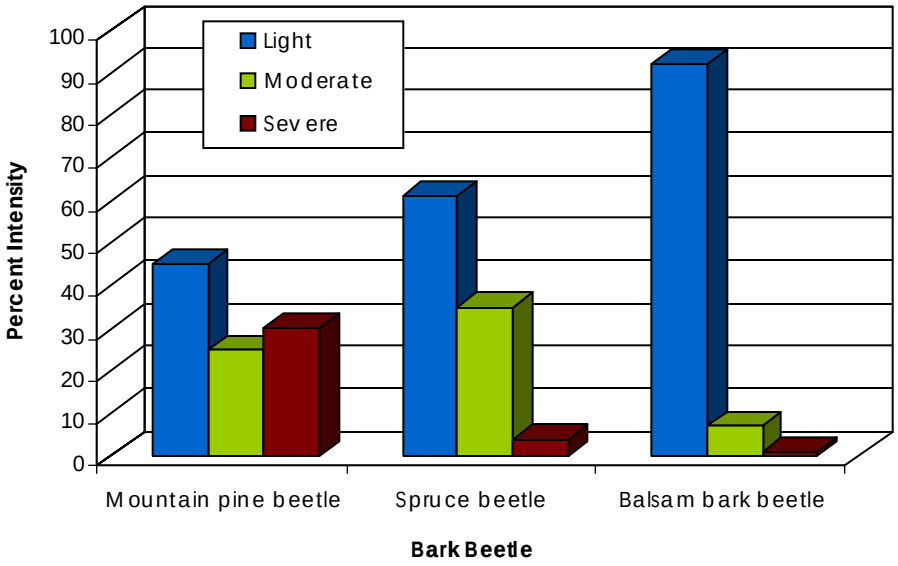

Figure 8. Comparison of intensity of attack between the major bark beetles in British Columbia in 2002.

Prince Rupert Forest Region experienced a large drop in western balsam bark beetle attack to 251,451 ha, which is 30% of the hectares affected in 2001 (Figure 9). Hectares of attack dropped substantially in all districts except for Bulkey-Cassiar Forest District, where 119,152 ha affected by western balsam bark beetle represented almost half of the regional total. Just under 100 polygons were surveyed across the region to determine if western balsam bark beetle was properly accounted for in the Timber Supply Review (TSR). The study concluded that indeed, most impacts are included in the Variable Density Yield modeling tool that is used to predict the volumes for the TSR.

The large fluctuations in hectares affected in the Prince George and Prince Rupert Forest Regions may be in part a result of differing observer techniques. Due to the vast number of hectares of low attack levels, some aerial observers tend to record only areas sustaining greater than normal attack with primary focus on spruce beetle and mountain pine beetle, while others record everything. A more standardized approach will be implemented in 2003. In general, nearly all mature sub-alpine fir stands in the northern regions have some detectable levels of damage caused by western balsam bark beetle.

Western balsam bark beetle attack more than tripled in the Cariboo Forest Region in 2002 for a total of 142,817 ha affected. Three quarters of the attack occurred in the high elevation stands of Horsefly and Quesnel Forest Districts, at 43% and 32% of the regional total, respectively. Very few sub-alpine fir stands exist in the Williams Lake Forest District, therefore area attacked was low. Chilcotin and 100 Mile House Forest Districts contained the remaining attack in small, scattered patches.

The three other regions sustained significantly lower levels of western balsam bark beetle attack, in part because sub-alpine fir is not as large a component of their forested ecosystems. Mortality remained relatively steady in the Kamloops Forest Region with 24,455 ha affected in 2002 (Figure 9). Most high elevation forests sustained low levels of attack. Hectares affected remained very low in the Vancouver and Nelson Forest Regions.

