Abstract

Forest health conditions in British Columbia (BC) in 2003 were compiled from annual provincial aerial overview surveys, insect population predictions, information on forest health agents not aerially detectable and special project information.

The largest mountain pine beetle epidemic ever recorded in BC continued to expand, with area affected more than doubling to just over 4 million hectares. The largest increase occurred in the Chilcotin Forest District with 880,259 ha damaged vs. 34,519 ha last year. The highest attack levels occurred in Quesnel Forest District, with just over 1 million hectares affected. Large infestations continued to expand in the Northern Interior Forest Region (NIFR), with 1.4 million hectares located in the Nadina, Vanderhoof, Prince George and Fort St. James Forest Districts. Mountain pine beetle attack was lower in the southern part of the province, but infestations still continued to expand. Recent mild winters and an abundance of mature lodgepole pine have contributed to the current epidemic. Despite aggressive control tactics, a further population expansion is expected next year if the winter weather is mild.

Western balsam bark beetle damaged almost 1.4 million hectares of subalpine fir stands. The area affected by spruce beetle increased 22% to almost 316,000 ha. The majority of attack by these beetles occurred in the NIFR.

Defoliation damage by insects was also significant. Western spruce budworm infestations continued to increase, defoliating 522,236 ha of Douglas-fir from Williams Lake south to Princeton and Pemberton. Sampling indicated continued defoliation for next year. True fir and spruce stands were defoliated by 2-year-cycle budworm and eastern spruce budworm, affecting 186,622 ha and 166,490 ha, respectively. Most of the 2-year-cycle budworm damage occurred northwest of Prince George Forest District, and eastern spruce budworm in the Fort Nelson Forest District. Western hemlock looper was predominant in the peak third year of a predicted four-year cycle in the southern portion of the province, with 42,541 ha affected. The biological control agent *Bacillus thuringiensis* var. *kurstaki* was applied to over 10,135 ha of western hemlock looper and 22,139 ha of western spruce budworm infestations to reduce damage and population levels. Other defoliating insects, principally large aspen tortrix, damaged 854,718 ha of deciduous trees across BC.

Fire damage was the most significant abiotic factor with a total of 2,466 fires engulfing 248,131 ha. The Southern Interior Forest Region (SIFR) sustained 90% of the damage.

Various needle and leaf diseases caused damage, notably 32,478 ha of larch needle blight in the southern-most districts of the SIFR, and approximately 36,000 ha of Dothistroma needle blight in the NIFR. Aspen and poplar leaf and twig blight also continued to infect aspen and cottonwood stands throughout the NIFR.

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

2003 Summary of Forest HealthConditions in British Columbia

Introduction

Damage from insects, diseases, animals and environmental factors that affect the forests of British Columbia (BC) are monitored and recorded on an annual basis by the BC Ministry of Forests (BCMOF), Forest Practices Branch. Most of the information is gathered by aerial overview surveys. Recently, several BCMOF regions and districts were amalgamated, and data from past surveys have consequently been re-organized according to the new boundaries for this report (Figure 1).

Since 1999, the BCMOF has been responsible for conducting the 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). Since 2002, survey methodology has been standardized to produce a more consistent, cohesive picture of forest health throughout British Columbia.

Certain forest health concerns, particularly diseases such as rusts, cankers, decays and dwarf mistletoes, are not usually discernable during aerial overview surveys. These disturbances are primarily discussed in this report when identified by other surveys such as low-level helicopter flights or ground surveys. This report is a summary of the 2003 aerial overview survey results, with additional insect population predictions and special projects information supplied by various sources throughout the province.

Aerial observers with typical survey plane

Forest Region and District Boundaries - April 1, 2003

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

For the aerial overview surveys, experienced personnel draw sketch maps of forest health disturbances from fixed wing aircraft. Usually a map scale of 1:100,000 is used to provide an efficient, economical coverage of the province with an acceptable level of accuracy. 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 2003 provincial aerial overview surveys were conducted from mid July through the beginning of October (Table 1). Although surveys commenced in a timely fashion, completion was delayed in several areas due to poor visibility caused by smoke from forest fires. Unusually large forest fires were burning during a significant portion of the available survey window, forcing flights to be conducted during less than optimal conditions. A total of 635.9 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 determine adequate survey coverage (Figure 2). Relatively flat expanses of forested land were flown in a grid pattern. Drainages were flown in more mountainous terrain. Non-forested types such as alpine tundra and agricultural belts were not surveyed. The majority of all forested lands were surveyed, with the exception of the Highway 37 corridor, north of Bob Quinn Lake to Atlin because of poor weather conditions.

Forest health disturbances that killed trees (beetles, fire, flooding, windthrow, porcupine, etc.) were mapped during aerial surveys by observing foliage colour changes on dead trees. Generally, dying tree foliage turns yellow to bright red, then colour intensity fades and foliage is shed. Only mortality that occurred within the previous year is mapped annually. Hectares damaged in previous years cannot be added cumulatively, since new mortality may appear in areas that previously had a portion of the trees killed. Small areas of up to 50 trees killed were recorded as spots. Larger areas of damage were drawn as polygons on the survey map, with the percentage of recently killed trees separated into three intensity classes (Table 2).

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 affected, 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.

A major limitation of the aerial overview survey methodology is it is a poor means of estimating the actual number of trees killed (and consequently, volume killed), because of the broad incidence classes used and known errors of omission (i.e., missed trees). The main function of the survey is to provide general trends in the annual change in the distribution and magnitude of detectable forest damage.

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).

Table 1. Number of flying hours required by each Region to complete the 2003 provincial aerial overview surveys.

Region	Zone	Flight hours	Survey Dates
Southern Interior Forest Region	Cariboo	145.7	July 28 – Sept 27
	Kamloops	55.0	July 29 – Aug 30
	Nelson	61.6	July 27 – Aug 8
Northern Interior Forest Region		309.0	July 12 – Oct 3
Coast Forest Region		64.6	Aug 2 – Sept 1
Total		**635.9**	**July 12 – Oct 3**

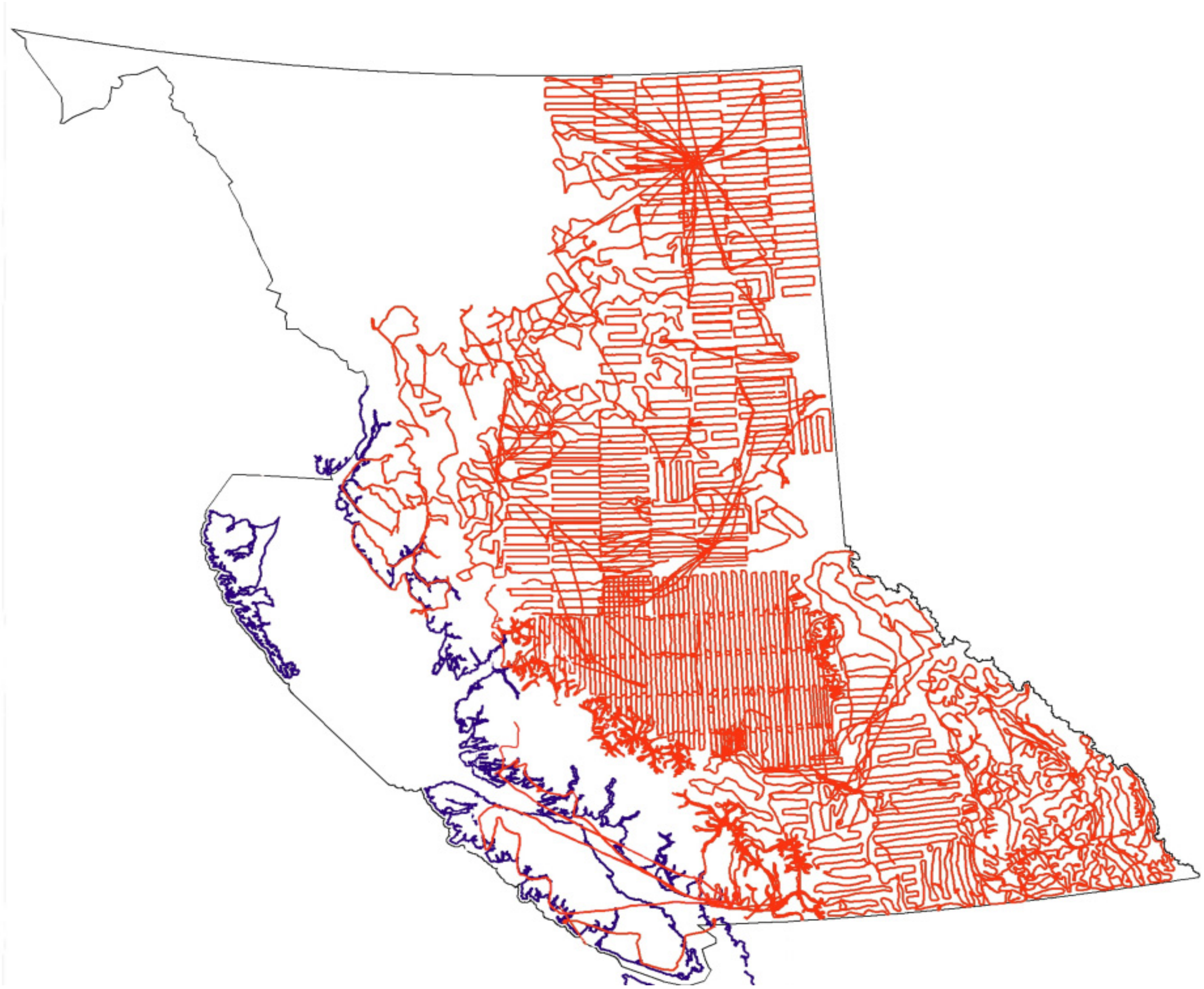


Figure 2. Flight paths flown to conduct the 2003 aerial overview surveys.

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

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.

General Conditions

Forest health conditions in BC as recorded during the aerial overview surveys are summarized in table 3. In 2003, mountain pine beetle continued to cause the most damage in the province, with infested hectares double the amount recorded in 2002, and quadruple the area affected in 2000. Other significant damaging agents included: western balsam bark beetle, western spruce budworm, spruce beetle, two-year cycle budworm, eastern spruce budworm, western hemlock looper, large aspen tortrix, pine needle diseases, and larch needle blight. 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 were the primary forest health factors recorded during the aerial overview surveys over the last five years. Bark beetle activity has constantly increased, due to mild winters and low beetle mortality rates. In contrast, defoliator populations tended to fluctuate widely over a relatively short time period (Figure 3).

A *Provincial Forest Health Strategy* is now in the draft stage. This strategy provides overall objectives and actions to achieve forest health goals and helps to identify 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*.

At the TSA level, legislation is currently being developed to direct major licensee groups operating under the new Defined Forest Area Management (DFAM) model to develop forest health strategies based on these two documents. The aerial overview survey provides annual information on forest health conditions to update these forest health strategies. The bark beetle information is key to defining performance measures for the beetle management portion of the strategies.