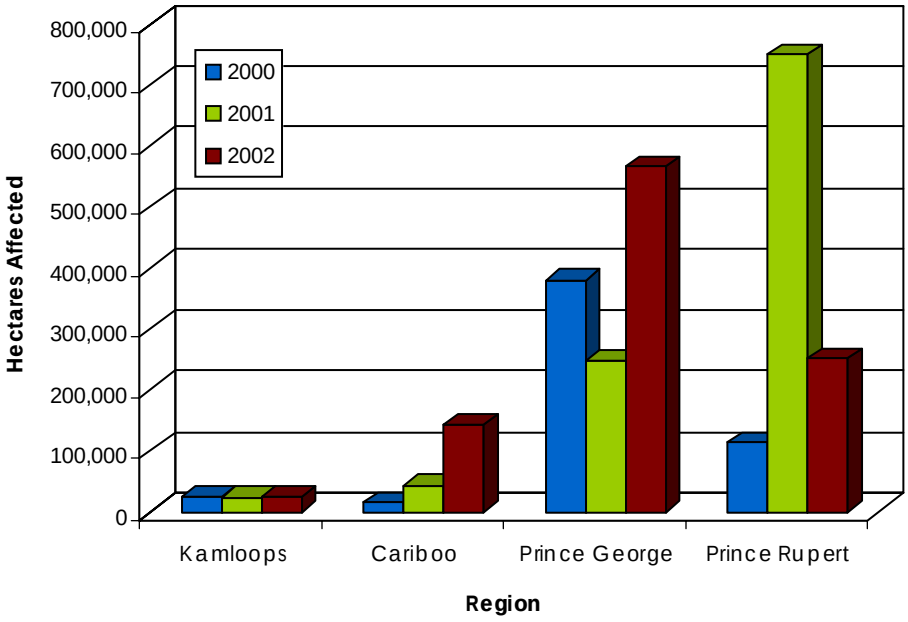

Figure 9. Hectares affected by western balsam bark beetle in British Columbia for regions with more than 5,000 ha infested.

Balsam bark beetle infested stand

Fir engraver beetle, *Scolytus ventralis*

The fir engraver beetle is a pest of true firs and occasionally Douglas-fir and spruce in southern BC. Trees may be partially attacked and survive, or, if beetles mass attack, top-kill or mortality can occur. In the southern part of the Nelson Forest Region, particularly in the Arrow Forest District, widespread mortality of grand fir occurred at the lower elevations. The mortality was thought to be due to a combination of the continued drought and the fir engraver beetle. Much of the damage occurred on private land. Grand fir in these areas tends to be present as a small percentage of mixed stands. Therefore, attack was very scattered and hard to see during the overview survey. Mainly light mortality, totaling 111 ha, was recorded for the region, but the actual total hectares affected was higher (ground observations).

Damaging Agents of Hemlock

Western hemlock looper, *Lambdina fiscellaria lugubrosa*

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

Western hemlock looper populations can increase suddenly to outbreak levels, which can result in extensive tree mortality. 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.

Western hemlock looper infestations increased over six fold from 6,801 ha in 2001 to 44,277 ha in 2002 across BC. Recorded levels of defoliation were 47% light, 36% moderate and 17% severe. Defoliation continued in the same areas as last year in the Vancouver Forest Region: the west side of Howe Sound, in the Capilano Watershed and eastward to Chehalis River. These infestations were ahead of most in the province and are now in the decline phase. Infested hectares dropped from a high of 4,445 ha to 2,818 ha. Defoliation resulted in patches of mortality on the west side of Howe Sound. These areas will be salvage harvested, if possible.

In the Cariboo, Nelson and Kamloops Forest Regions, the western hemlock looper is generally in the 2nd year of the outbreak cycle, and significant defoliation was recorded for the first time during this outbreak in most areas. The Cariboo sustained 24,117 ha of defoliation, primarily around Quesnel Lake in Horsefly Forest District.

Most of the 10,719 ha of defoliation in Nelson Forest Region occurred in the Columbia Forest District. The majority of the attack was situated on both sides of Revelstoke Lake, from Mars Creek to Mica Creek. Larval counts at 72% of the permanent sample plots exceeded threshold values for the second consecutive year, indicating that visible defoliation will continue in 2003. The average number of larvae per beating increased from 32 to 112 in the infested plots. Sites with high larval counts, other than on Revelstoke Lake, included locations at Trout Lake and Beaver River.