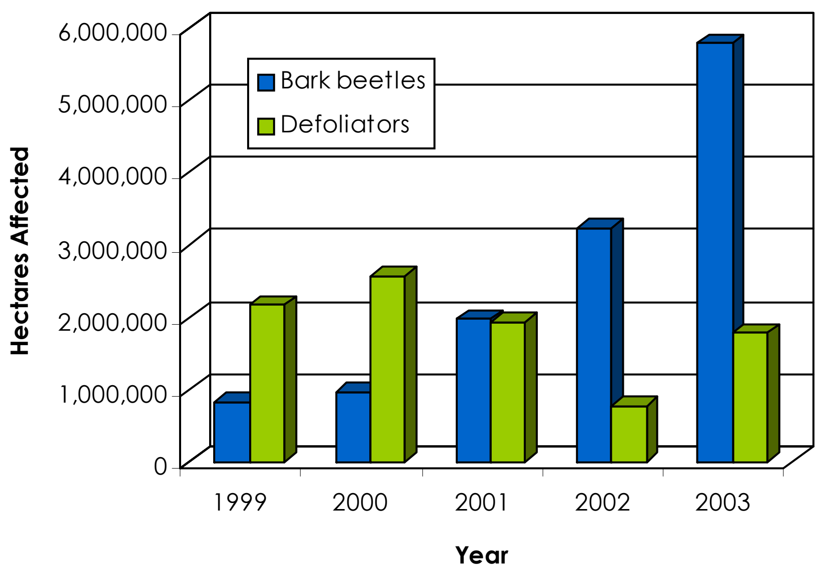


Figure 3. Hectares affected by bark beetles and defoliating insects from 1999 - 2003 in British Columbia.

Mortality caused by mountain pine beetle

Table 3. Summary of hectares affected by forest damaging agents as detected in 2003 aerial overview surveys in British Columbia.

Damaging Agent	**Hectares Affected**
Bark Beetles:	
Mountain pine beetle[a]	4,066,817
Western balsam bark beetle	1,390,286
Spruce beetle	315,947
Douglas-fir beetle	24,047
Lodgepole pine beetle	363
Engraver beetles	305
Western pine beetle	112
Total Bark Beetles:	5,797,876
Defoliators:	
Large aspen tortrix	794,303
Western spruce budworm	522,236
2-year-cycle budworm	186,622
Eastern spruce budworm	166,490
Western hemlock looper	42,542
Satin moth	37,819
Birch leaf miner	22,507
Western blackheaded budworm	857
Forest tent caterpillar	89
Conifer Sawflies	79
Douglas-fir tussock moth	37
Unspecified conifer defoliator	773
Total Defoliators:	1,774,354
Abiotics:	
Fire[b]	248,131
Flooding	6,495
Redbelt	1205
Slide	698
Drought	561
Windthrow	213
Frost	108
Total Abiotics:	257,411
Diseases:	
Unspecified needle disease	12,888
Pine needle cast	40,940
Larch needle blight	32,478
Aspen/poplar leaf/twig blight	15,772
Dothistroma[c]	2,209
Comandra blister rust	2,036
White pine blister rust	192
Armillaria root disease	5
Total Diseases:	106,520
Animals:	
Bear	452
Porcupine	629
Total Animals:	1,081
Provincial Total	7,937,737

[a] Includes infestations in parks totalling 608,775 ha.
[b] Provided by BCMOF Protection Branch & Ministry of Sustainable Resource Management
[c] Does not include areas recorded in low elevation surveys (approx. 34,000 ha).

Defoliation caused by western spruce budworm

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.

The most extensive mountain pine beetle epidemic in recorded history is presently underway in BC (Figure 5). 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. The province-wide drought in the summer of 1998 increased tree susceptibility to beetle attack. Through 2002, this drought situation persisted to a lesser extent in the late summer months. In the summer and fall of 2003, southern BC experienced extreme drought conditions. Beetle populations were further bolstered by 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. Without prolonged cold periods in the winter, beetle larval mortality has been very low. This has also contributed to the current mountain pine beetle outbreak.

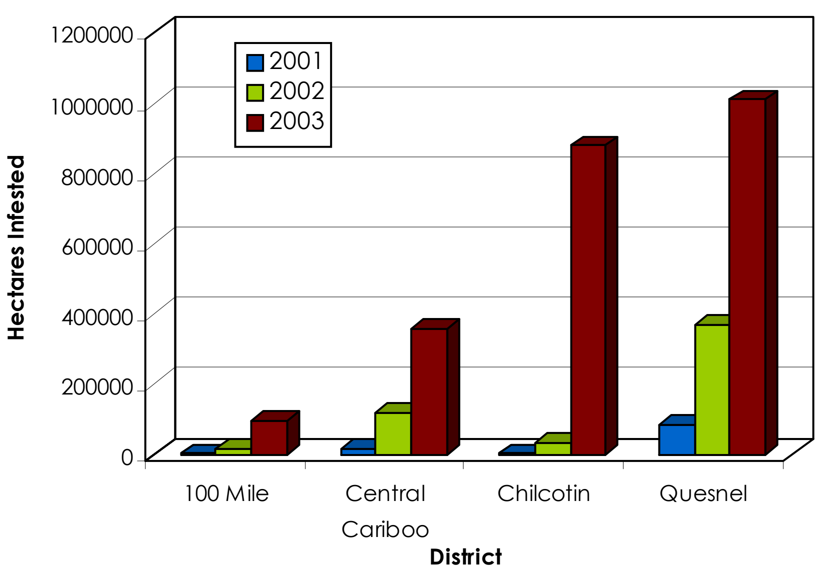


Figure 4. Hectares infested by mountain pine beetle from 2001 - 2003 in the Southern Interior Forest Region (districts with more than 30,000 ha affected).

Hectares infested by mountain pine beetle in BC have increased almost twenty-five fold from the 1999 level of 164,567 ha to 4,066,817 ha in 2003 (of which 608,775 ha are located in provincial parks and protected areas). Of the stands affected by mountain pine beetle this year, 17% sustained severe mortality, 19% moderate, and 64% light mortality. Overall, intensity of attack has dropped since last year, when 55% of the mortality was moderate to severe.

The Cariboo zone of the Southern Interior Forest Region (SIFR) experienced the greatest increase and the largest affected area in BC totaling over 2.3 million hectares (Figure 4). The largest increase occurred in the Chilcotin Forest District, with 880,259 ha infested in 2003 compared to 34,519 ha in 2002. Vast areas of previously unattacked lodgepole pine stands in this district are now covered in diffuse, small spots of mortality. The attack was very light over 96% of the recorded hectares, but with this scattered pattern the intensity of the attack is expected to grow very quickly. The highest attack levels occurred in Quesnel Forest District, with 1,010,306 ha affected. This represents a quarter of the damage recorded for the entire province. Infestation intensity was 55% light, 29% moderate, and 16% severe. Mountain pine beetle infestations also grew substantially in the Central Cariboo Forest District,

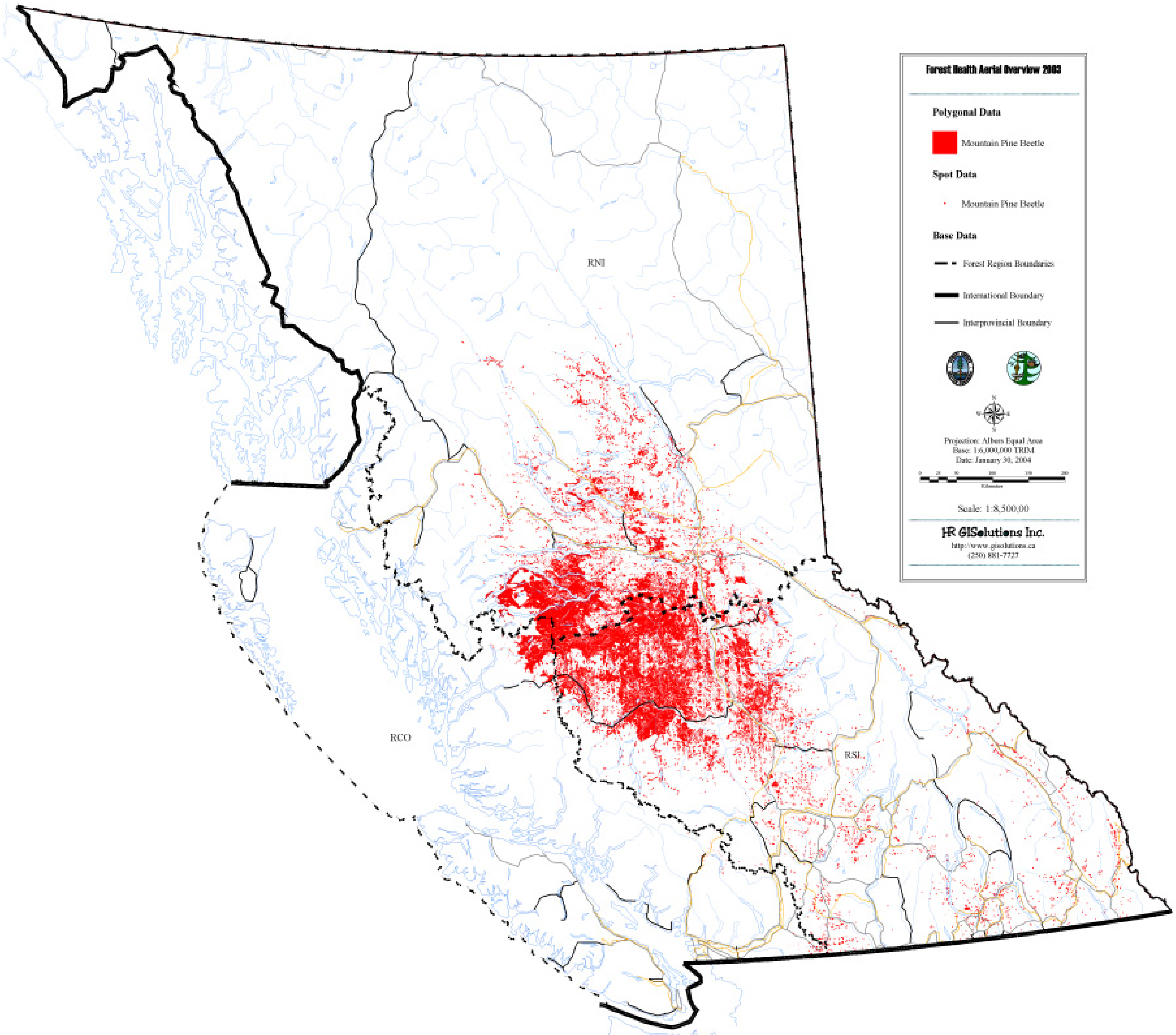


Figure 5. Mountain pine beetle infestations recorded in British Columbia during the 2003 aerial overview surveys.

from 119,881ha in 2002 to 357,036 ha in 2003. As in the neighboring Chilcotin Forest District, a large percentage (90%) of the attack was light. 100 Mile House Forest District sustained a six-fold increase in attack over last year, with 94,605 ha affected.

Less than 4% of the total mountain pine beetle attack in the SIFR occurred in the remaining districts, totaling 78,215 ha of affected stands. The beetle populations however are quite active in most areas. These districts represent some of the best opportunities for suppression in the province due to the relatively small infestation sizes. Infestations in the Kamloops Forest District have been on the rise for the last four years, with 28,035 ha of attacked stands recorded in 2003. The main area of concern is at the south end of the boundary with the 100 Mile House Forest District. Infestations recorded in the Arrow Boundary Forest District have been on the increase for the last three years, and totaled 11,710 ha in 2003. Okanagan Shushwap Forest District has also experienced a rise in infestations over the last four years to 10,569 ha of affected stands. Silver Star Provincial Park, TFL 49, Pinaus Lake, Chase Creek and the Ashnola River south of Penticton are areas of concern in this district. Mountain pine beetle attack recorded in the Headwaters, Cascades, and Rocky Mountain Forest Districts actually declined in 2003, though the beetle attack around Cranbrook is still very active.

Four of the most southerly districts in the Northern Interior Forest Region (NIFR) contained almost 100% of the mountain pine beetle attack recorded for the region (Figure 6), totaling 1,431,626 ha. The area under attack in the Nadina Forest District remained relatively constant at 506,001 ha, of which 231,617 ha were in Tweedsmuir Provincial Park and the Entiako protected area. Most of the infestations occurred in the southern part of the Lakes TSA. The severity of attack however has dropped substantially (from 74% moderate - severe in 2002 to 54% in 2003), because most of the lodgepole pine around the park area is now dead.

The Vanderhoof Forest District was the second most affected district in the NIFR, with 481,839 ha damaged, of which 61,531 ha were in the Entiako protected area. Over 60% of the mature lodgepole pine has been attacked, with vast areas affected from the Highway 16 agricultural belt south to the SIFR boundary. Ground surveys have frequently found dead immature trees, which is an indication that the supply of suitable mature hosts is running out. Most lodgepole pine stands showed some level of mortality in 2002 and it intensified in 2003, which was reflected in the relatively small increase in total infested hectares in 2003.

In Prince George Forest District, the mountain pine beetle expanded into the western and southern portions of the district. In the north, attack extended up to McLeod Lake and to the east as far as Upper Fraser / Sinclair Mills. Hectares affected have doubled over 2002 to 283,496 ha. Hectares of damage in the Fort St. James Forest District have risen from 65,264 in 2002 to 157,865 in 2003. Attack was prevalent in the southern half of the district, and a separate infestation existed around the Sustat River in the northern portion. Evidence of range expansion was observed through the confirmation (by CFS) of small spots of mountain pine beetle mortality in the Peace Forest District along Highway 97 north of

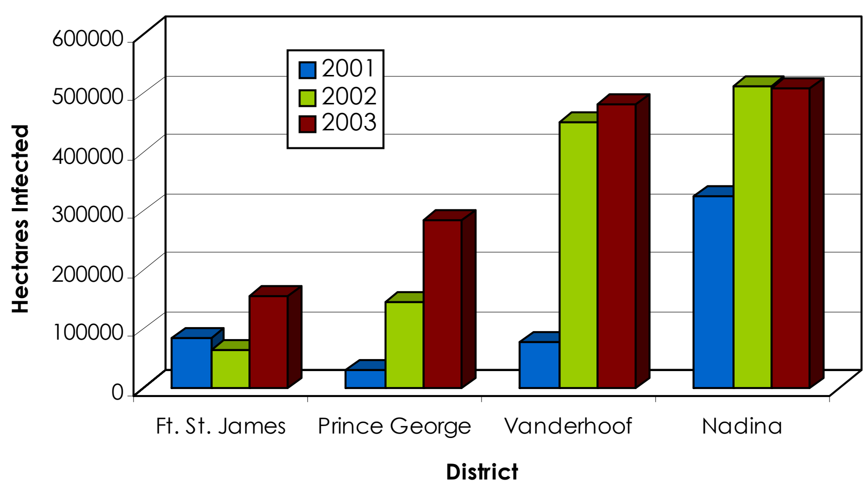


Figure 6. Hectares infested by mountain pine beetle from 2001 - 2003 in the Northern Interior Forest Region (districts with more than 30,000 ha affected).

Mountain pine beetle infestation near Vanderhoof moving from mature into immature lodgepole pine

Chetwynd and in the Pine Pass southeast of Chetwynd.

Mountain pine beetle attack continued to rise in the Coast Forest Region (CFR) with a 23% increase from 2002 to a total of 214,770 ha affected. Most of the mortality continued to occur in the North Island - Central Coast District (206,014 ha), with 197,822 ha of that located in Tweedsmuir Provincial Park. Additional areas of significant 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.

The increase of mountain pine beetle attack across the province reflects a healthy population. In general, large infestations continued to show dispersal along the leading edges as small areas of mortality were recorded in previously uninfested stands. In some areas, particularly the Chilcotin Forest District, an unprecedented number of small scattered spots appeared over a large area that was located far from any advancing infestation. As described for the Vanderhoof Forest District, in the large infestations, beetle "filled in" the previously unattacked areas, even attacking small stems.

Provincially, the beetle flights on average were normal, certainly more so than over the past few years. Due to the warm weather, second flights were observed in low elevation stands in the southern part of the province where beetle pressure was high, such as the southern portion of the Kamloops Forest District.

The drought combined with high beetle attack levels in trees in the lower elevations of the Central Cariboo Forest District had the highly unusual result of current "green" attacked trees fading prematurely by the early fall, instead of next spring. The summer drought in the southern interior portion of the province (especially south of Central Cariboo Forest District) resulted in moisture stressed trees. When the beetle attacked, the trees were often too weak to produce pitch tubes. This made ground detection of current attack very difficult, especially if the minor amount of frass produced by the beetle was washed off by rain. In the north and along the coast, pitch tubes were evident in the moister zones, and lacking in the drier, rocky areas.

Currently attacked trees usually remain undetectable when the aerial overview survey is conducted because the foliage is green. Current attacks begin to fade in the spring following attack. Therefore, ground surveys are required to determine the average number of

Typical mountain pine beetle pitch tubes new attacks for each aerially detected red tree. This statistic is vital 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 detection and treatment for the following year. Green to red ratios must be interpreted carefully. Exceptionally high ratios (usually greater than 5:1) may indicate that sampling was done in areas that were being inundated by beetles from a neighbouring source, and may not be truly representative of the average reproductive rate. High ratios are not biologically possible due to high levels of natural mortality. However, high ratios on the leading edge of a large infestation may well represent the true situation and indicate that the outbreak has expanded into the area thereby limiting the opportunities for reducing the population through management.

Table 4 details green to red ratios observed in various districts throughout the province in 2003. 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 (15:1). Vanderhoof Forest District had immense beetle pressure on the few remaining susceptible trees left from last year's attack, therefore G:R ratios were not felt to be a meaningful statistic. In the SIFR, ratios varied even more than in the NIFR, 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 G:R ratios.

These results indicate that despite aggressive control tactics, and barring a significant cold weather event during the winter, the epidemics will continue to expand in 2004.

Table 4. Green to red mountain pine beetle attack ratios observed in 2003.

Region / District	High	Average	Low
NIFR – Skeena Stikine	5:1	1:1	< 1:1
Nadina	15:1 (south)	4:1	1:1
Prince George	15:1 (south)	4:1 (central)	1:1 (north)
SIFR - Quesnel	50:1	20:1	7:1
Central Cariboo	40:1	11:1	7:1
Chilcotin	50:1	25:1	1:1
100 Mile	22:1	8:1	3:1
Kamloops	20:1	5:1	1:1
Okanagan Shuswap	15:1	4:1	< 1:1
Cascades	15:1	2:1	< 1:1

Pine Needle Diseases

Pine needle cast, *Lophodermella concolor* Dothistroma (red band) needle blight, *Mycosphaerella pini*

Pine needle cast pathogens, 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.

Dothistroma (red band) needle blight (*Mycosphaerella pini* pathogen) damages needles of all ages, when conditions are suitable for spore dispersal and infection during the growing season; hence in mild wet weather, damage to lodgepole pine can be very devastating. Immature and mature stands can experience significant mortality.

For both foliage diseases, the aerial overview survey likely underestimates 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 for these diseases. The ideal survey period is in May to early June before new elongating shoots and foliage obscure the damage to previous year's foliage.

Pine needle cast damaged 40,940 ha of lodgepole pine in 2003, of which 99% was recorded in the 100 Mile House Forest District. This is the lowest level of disease incidence recorded over the previous 5 years, primarily due to dry spring conditions in 2002.

Dothistroma needle blight continued to be the most significant forest health disease in northwest BC. Severely damaged lodgepole pine stands were detected in portions of five Timber Supply Areas (TSAs): Kalum, Nass, Kispiox, Cranberry and Bulkley. The most severely damaged 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.

In the Kispiox TSA, based on re-measurement of 30 randomly located permanent sample plots (PSPs), juvenile lodgepole pine trees suffered an average increase in defoliation due to Dothistroma of 15% over 2002 levels. All of these PSPs had been established in low to moderate rather than severely defoliated stands. It is thought that this relatively low increase in the extent of defoliation is largely due to the dry summer conditions experienced across the region in 2002.

Dothistroma damage at Sunday Lake

In the Kispiox, Cranberry and Nass TSAs, 500 ha of failed lodgepole pine plantations were fill-planted with a mixture of shade-tolerant species. Stands eligible for fill-planting had to have suffered greater than 80% defoliation with less than 400 stems/ha of non-pine conifers on site. The worst-hit stands had been identified based primarily on the low-level aerial surveys of 2002 which covered over 21,500 ha of juvenile lodgepole pine stands in the Kispiox and Cranberry TSAs. Unfortunately this reforestation effort has coincided with a peak in snowshoe hare populations. It is expected that a considerable amount of the area fill planted in 2003 will require further planting due to the excessive levels of hare feeding damage.

Over 15,100 ha of lodgepole pine-leading, juvenile stands in the Nass and Kalum TSAs were assessed this year with low-level aerial surveys. Over 5% of the surveyed area contained stands suffering >10% mortality. The most severely impacted stand was a 20 ha opening in which approximately 80% of the trees were dead. A total of 1,670 ha will require stocking or plantability surveys.

In the CFR on Texada Island and around Powell River, Dothistroma has been recorded in wetter mixed species plantations on Western white pine (*Pinus monticola*). Infections are scattered however, and with the recent dry weather damage is relatively low.

Phaeoseptoria contortae

A needle disease caused by the pathogen *Phaeoseptoria contortae* can affect young lodgepole pine trees. Infections occur on the previous year's growth, and cause defoliation. Infested stands were noted throughout the SBS and lower elevation of the Engelmann Spruce Subalpine Fir (ESSF) biogeoclimatic zones in the Nadina and Skeena - Stikine Forest Districts in 2003.

Pine Stem Rusts

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

Pine stem rusts affect lodgepole pine throughout BC. Trees of all ages can be infected, 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.

In 2003, conditions were conducive to aerial detection of 2,010 ha of young pine mortality in the Prince George Forest District, and 26 ha in the MacKenzie Forest District. The damage was attributed to Comandra blister rust (*Cronartium comandrae*), as it is most likely to cause mortality, but is probably due to a combination of the three rusts, and perhaps other forest health factors that affect young lodgepole pine such as Warren's root collar weevil (*Hylobius warreni*).

Pine stem rusts are particularly common north of the Central Cariboo Forest District. In 2001, the Nadina Forest District began encouraging a mid-term survey between establishment and free-growing (at about year 7) in lodgepole pine plantations. The results identified approximately 1000 ha that potentially require underplanting to compensate for rust mortality. If these surveys had not been conducted, significant free-growing delays would have occurred. Some young stands in this district have been found to have up to 80% incidence of Comandra blister rust. Planting at higher densities to offset expected pine mortality due to rust is now recommended in the high hazard areas of the Nadina Forest District and mixed species planting is also encouraged.

Infection caused by Comandra blister rust on young pine tree

Damaging Agents of Douglas-Fir

Western Spruce Budworm, *Choristoneura occidentalis*

Western spruce budworm (*Choristoneura occidentalis*) is a serious defoliator of interior Douglas-fir (*Pseudotsuga menziesii*) in BC. Outbreaks of this budworm cause significant damage via larval feeding on foliage, resulting in reduced seed production due to damaged cones, growth loss, topkill, creation of stem deformities and even mortality, particularly to understory trees.