Western hemlock looper infestations totaled 7,387 ha in the Kamloops Forest Region. The majority of these infestations occurred east and north of Salmon

Western hemlock looper defoliation along Revelstoke Lake

Arm in Salmon Arm Forest District and Wells Gray Provincial Park and the upper ends of Raft and Mad River drainages in Clearwater Forest District. 702 ha of defoliation also occurred in the Hidden Lake/Kingfisher areas of Vernon Forest District. Two highly unusual infestations in low elevation dry Douglas-fir stands (totalling 512 ha) occurred in the vicinity of Inks and Mowich Lakes in Kamloops Forest District, in association with western false hemlock looper. Moth trap catches at permanent sample sites remained high for the third year, with the highest catches in the Perry River and Kingfisher Creek areas.

The biological control agent *Bacillus thuringiensis* var. *kurstaki* under the brand name Foray 48B is now registered for use on western hemlock looper infested stands in Canada. Pending funding, operational treatments and research trials are planned on approximately 10,000 ha in Nelson, 2,500 ha in Cariboo and 2,000 ha in Kamloops Forest Regions for next year.

Hemlock looper larva

Damaging Agents of Deciduous Trees

Forest tent caterpillar, *Malacosoma disstria*

The forest tent caterpillar is a major defoliator in BC throughout the range of its primary host, trembling aspen. Other deciduous tree species, shrubs and even some conifers can be defoliated during severe infestations. Outbreaks occur periodically across large areas of susceptible stands. Sustained, severe defoliation can result in top-kill, reduced growth, and occasional minor mortality.

Infestations by the forest tent caterpillar were down sharply in 2002 to 4,127 ha from 60,415 ha. This continues a downward trend expressed over the last several years. All of the recorded infestations were located in the Vanderhoof Forest District, and defoliation was primarily light.

Satin Moth, *Leucoma salicis*

Satin moth is an important defoliator of all poplars, and occasionally feeds on willow. This insect was introduced from Europe, and was first discovered in southwestern BC in 1920. Since then it has spread throughout the southern and central interior. Periodic outbreaks often cause total defoliation of the host, which can result in top-kill, growth reduction and occasional tree mortality.

Defoliation by the satin moth continued to increase in the Cariboo Forest Region from 6,575 ha in 2001 to 45,070 ha. Defoliation levels were moderate in 60%, light in 29% and severe in 11% of the affected stands. Part of the large increase is attributable to higher survey accuracy in the Quesnel Forest District, where over half of the entire regional defoliation was mapped in 2002 as opposed to a negligible amount last year, when it was underestimated. The remainder of the infestations were spread throughout poplar stands in the rest of the Cariboo districts. The heaviest defoliation occurred along the Quesnel River and at Tatalayoko Lake. Infestations in the Kamloops Forest Region shrunk substantially in 2002 to a total of only 324 ha.

Serpentine leaf miner, another defoliator of aspen, was present to an extensive degree throughout 100 Mile House Forest District. Aerial mapping of this forest health pest was not conducted.

Birch Leaf Miner, *Fenusa pusilla*

The birch leaf miner was introduced into North America from Europe, and can now be found throughout the range of its host, paper birch, in BC. Damage to the foliage occurs when the larvae feed between the leaf layers. Severe defoliation can result in top die-back, minor growth loss and tree stress.

Defoliation by the birch leaf miner more than doubled from 2001 levels to 9,720 ha in Kamloops Forest Region. The majority of the infestations occurred in the Vernon, Kamloops and Clearwater Forest Districts.

Substantial defoliation was also recorded in the Nelson Forest Region on 8,464 ha in the Arrow, Columbia and Kootenay Forest Districts in 2002. Some defoliation did occur in Nelson Forest Region in 2001, but it was not recorded during the aerial survey. Defoliation recorded as birch leaf miner was actually identified as a complex of various insects. Trees affected by defoliation in combination with the ongoing drought are beginning to experience significant dieback in mature stands over many parts of the region.

Gypsy Moth, *Lymantria dispar*

The gypsy moth 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. It is an insect that has been periodically intercepted in BC since 1978 but aggressive monitoring and eradication programs have thus far prevented its establishment in BC.