Area defoliated by western spruce budworm has expanded substantially over the last four years. Total defoliation in the province reached a high of 522,236 ha in 2003 (Figure 7). Fortunately, the majority of the defoliation was light (81%), with 17% moderate and only 2% severe. As in the past two years, the majority (82%) of the defoliation occurred in the SIFR 100 Mile House and Central Cariboo Forest Districts at 199,108 ha and 230,402 ha affected, respectively (Figure 8). Defoliation was widespread, present to some extent in many Douglas-fir stands ranging from Loon Lake / Clinton in the south to slightly north of Williams Lake, and west of Young Lake / Horse Lake all the way to the borders of Chilcotin Forest District. Cascade Forest District experienced 66,646 ha of western spruce budworm

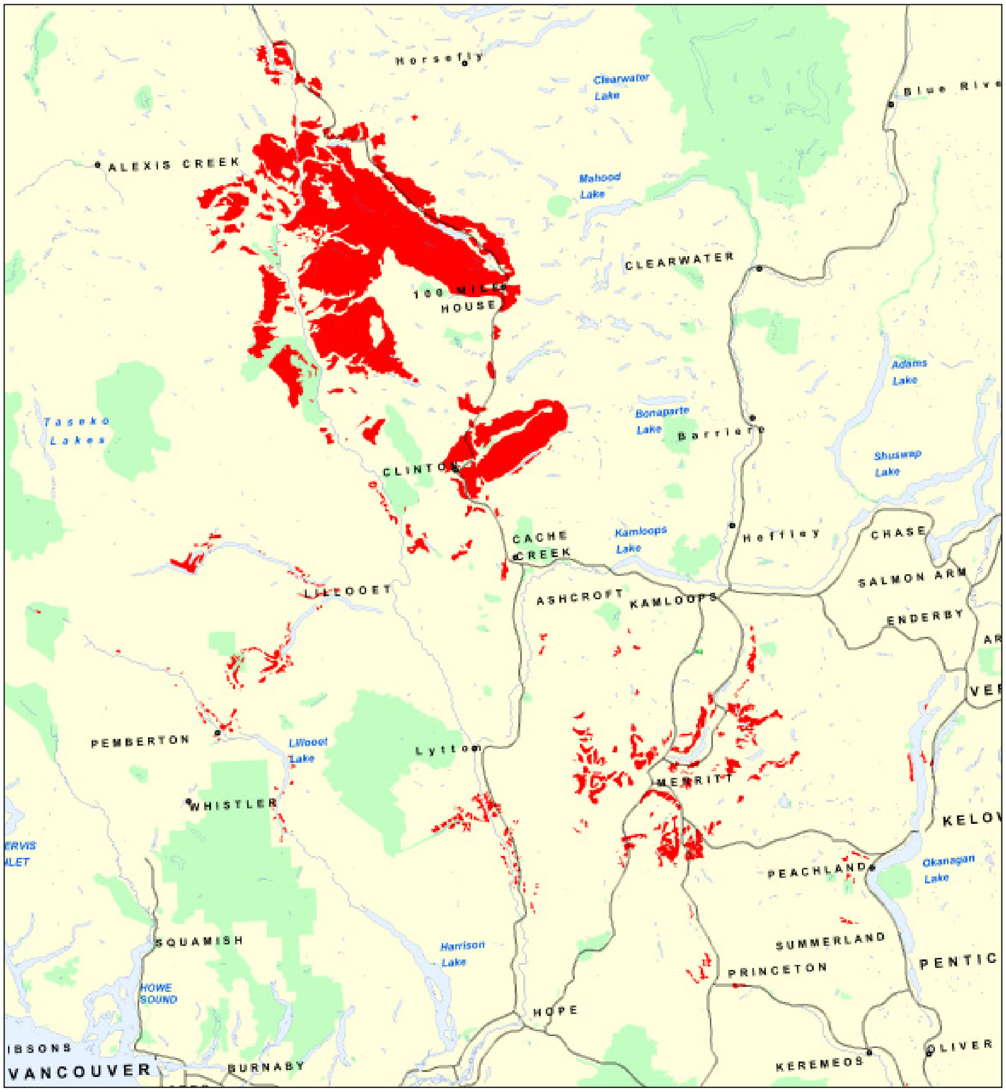


Figure 7. Areas defoliated by western spruce budworm as mapped during the 2003 aerial overview surveys.

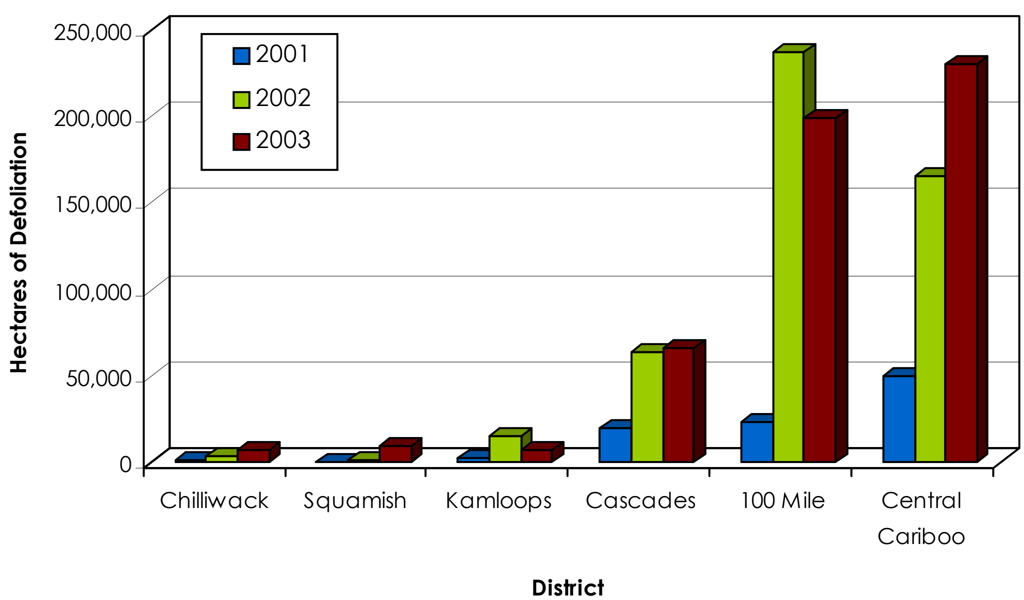


Figure 8. Hectares of western spruce budworm defoliation from 2001 - 2003, for districts with over 5,000 ha affected.

defoliation, primarily surrounding Merritt, with some scattered infestations around Princeton and in the drier areas of the Lillooet TSA. Kamloops Forest District had 7,125 ha of defoliation, with the majority located northwest of Cache Creek.

Infestations in the CFR continued to expand. Squamish Forest District experienced the highest level of defoliation at 9,206 ha around Pemberton, Anderson Lake, Lillooet Lake, Birkenhead and Halymore areas. In Chilliwack Forest District, defoliation of 6,997 ha was observed from Boston Bar north to the Nahatlatch area.

Egg mass surveys conducted in the fall predict significant defoliation for next year, particularly in the Central Cariboo, 100 Mile House, and Cascade Forest Districts (Table 5). Some areas in the Kamloops, Squamish, Chilliwack, and for the first time, Chilcotin Forest Districts are predicted to sustain damaging levels of defoliation as well.

Direct control using a single application of Thuricide 48LV® at 2.4 litres per ha (a biological insecticide containing the active ingredient *Bacillus thuringiensis* var. *kurstaki* (*B.t.k.*)) was utilized as a management option. In the spring of 2003, 15,127 ha were treated in the Central Cariboo Forest District south-east of Williams Lake, and 7,022 ha in the 100 Mile House Forest District between Clinton and Upper Loon Lake. The treatments were successful, with egg mass counts predicting low defoliation for 2004 in treated areas. More detailed information is contained in the internal publication *2003 Overview of Forest Health in the Southern Interior Forest Region*. 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.

Table 5. Summary of 2003 western spruce budworm egg mass survey results.

Predicted 2004 Defoliation		Forest District						
		Squamish	Chilliwack	Chilcotin	Kamloops	100 Mile	Cascades	Central Cariboo
Nil	# Sites	0	11	0		2	7	5
Light	# Sites	6	25	3	20	50	45	41
	EM/10m^2	28.6	17.5	37.7	29.5	31.4	26.2	26.8
Moderate	# Sites	6	6	2	21	57	67	25
	EM/10m^2	67.2	77.6	78.5	78.0	94.4	90.2	98.8
Severe	# Sites	1	0	0	9	2	20	6
	EM/10m^2	184.0	0	0	226.2	166.5	205.4	162.3
Total	# Sites	13	42	5	50	111	139	77
	EM/10m^2	58.4	16.4	54.0	83.6	65.6	81.5	59.0

EM/10m^2 = Average number of eggmasses/10m^2 of foliage.
Light = 1-50 EM/10m^2, moderate = 51-150 EM/10m^2, severe = 151+ EM/10m^2.

Mortality caused by western spruce budworm defoliation

Western spruce budworm larvae

Douglas-fir beetle, *Dendroctonus pseudotsugae*

Douglas-fir beetle (*Dendroctonus pseudotsugae*) is an important pest of mature Douglas-fir in BC. At low population levels, the beetle infests scattered, stressed trees. 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 are often the precipitators of outbreaks. Although the total hectares affected by this beetle tend to be comparatively minor, the attacked trees are frequently located in old growth management areas or within valuable mule deer winter range. The increasing occurrence of beetle-killed trees may limit the suitability of these habitats for wildlife.

The provincial total of hectares affected by Douglas-fir beetle rose to 24,047 ha after a four year low of 9,078 ha last year. This was primarily due to large increases in the Central Cariboo and 100 Mile House Forest Districts, where infestations rose to 12,292 ha and 7,659 ha respectively (Figure 9). This represented 83% of the attack across BC. The majority of the infestations (72%) were typically small (< 1ha), though there were eight times as many sites recorded in the 1 to 10 ha range in 2003 as in 2002. The majority of the attack occurred in the Fraser River corridor, Young Lake and Loon Lake.

Other districts with over 500 ha of Douglas-fir beetle affected in 2003 were Headwaters, Rocky Mountain and Okanagan Shuswap Forest Districts (Figure 9). Infestations peaked in Headwaters and Okanagan Shuswap in 2001, and have been declining since. Infestations in Rocky Mountain Forest District peaked in 2000, but grew from a low of 364 ha in 2002 to 847 ha in 2003. The main infestations in this district were located at Shuswap Creek, Windermere Creek, Lodgepole Creek and the Steeples.

Only scattered, minor Douglas-fir beetle mortality was recorded in other districts. However, the southern portion of the province experienced severe drought and unprecedented fire activity in the summer of 2003, as well as several significant windthrow events in the late fall (see *Abiotic Injury* section for details). These events may have increased host susceptibility in many areas, and Douglas-fir beetle populations could consequently increase next year.

Mortality caused by Douglas-fir beetle

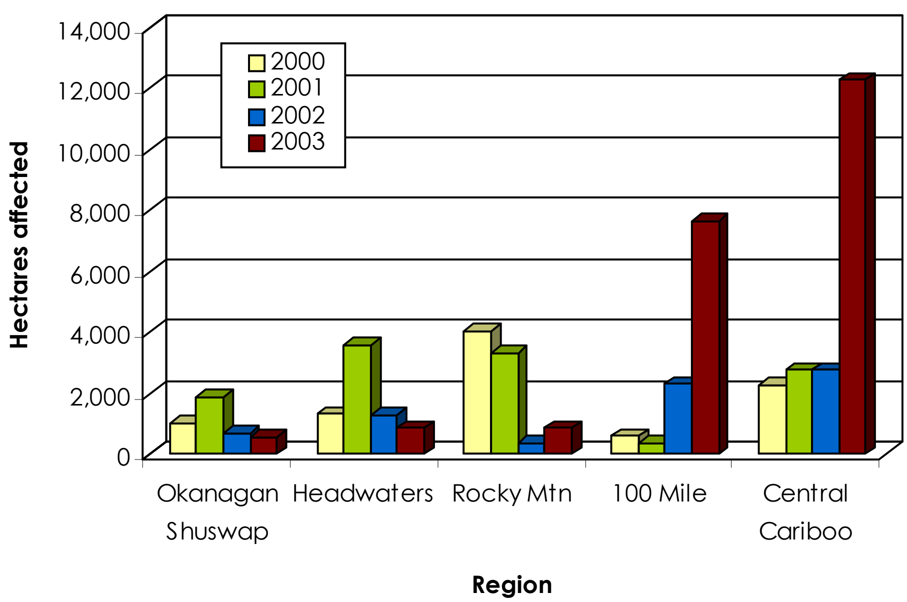


Figure 9. Hectares affected by Douglas-fir beetle in BC from 2000 - 2003, for districts with over 500 ha of damage.

Douglas-fir tussock moth, *Orgyia pseudotsugata*

The Douglas-fir tussock moth (*Orgyia pseudotsugata*) is a destructive defoliator of Douglas-fir of all ages. Since the larvae consume both old and new foliage, even one year's defoliation can result in top kill and mortality. When an outbreak occurs, populations build rapidly and by the time defoliation is visible, stands often suffer mortality. Historically, infestations have occurred in the driest parts of the southern interior.

Pheromone trapping sites are used by the BCMOF to monitor the population in high hazard areas in Kamloops, Cascades, Okanagan Shuswap and 100 Mile House Forest Districts. This monitoring system developed by the CFS and the BCMOF, provides an early warning of a building population before significant defoliation occurs. Trap catches in the Kamloops and Cascades Forest Districts 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 sharply again at the majority of sites in 2003, and 37 ha of severe defoliation were recorded north of Cache Creek in the Scottie Creek area.

Douglas-fir tussock moth larva

Trap catches in the southern portion of 100 Mile House Forest District have not reached the threshold where significant defoliation would be expected, though numbers have climbed for three consecutive years after a sharp drop in 2000. Areas of concern are around the Deadman Creek valley, Chasm, Loon Lake and Bonaparte River.

Defoliation of a Douglas-fir stand north of Cache Creek by Douglas-fir tussock moth

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 weakened trees and downed host material. If a large amount of preferred host such as windfall is available, populations can build to outbreak levels, when beetles can move into healthy trees and cause widespread mortality.

Recorded incidence of spruce beetle attack totaled 315,947 ha in 2003 across the province, up 22% over 2002. Of this total 91% of the hectares affected sustained light mortality, 6% moderate mortality, and 3% 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.

The largest increases in hectares affected by spruce beetle occurred in Fort St. James and Mackenzie Forest Districts, recorded at 56,986 ha and 133,244 ha, respectively (Figure 10). Ground surveys also reflected an increasing population, although accurate aerial delineation of infestations was difficult due to large areas of 2-year-cycle budworm defoliation, which masked the mortality.

Prince George Forest District experienced the largest drop in infested hectares, to 53,741 ha this year from 164,381 ha last year (Figure 10). The biggest area of attack was situated near Carp Lake. Many minor windthrow events occurred throughout the district in 2003, which may result in increased spruce beetle populations. Modest increases in mortality caused by spruce beetle were noted in Nadina, Skeena Stikine and Peace Forest Districts in the NIFR. However, ground surveys have indicated very low levels of current attack.

In general, the SIFR forests have lower percentages of spruce than the NIFR forests, and this is reflected in the lower amount of spruce beetle attack. 100 Mile House Forest District had the largest increase in affected hectares, which rose from 4,358 ha in 2002 to 21,152 ha in 2003 (Figure 10). The majority of the attack occurred in

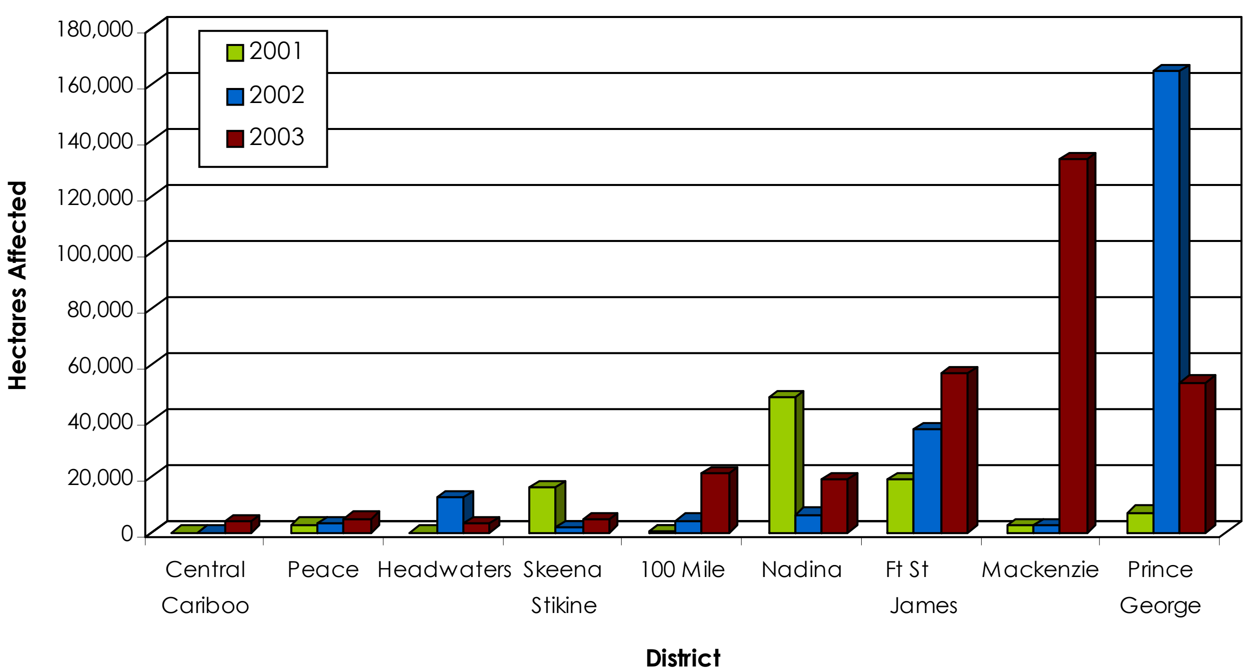


Figure 10. Hectares affected by spruce beetle in 2001 - 2003, for districts with more than 3000 ha infested.

the Hendrix Lake and Spanish Creek area, adjacent to an active infestation in Wells Gray Provincial Park. Spruce beetle infestations also rose in the Central Cariboo Forest District, from only 282 ha last year to 4,182 ha. It is expected that spruce beetle populations will continue to grow in these districts due to large windthrow events in November in the same general areas as the present infestations. In the Headwaters Forest District (primarily in Wells Gray Provincial Park) the number of recorded infestations dropped sharply from 12,442 ha in 2002 to 3,542 ha in 2003. Other areas of concern in the SIFR were around Salmon Arm and the Cathedral Provincial Park / Snowy Protected Area. A windstorm at the end of October caused approximately 300 ha of blowdown on the boundary between Taweel Park / TFL 18 in the Kamloops TSA, which is of concern due to an infestation nearby at Windy Lake.

Hectares affected in the CFR doubled to 3,071 ha, with infestations primarily located in the Haylmore Creek area of the Squamish Forest District.

Mortality caused by spruce beetle

Spruce foliar disease, *Rhizosphaera kaukhoffii*

An unusual needlecast disease caused by the fungus *Rhizosphaera kaukhoffii* was noted in the Nadina Forest District in 2002. At least ten openings with juvenile spruce (<10 years old) were found to be 100% affected by this foliar disease. All foliage below 1.5 meters was infected, but buds were unaffected. These stands recovered quite well in 2003, however other stands were recorded as infected in the Nadina and Skeena Stikine Forest Districts. The majority of the infected stands were located in the Kispiox TSA, in the ICH biogeoclimatic zone. 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*

The eastern spruce budworm (*Choristoneura fumiferana*) is a significant defoliator of all ages of sub-alpine fir (*Abies lasiocarpa*) and spruce in northeastern BC. 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, top-kill and tree mortality.

Eastern spruce budworm continued to be a chronic problem in the NIFR. A total of 166,490 ha of defoliation were recorded (Figure 11), of which 77% was light, 22% moderate, and only 1% severe. Last year, conditions did not allow for an aerial survey of the defoliation, but in 2001 1.6 million hectares were recorded as affected. The large drop is at least in part due to a change in survey methodology. In 2001, the survey was conducted by low elevation helicopter, and the defoliation categories utilized were not to provincial standards.

The majority of the 2003 defoliation (147,109 ha) was located in the Fort Nelson Forest District, primarily along the major river valley bottoms. Eastern spruce budworm has been active for many years in this district, and has caused significant mortality over time. A flight was conducted in 2003 that identified 4,300 ha of mortality for salvage opportunities. 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 2004. The sample results indicated light defoliation next year at all six survey sites, located at Clarke Lake, Snake River (two), Kotcho, Liard and Muskwa. This is the second consecutive year that larval densities have dropped sharply. The remainder of the defoliation identified in 2003 was located in the Peace and Mackenzie Forest Districts at 17,528 ha and 852 ha affected, respectively.

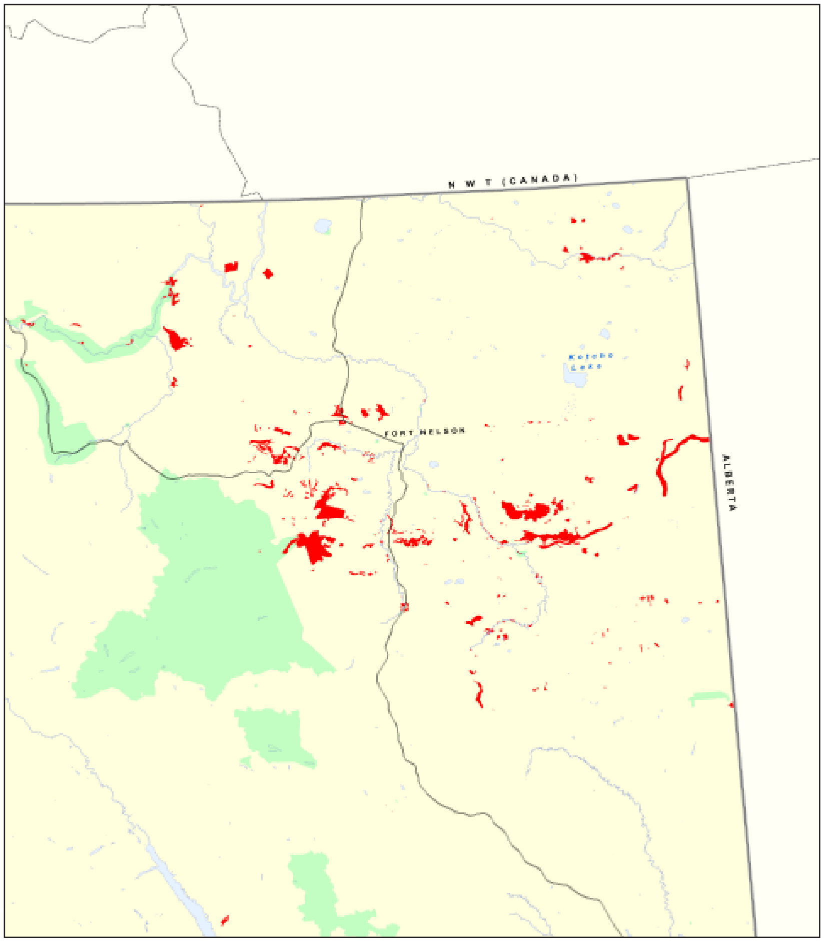


Figure 11. Areas defoliated by eastern spruce budworm as mapped during the 2003 aerial overview surveys.