During the past 23 years, province-wide monitoring using pheromone-baited traps has been conducted to detect incursions of gypsy moth in BC and throughout western North America where the moth has not established. Where trap catches identify potential infestations, eggmass and larval surveys are conducted to determine if treatments are warranted. Where a population is detected and is determined to be on the verge of becoming established, eradication treatments have historically been very successfully conducted. In 2002, fifteen moths were caught during the Canadian Food Inspection Agency's annual monitoring survey. The pheromone traps caught moths at seven different sites: three on Vancouver Island, two on the Lower Mainland and two in the southern interior. Most sites recorded only one or two moths with the exception of the Delta site that was trapped using a higher density of traps. The Delta site was ground sprayed with Btk in 2000 and has been "mass trapped" in 2001 (3 moths caught) and 2002 (6 moths caught). The two sites in the southern interior are associated with high-use recreation areas where pupae may have been transported on recreational vehicles.

A full history of the gypsy moth in B.C. is available on the MOF web site at http://www.for.gov.bc.ca/hfp/gypsymoth/.

Foliage damage caused by birch leaf miner

Aspen and Poplar Leaf and Twig Blight, *Venturia spp.*

Aspen and poplar leaf and twig blight infects trembling aspen and poplars. These fungi 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.

Aspen shoots affected by Venturia

The unseasonable cool and wet spring weather experienced in the Prince Rupert and Prince George Forest Regions over the last four years have provided optimum conditions for the build-up of infections by aspen and poplar leaf and twig blight. In Prince Rupert Forest Region, infestations more than doubled from 2001 to a total of 47,239 ha. All districts experienced increases except for Kispiox Forest District, where affected hectares fell. The majority of the infected stands were located in the Cassiar, Lakes, Bulkley and Morice Forest Districts. In general, aspen stands were heavily defoliated in the sub-boreal spruce biogeoclimatic zone, and cottonwood stands sustained severe defoliation in the interior cedar-hemlock biogeoclimatic zone. Trees of all ages were affected.

In Prince George Forest Region, infection by aspen and poplar leaf and twig blight affected 32,918 ha in 2002. This was up sharply from only 162 ha recorded the previous year. Defoliation was recorded in all districts, but was most prevalent in Dawson Creek and Fort St. James Forest Districts.

Aspen stand defoliated by Venturia

Damaging Agents of Multiple Hosts

Armillaria Root Disease, *Armillaria ostoyae*

Armillaria root disease occurs throughout the southern portion of BC. A variety of conifers are its principal hosts, though many deciduous trees and shrubs are also attacked. Armillaria can cause growth loss and minor butt rot in diseased trees, however mortality is very common. In coastal forests, observed mortality seldom occurs in trees older than about 25 years but in the interior trees of all ages are killed. Although Armillaria root disease centers can be identified from the air, they are not usually seen during an overview survey due to the height and speed of the aircraft.

A survey of Armillaria incidence and impacts in managed forest areas was recently completed in the Invermere TSA. A total of 561 harvested or designated for harvest blocks were examined for evidence of Armillaria. The pre-harvest forest age of the cutblocks was 101 to 120 years. Infections were confirmed on 76% of the blocks through a survey of trees and stumps using transects that covered approximately 5% of each block. The weighted average infection using above ground Armillaria signs was 8.1%. Areas with lodgepole pine and/or

Douglas-fir had the most frequent occurrence of Armillaria root disease and the highest incidence of infected area per block. In several blocks, Armillaria induced a change in tree species composition from initially established Douglas-fir to less-susceptible species. In a few blocks, reforestation efforts failed. The results of these surveys substantiate previous opinions about the widespread occurrence and potentially major impacts of Armillaria root disease on forest productivity in the Invermere TSA.

Armillaria root disease center

Since 1992, Dr. Bill Chapman (Research Section, Cariboo Forest Region) and Dr. Guoping Xiao have been conducting research into possible innovative methods to control Armillaria root disease. Several research trials have been established in the Nelson and Cariboo Forest Regions. The work has been done with the cooperation of many major forest licensees, including Lignum Ltd., Riverside Forest Products Ltd., Weldwood of Canada Ltd., West Fraser Timber Co. Ltd., Tembec (formerly CFI) as well as with several woodlot holders and the Small Business Program.

Armillaria mycelial fan beneath Douglas-fir bark and a fruiting body

The main focus of the work has been to inoculate stumps in logged areas with a saprophytic fungus (*Hypholoma fasciculare*), with the hope that it can compete with the fungus that causes Armillaria root disease *(Armillaria ostoyae* in the BC interior). Initial results from five and six year old trials indicate that mortalities are significantly lower in Hypholoma treated areas than in untreated areas. Treated areas have mortality rates that are 1/3 (or less) of those in untreated areas. Further questions include: will these types of results occur over a wide range of conditions and; will Armillaria caused mortalities begin to increase over time, similar to what happens in stumped areas, or will the Hypholoma remain effective over time and continue to reduce mortalities.