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 requires two years to complete its life cycle. Most of the defoliation damage occurs in the 2nd year, when larvae are bigger and hence consume large amounts of foliage. The portion of the province north-west of Prince George Forest District is on an odd year cycle, hence 2003 was the 2nd year in the budworm life cycle for this area. A total of 150,478 ha were recorded as affected (Figure 12), with 66% light, 33% moderate and 1% severe defoliation. Fort St. James forests suffered 103,583 ha of defoliation around Tchentlo Lake, Indata Lake, Tsayta Lake, south-central Takla Lake and west towards Natowite Lake. This infestation carried on into the western portion of the Mackenzie Forest District, affecting 44,170 ha and east into the Nadina Forest District near Natowite and Babine Lakes where 2,725 ha were defoliated.

From Prince George Forest District south the 2-year-cycle budworm is on an even year cycle, so the larvae will not reach maturity until 2004. Even though the budworm was in the 1st year of its life cycle in 2003, a total of 36,144 ha of light defoliation were recorded. Most of this defoliation occurred in the Central Cariboo and Quesnel Forest Districts at 15,241 ha and 18,923 ha affected, respectively. The remainder was located in TFL 18 of the Headwaters Forest District. This amount of defoliation is quite significant for the 1st year of the cycle, and may be due to the long, warm feeding season that the larvae experienced in these areas.

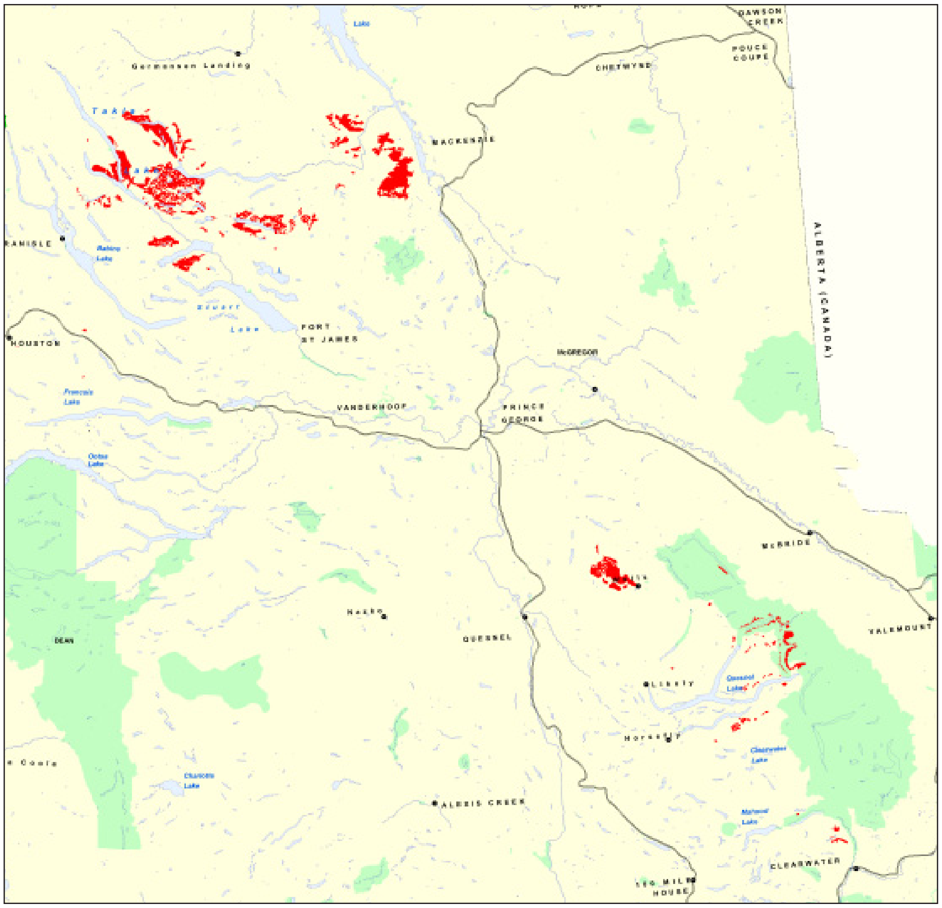
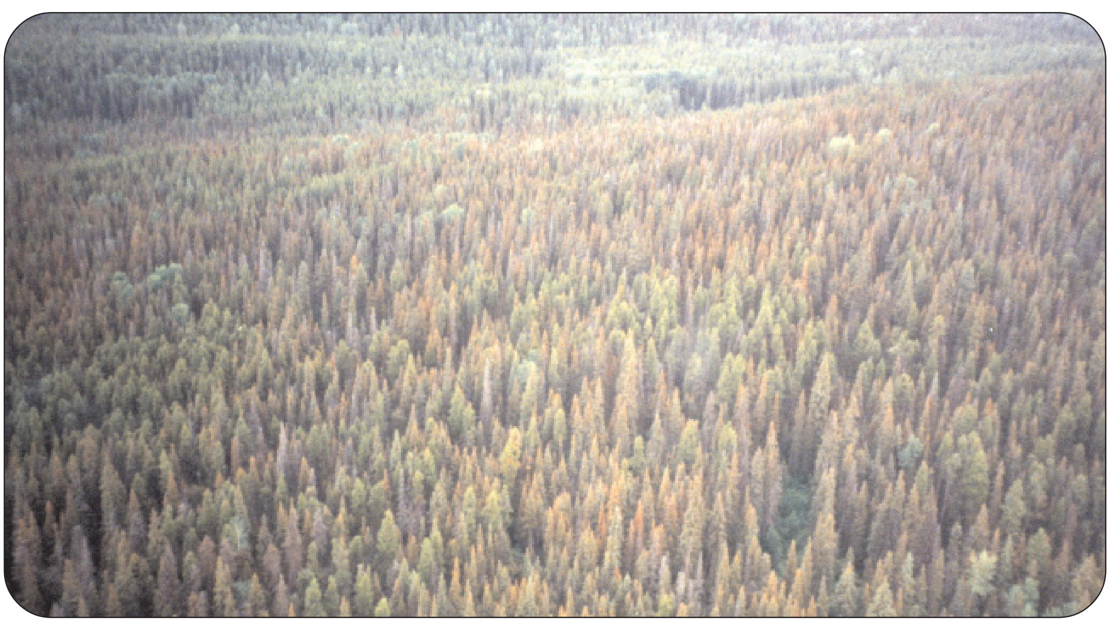


Figure 12. Areas defoliated by 2-year-cycle budworm as mapped during the 2003 aerial overview surveys.



2-year-cycle budworm defoliation near Tchentlo Lake in 2003

Western balsam bark beetle, *Dryocoetes confusus*

The western balsam bark beetle (*Dryocoetes confuses*) is the most significant damaging agent of its primary host, mature sub-alpine fir, in BC. This beetle and an associated pathogenic fungus can be responsible for extensive tree mortality in high elevation ecosystems.

In 2003, almost 1.4 million hectares sustained mortality due to western balsam bark beetle. The annual impact is usually less than most bark beetles, because the mortality rate per year is very low but chronic. Similar to last year, percent mortality was 94% light, 5% moderate, and only 1% severe. The majority of the light polygons were estimated to have about 1% incidence. This reflects the typically low percentage of western balsam bark beetle attack in a given stand, as compared to spruce beetle or mountain pine beetle. However, western balsam bark beetle attack tends to occur year after year in a susceptible stand, resulting in extensive cumulative damage. Due to the scattered nature of the attack, accessibility issues and harvesting restrictions for caribou habitat, implementing control measures for this beetle is very difficult.

The greatest increases in hectares affected by western balsam bark beetle for the second consecutive years occurred in the Fort St. James and Mackenzie Forest Districts, where 410,988 ha and 344,448 ha were infected, respectively (Figure 13). Hectares affected also rose substantially in the Nadina Forest District, to 85,591 ha after a dip to a low of 28,634 ha in 2002. Conversely, infestations have declined dramatically for the last two years in the Skeena Stikine Forest District to 85,335 ha this year, down 82% from 2001. Area affected in the Prince George Forest District remained relatively constant at just under 79,000 ha. The only other district in the NIFR with significant infestation levels was Fort Nelson with 43,407 ha affected.

In the SIFR, the highest amount of western balsam bark beetle attack in 2003 was located in the Quesnel Forest District, where 84,551 ha were affected, more than twice the level of last year (Figure 13). The Okanagan Shuswap Forest District was the only other district in the SIFR to experience a significant rise in attack, from 13,846 ha last year to 20,050 ha this year. Central Cariboo and Chilcotin Forest Districts both had modest declines, to 47,505 ha and 10,484 ha respectively. All other districts in the SIFR had attack levels under 4,000 ha. In the most southerly areas of the SIFR, it was observed that the western balsam bark beetle flight was much reduced from normal, likely because of the dry, hot extended summer.

Hectares affected in the CFR were very low, with the exception of North Island - Central Coast Forest District, where 12,599 ha were attacked, up from 4,292 ha in 2002.

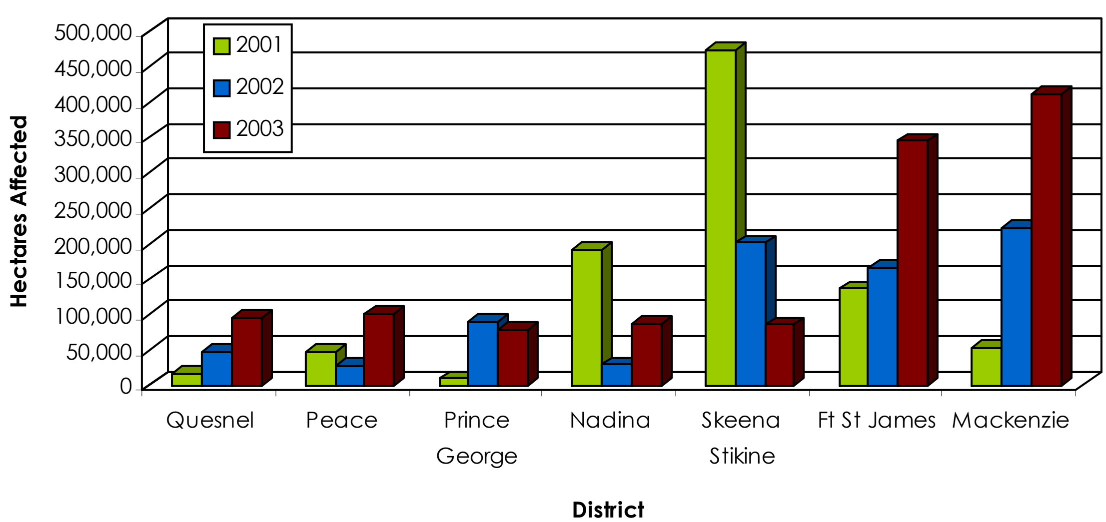


Figure 13. Hectares affected by western balsam bark beetle in BC, for districts with more than 50,000 ha infested.

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 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 in only one year.

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.

Infestations in the SIFR are primarily in the 3rd year of the cycle, with defoliation down slightly from last year (41,776 ha) to a total of 39,398 ha affected, of which 53% was light, 43% moderate and 4% severe. The majority of the infestations were focused around Quesnel Lake, Revelstoke Lake and in scattered pockets in the Okanagan Shuswap Forest District. Unusual infestations in Douglas-fir stands (first recorded in 2002) continued in small areas in the vicinity of Inks Lake, Mowich Lake and Six Mile Creek in the Kamloops Forest District.

The relatively low level of defoliation intensity and hectares affected this year in the SIFR are due in part to very successful treatment of priority stands with single applications of Foray 48B® (active ingredient *B.t.k.*). A total of 10,135 ha were treated, consisting of 955 ha in the Inks Lake area and the remainder around Revelstoke Lake. Sampling results showed 95 to 100% larval mortality. This exemplary success is due in part to the open feeding habits of the western hemlock looper; they had greater opportunity of ingesting the *B.t.k.* than larvae that prefer to eat in the shelter of a bud. The results of this treatment will likely lead to the inclusion of the western hemlock looper to the Foray 48B® label. More information on the spray program is contained in the internal publication *2003 Overview of Forest Health in the Southern Interior Forest Region*.

CFS pheromone trap catches of moths and larval beatings in various areas in the interior indicated an increasing population from 1998 to 2002, with stabilization in 2003 suggesting a population peak. This corresponds with BCMOF observations, where average trap catches rose only moderately in 2003, and decreases were recorded in areas with no visible defoliation. Infestations in the CFR continued to decline, with only 1,959 ha of light defoliation recorded. Results of CFS sampling at the GVRD Coquitlam watershed and UBC Research Forest reflect this decline. The only newly discovered infestation was approximately 1,200 ha of trace to light defoliation in the Hotham Sound / Lois Lake area near Powell River. Mortality is still continuing due to previous severe defoliation in the Rainy River drainage, and predictions are that 90% of the trees covering approximately 300 ha will be dead by next year.

Miscellaneous loopers

Several small areas of defoliation totaling 363 ha were recorded just north of Prince George. These were unusual as they were located in true fir/ minor spruce stands, a significant distance west from the hemlock stands where infestations have traditionally occurred. Samples were submitted to CFS, and were identified as the eastern hemlock looper, *Lambdina fiscellaria fiscellaria*. Its preferred hosts are true fir, spruce and hemlock but its range is normally east of BC.

In the North Island - Central Coast Forest District, 773 ha of an unidentified defoliator was mapped. It was inaccessible for ground confirmation, but it was believed to be caused by the green - striped forest looper (*Melanolophia imitata*), the western hemlock looper or the western blackheaded budworm (*Acleris gloverana*).

Damaging Agents Of Larch

Larch Needle Blight, *Hypodermella laricis*

Larch needle blight (pathogen *Hypodermella laricis*) infects needles of western larch (*Larix occidentalis*) of all ages, causing yellow and then red-brown foliage colour change in the spring and early summer. Diseased needles are retained after normal needle drop in the fall. The entire crown can be severely infected. Repeated infection can result in growth reduction. Mortality is possible in young trees.

Defoliation resulting from larch needle blight

In the southern-most districts of the SIFR, 32,478 ha were affected in 2003. Intensity of infection was recorded at 14% light, 63% moderate, and 23% severe. Most of the affected hectares (21,733) were located throughout the Arrow Boundary Forest District, particularly in valley bottoms. The Kootenay Lake, Rocky Mountain and Okanagan Shuswap Forest Districts contained the remaining infected stands at 7,047 ha, 2,710 ha, and 988 ha affected, respectively.

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*). Infestations usually last 2 to 3 years, and reoccur approximately every 10 years. Severe defoliation can result in reduced radial growth, but mortality is rare. Outbreaks of the large aspen tortix tend to precede those of the forest tent caterpillar (*Malacosoma disstria*).

Defoliation was recorded throughout the NIFR in 2003. A total of 794,303 ha were affected, resulting in 81% light and 19% moderate defoliation levels. Ground sampling confirmed the presence of large aspen tortrix in damaged stands. It is possible that some of the damage was due to other defoliators such as the forest tent caterpillar, however this was not evident in sampled stands. Fort Nelson Forest District experienced the majority of the attack with 460,464 ha defoliated. Some level of defoliation was observed in nearly every aspen stand in the district. Most of the remaining attack occurred in the Peace and Mackenzie Forest Districts, with 240,187 ha and 68,936 ha affected, respectively. Other minor infestations were scattered throughout the remaining NIFR districts, with the exception of the Skeena Stikine Forest District.

Empty large aspen tortrix pupal cases protruding from webbed leaves

Satin Moth, *Leucoma salicis*

Satin moth (*Leucoma salicis*) is an important defoliator of all poplars, and occasionally feeds on willow (*Salix* spp.). This insect was introduced from Europe, and was first discovered in southwestern British Columbia 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 satin moth was recorded throughout the SIFR in 2003. The total affected hectares were 37,819 ha, down marginally from a peak of 45,394 ha in 2002. The severity of defoliation decreased overall from last year, to 55% light, 30% moderate and 15% severe. In 2003, 66% of the affected hectares were equally divided between the Chilcotin, Quesnel and Columbia Forest Districts. This contrasted with more than half the defoliation observed in Quesnel Forest District and none in the Columbia Forest District in 2002 (Chilcotin Forest District defoliation remained relatively constant). The remainder of the hectares affected were scattered across most of the other SIFR districts.

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. Aerial mapping of this forest health pest was not conducted.

Damage to aspen caused by serpentine leaf miner

Birch Leaf Miner, *Fenusa pusilla*

The birch leaf miner (*Fenusa pusilla*) was introduced into North America from Europe, and can now be found throughout the range of its host, paper birch (*Betula papyrifera*), 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 continued an upward trend with 22,507 ha affected, up 24% over last year at the provincial level. Half the damage occurred in the SIFR, up slightly in each of the affected forest districts of Arrow Boundary, Columbia, Headwaters, Kamloops, Kootenay and Okanagan Shuswap. The rest of the provincial defoliation occurred in the NIFR in the Peace Forest District. Damage by the birch leaf miner was not recorded in this district in 2002. In the southern most districts, defoliation attributed to birch leaf miner was found to actually be a complex of various insects, including birch leaf miner. Trees affected by defoliation in combination with the ongoing drought are beginning to experience significant dieback in some mature stands in the southern portion of the province.

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. 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. All previous occurrences of gypsy moth in BC have been successfully eradicated by aerial spray applications of *B.t.k.*

Gypsy moth larva

During the past 23 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, eradication treatments are usually conducted. In 2003, one hundred moths were caught at 16 different locations. Egg masses were also discovered at two of these sites, in North Delta and Mt. Douglas Park, Saanich. For these sites, an aerial treatment with *B.t.k.* is proposed this spring: 23 ha in Delta and 570 ha in Saanich. Other locations with significant moth catches (2 or more) were Gabriola Island, Burnaby, Abbotsford, Langley and Duncan. Single moths were caught in Oak Bay, Sooke, and View Royal in the greater Victoria area, as well as Campbell River, Nanaimo, Chilliwack, North Vancouver, Vancouver, and Richmond. These sites will be monitored at a higher trap density in 2004.

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/gypsymoth.

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. The present outbreak is even resulting in some mortality, including mature trees.

The unseasonable cool and wet spring weather experienced in the NIFR over the last five years have provided optimum conditions for the build-up of infections by aspen and poplar leaf and twig blight. Incidence of damage has continued to increase, particularly in cottonwood stands in the ICH biogeoclimatic zone and in aspen stands in the SBS biogeoclimatic zone. Trees of all ages were damaged.

The ongoing outbreak was not well represented in the aerial overview survey this year, as only 15,217 ha were recorded as infected across the NIFR, compared to 82,376 ha in 2002. The majority of the affected stands in the Nadina and Skeena Stikine Forest Districts occurred in the agricultural belt, which was not surveyed to a high level of intensity in 2003. In the CFR, 555 ha were affected.

Damaging Agents of Multiple Host Species

Abiotic Injury

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 vary from slight (ephemeral) growth reduction to severe, chronic tree deformities and even mortality. Additionally, trees damaged by climatic injuries are often more susceptible to insects and disease.

Fire was by far the most significant abiotic agent causing damage to the forests of BC in 2003. A total of 2,466 fires were ignited, which burned 248,131 ha. The SIFR sustained the greatest damage, with 75% of the fires burning 90% of the hectares. The NIFR had 14% of the fire starts, with just over 9% of the hectares. Although the CFR had 10% of the total number of fires, less than 1% of the total area was affected. Figure 14 depicts the fires in 2003 that were larger than spot size.

The fires were mosaics of varying burn intensities, from complete stand destruction to singeing of the needles and/or bark. Depending on the burn intensity and nearby insect populations, a variety of post fire insect damage could occur. Many of the large fires occurred in lower elevation stands that were composed primarily of Douglas-fir, ponderosa pine and lodgepole pine. This could result in population increases for Douglas-fir beetle, mountain pine beetle, western pine beetle and turpentine beetle in fire stressed trees. Trees that are dead or dying may sustain sapwood damage from woodborer and ambrosia beetles, which would degrade the value of the wood for salvage.

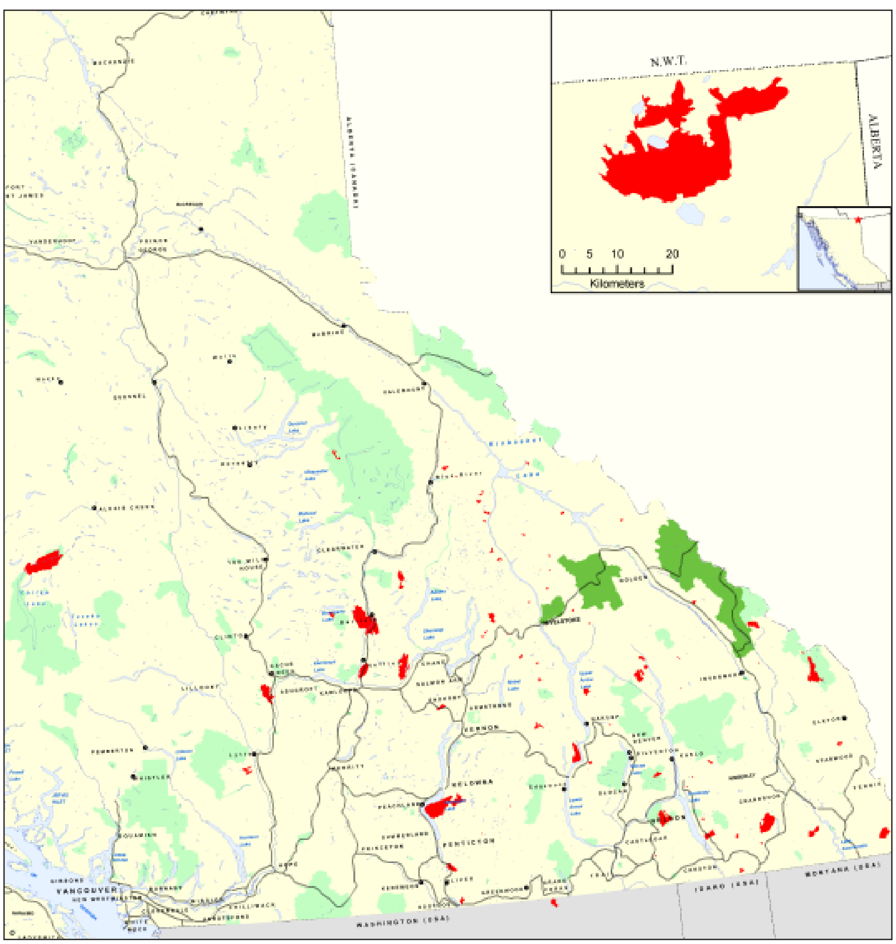


Figure 14. Forest fires larger than spot size that burned across BC in 2003.

Okanagan Mountain fire

Mortality caused by flooding was the next most significant abiotic damaging agent recorded in BC in 2003, affecting 6,495 ha. Almost all of the damage occurred in the NIFR, due to wet, cool spring weather over the last five years. The Fort Nelson and Peace Forest Districts sustained 85% of the flood mortality at 3,731 ha and 1,817 ha respectively.