This research into the use of Hypholoma has explored a commonly held theory about the mechanisms that limit Armillaria in nature. It is postulated by the researchers that after stand destroying events, the populations of various saprophytic fungi rise dramatically with the inputs of fresh bole and other woody material and these saprophytic fungi may outcompete root disease fungi in woody substrate (roots). It is suggested that this natural process never fully eliminates root disease organisms, but lowers their inoculum potential for several decades, so that well-stocked stands are able to establish. To test this hypothesis, many of the new trials contain a component of woody debris management. All trials are at the research (not operational) level at this time. For more information, contact Dr. Bill Chapman, (Bill.Chapman@Gems8.gov.bc.ca).

Climatic Injury

Tree species of all ages can be affected by a variety of climatic injuries, including drought, flooding, windthrow, frost, red belt and snow. Damage can vary from slight growth reduction to serious tree deformities and mortality. Additionally, trees damaged by climatic injuries are often more susceptible to insects and disease.

Mortality caused by flooding continued to be the most significant climate related damage agent in BC, affecting 4,902 ha. Nearly 100% of the damage occurred in the three most northern regions, due to unseasonably wet and cool spring weather over the last four years.

Windthrow or blowdown was not recorded as a significant damage agent in 2002 during the aerial overview survey. However, approximately 1000 ha in the Wigwam area of the Cranbrook Forest District were identified by ground surveys. The forest in this area was a lodgepole pine/Douglas-fir mix 60 to 80 years old. This site will be monitored for a possible increase of Douglas-fir beetle and *Ips* spp. beetle (common colonizers of recently killed and damaged trees).

Drought affected 78 ha in the Squamish Forest District. Vancouver Forest Region has been drier than average for several years now, and further drought mortality is expected in 2003.

Animals

A variety of animals cause damage to various tree species throughout BC, particularly at the seedling to sapling stages. Animal feeding 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. Most animal damage is not visible during aerial surveys. The most visible damage is stem girdling, resulting in dead tops or mortality. Bear and porcupine are most often responsible.

In 2002, black bear damage affected 796 ha in Nelson Forest Region, primarily in the Columbia and Invermere Forest Districts. Although black bear damage in the Vancouver Forest Region was not surveyed this year, damage has spread and intensified. Porcupine damage affected 5,717 ha in Prince George Forest Region, with most of the damage located in Prince George Forest District on lodgepole pine. An additional 527 ha of porcupine damage was mapped in Prince Rupert Forest Region, primarily in the Kalum and North Coast Forest Districts. This mapped area is probably underestimated based on ground survey information that indicates damage is widespread and somewhat chronic throughout many drainages in these two districts. It is difficult to accurately detect chronic porcupine damage using the overview survey method, particularly in hemlock stands. Almost all of the porcupine damage in the province was of very light intensity.

Bear damage to young pine

American porcupine

BC Ministry of Forests Forest Health Links on the World Wide Web:

BC Ministry of Forests forest health home page:
http://www.for.gov.bc.ca/hfp/forsite/Forest_Health.htm

Forest health aerial overview survey
http://www.for.gov.bc.ca/hfp/forsite/overview/overview.htm

Standardized forest health aerial overview survey standards for British Columbia:
http://srmwwww.gov.bc.ca/risc/pubs/teveg/foresthealth/index.htm

Aerial overview digital data standards:
http://www.for.gov.bc.ca/hfp/forsite/overview/arcinfo.htm

Aerial overview survey data on MOF FTP server:
ftp://ftp.for.gov.bc.ca/branches/forest_practices/external/!publish/Aerial_Overview/

Bark beetles in BC:
http://www.for.gov.bc.ca/PAB/News/Features/beetles/index.htm

Field guide to forest damage in British Columbia:
http://www.for.gov.bc.ca/hfp/forsite/pest_field_guide/index.htm

Ministry of Forests, Forest Practices Branch

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Pro-Tech Forest Resources Ltd.

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