Drought damage totalled 561 ha was scattered across the SIFR and the Squamish Forest District. However, the majority of flagging and mortality due to drought did not appear until the fall, after most of the overview surveys were completed. South of the Central Cariboo Forest District in the SIFR, drought effects were evident in the fall throughout the lower elevations. Young and intermediate trees of all species were affected on all aspects, though damage was the worst on the south aspect. Areas that were most affected were around Vernon, Kelowna, Kamloops, Salmon Arm / Shuswap (in the dry ICH), and the dryer portions of the 100 Mile House Forest District and the Lillooet TSA.

Aside from damage caused directly by drought, other forest health issues can be exacerbated indirectly. For example, the unusually severe fire year was due to a great extent to drought conditions, and drought stressed trees are more susceptible to a variety of insect and disease damage. In the southern portion of the CFR, drought effects were most evident in young trees situated on poor sites with rocky soils. Cedar was particularly affected. On the positive side, the warm and dry weather reduced the occurrence of pathogens such as needle diseases that need moist conditions to germinate, particularly on the highly valued arbutus trees.

Young Douglas-fir trees affected by drought

Only small, scattered areas of windthrow or blowdown damage were recorded across the province in 2003, affecting 213 ha. The actual amount of damage was underestimated for two reasons: first, it is very difficult to pick up scattered windthrow damage from an aerial overview survey, as the overtopping canopy often masks it. Secondly, a significant number of high wind events resulting in damage occurred in late October and early November this year, after the surveys were complete. Many stands were affected in the eastern portions of the Central Cariboo and 100 Mile House Forest Districts, in particular around Timothy Lake, Canim Lake and the Moffat area. A large area of blowdown was also noted straddling Taweel Park and TFL 18 in the Kamloops Forest District. Most of these stands had a high spruce component, which may result in increased spruce beetle mortality in those vicinities in the future. In the Chilcotin Forest District, windthrow occurred primarily in Douglas-fir stands in the Siwash Bridge and Little Chilcotin River areas. This increases the risk of higher Douglas-fir beetle mortality.

An interesting anomaly was noted as widely affecting Douglas-fir of all ages in the Chilcotin Forest District in 2002, and to a lesser extent in 2003. Affected trees had extensive flagging on the tips of the branches, and it was theorized that the damage might be due to a combination of drought and early cold weather in September.

Animal Damage

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 the result of bark girdling which is expressed in dead tops or mortality. Black bear (*Urus americanus*) and porcupine (*Erethizon dorsatum*) are most often responsible.

In 2003, black bear damage was recorded over 452 ha, primarily in the North Island - Central Coast, Chilcotin and Columbia Forest Districts. Porcupine damage was noted over 629 ha, mostly in the North Coast, Nadina, Mackenzie and Peace Forest Districts. Damage previously recorded in the Prince George and Kalum Forest Districts was not seen in 2003. Past ground survey information has indicated that damage in these districts and the North Coast Forest District tends to be widespread and somewhat chronic. Most of the porcupine damage in the province was of very light intensity. Decay caused by wound parasites infecting old porcupine feeding scars is probably the most significant impact of porcupine feeding on productivity of second growth western hemlock. Refer to the article by Woods and Zeglen (2003) for more information.

Forest Health Projects

Armillaria Root Disease Control

Dr. Bill Chapman, Ministry of Forests, Southern Interior Forest Region

Armillaria root disease (*Armillaria ostoyae*) occurs throughout the southern portion of BC. A variety of living conifers are principal hosts, although many living deciduous tree species and shrubs are also attacked. Armillaria causes 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.

Since 1992, Dr. Bill Chapman (Forest Sciences, BC Ministry of Forests) and Dr. Guoping Xiao (Coast Mycotech) have been conducting research into possible alternative methods to control Armillaria root disease. 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 could compete with the fungus that causes Armillaria root disease.

Several research trials have been established in the SIFR, beginning in 1996. After allowing a few years for fungus development, five trials had sufficient Armillaria mortality to warrant a full evaluation, which was conducted in 2002. This was the second year of detailed assessment for one of the trials. All trials showed a reduction in yearly Armillaria root disease caused mortality of 60 to 80% on the *Hypholoma* treated plots over the non-treated plots. The results were statistically significant on two of the trials on their own and meta-analysis showed that overall the effect is statistically significant. A manuscript has been prepared and accepted for publication in the Canadian Journal of Botany.

Based on the trial findings to date, the process to register *Hypholoma fasciculare* as a microbial pest control agent has been undertaken. This process will take at least one year, but once the product is registered, it will be available for use as an operational treatment for Armillaria root disease.

Armillaria root disease center

Dothistroma Weather Study

Alex Woods, Ministry of Forests, Northern Interior Forest Region

A study was undertaken to correlate past weather conditions with a previous Dothistroma outbreak in the Kispiox TSA. This previous outbreak had been recorded by Forest Insect and Disease Survey (FIDS) in the early to mid-1980's. In 2003, two 50+ year old mixed stands of lodgepole pine and interior spruce were examined for evidence of past Dothistroma damage (one of these stands the FIDS surveyors had noted infected). In both stands a marked growth ring reduction occurred in 1982 in lodgepole pine and not interior spruce. Environment Canada weather data for the period of 1950-2003 for the Smithers weather station was analyzed. Weather conditions that appeared to be responsible for the collapse of this previous Dothistroma outbreak were two consecutive dry summers. This weather pattern has not occurred during the current epidemic. It is expected that the current Dothistroma epidemic will continue provided weather conditions remain favourable.

Canadian Forest Service Mountain Pine Beetle Initiative Project: Retrospective Spatial Analysis and Implications of Mountain Pine Beetle in Mixed-Species Stands.

Dr. Lorraine Maclauchlan, Ministry of Forests, Southern Interior Region; Stephen Viszlai, Riverside Forest Products Limited; Dr. Daryll Hebert; Janice Hodge, JCH Forest Pest Management; Dr. Clive Welham, University of British Columbia.

The early phase of a mountain pine beetle (MPB) outbreak, often described as the transition period between the endemic and the incipient stage, is critical in the understanding of MPB population dynamics and therefore in the implementation of effective management strategies to mitigate impacts of the beetle. The first of many challenges facing forest managers is to determine where incipient MPB spots will likely arise and the second challenge is to determine which of these incipient MPB spots will lead to an outbreak situation. Anecdotal observations suggest that many incipient MPB populations in the southern interior of British Columbia are first noticed building in mixed species, transitional Interior Douglas-fir - montane spruce stands. These stands are often categorized as Low Hazard (Shore and Safranyik 1992) due to the low component of lodgepole pine even though the susceptibility of the pine may be high (Shore *et al.* 2000). We intend to determine whether conditions in these mixed species stands (MSS) are more favourable to rapid and early transition from endemic populations to incipient than conditions found in stands containing a higher component of susceptible lodgepole pine. Using retrospective spatial analysis techniques we intend to study the spatial and temporal patterns of building MPB populations in select stands within the southern interior of BC. Factors influencing initiation of an outbreak, and the building and spread phases will be investigated in MSS (Low Hazard stands) and stands containing higher components of lodgepole pine (High Hazard stands). To accomplish this objective, spatial data of MPB occurrence from the Provincial Aerial Overview Survey (Canadian Forest Service and Ministry of Forests) and detailed aerial surveys from MOF Districts and major Forest licensees will be used and compared to other spatial data bases (e.g. forest cover, vegetation inventory, climate). Data from the current (1996 - present) and past outbreak (1970's through 1980's) periods will be compared to various stand attributes including forest cover, age, density, ecosystem and climate.

For more information and research updates please refer to the CFS MPB web site: http://mpb.cfs.nrcan.gc.ca/initiative_e.html.

Hemlock Dwarf Mistletoe Tree Growth Model

Dr. John Muir, Ministry of Forests, Forest Practices Branch

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 detailed and comprehensive tree growth model is being developed to predict HDM spread, effects of forest practices and impacts.

Funding provided by Forest Renewal BC supported initial development of a detailed model of spread for HDM. Recently, the Forest Innovation Investment forest research program granted funds to link the detailed HDM model to the BC tree growth simulator TASS and to undertake detailed tree sampling to quantify HDM effects on hemlock foliage, branches, stems and wood quality attributes. Data and outputs can also be incorporated into other models that are used to project growth in BC. The new HDM/TASS model will facilitate monitoring of the effectiveness of variable retention management regimes and mistletoe impacts.

Evaluation of Red Attack Detection Remote Sensing using Ikonos Satellite Imagery

Richard Reich, Ministry of Forests, Northern Interior Forest Region

Detailed red attack mapping is conventionally done using various forms of heli-GPS or aerial photography on priority areas identified by the aerial overview survey. A structured evaluation of Ikonos, a 4-meter resolution satellite, was conducted in order to determine its reliability for detecting "suppression" levels of red attack. The basis of the study was a digital comparison between Ikonos imagery, which was spatially registered to 1:20,000 scale softcopy colour aerial photography captured in October 2002 near Prince George. The study design utilized the random selection of 10 one-hectare plots in each of three classes of red attack severity. A one hundred meter square grid was overlaid onto the entire study area (~30,000 hectares). One-hectare plots were selected at random, rated for percent incidence of red attack and then placed in a matrix until 10 plots were obtained in each attack class. The three classes of attack evaluated represented the relatively low levels attack associated with suppression activities: no attack, >0% to 5%, and 6% to 10%. The crown outlines of all red crowns in the 30 plots were digitized using softcopy stereo photo interpretation. Several plots were 100% ground truthed to determine the reliability of the aerial photos. It was determined that close to 100% of all red crowns could be detected on the photos through digital stereo photo interpretation. The Ikonos predictive classification was then compared to the location of red trees for all 30 plots. Red attack detection accuracy (number of correctly identified red attack trees as a percentage of the total red attack trees) was determined, as well as omissions and commissions. The results will be presented in a final report due in March 2004 and will be available through the Forest Practices Branch web site.

Forestry Innovation Investment Forest research Program

Project R04-030: Spatial and temporal patterns of western spruce budworm outbreaks in Southern British Columbia.

Dr. Lorraine Maclauchlan, Ministry of Forests, Southern Interior Forest Region

Western spruce budworm occurs throughout most Douglas-fir types in southern BC. Outbreaks cover large areas of susceptible forest, and cause growth loss, defects, regeneration delays and mortality. Various silvicultural treatments are available for long-term management, but during outbreaks direct control is the most effective treatment to mitigate losses. Between 2000-2002 over 1,600 tree cores (host and non-host species) were collected from 167 sites in the old Kamloops Forest Region. These cores have been measured, analysed and a chronology built. In 2003, an additional 399 cores were collected and analysed to complete the coverage of susceptible forest type within the Kamloops Region. This tree ring data set will help elucidate the historic spatial and temporal outbreak patterns (frequency, duration, intensity, location and impact) of western spruce budworm in southern BC. In turn, this information will assist us in determining when direct control is most biologically and economically rational.

Project R04-016: Attack dynamics and management implications of western balsam bark beetle in manipulated and natural subalpine fir ecosystems.

Dr. Lorraine Maclauchlan, Ministry of Forests, Southern Interior Forest Region

The western balsam bark beetle (WBBB), *Dryocoetes confusus*, causes scattered mortality over large areas throughout BC causing significant, but generally non-quantified impacts. WBBB is considered to be the most destructive insect pest of subalpine fir. WBBB prefers downed subalpine fir and susceptible standing trees that are the largest and oldest in a stand. Outbreak dynamics seem closely linked with host susceptibility, which can be mimicked by various management practices such as falling trap trees and baiting dominant subalpine fir. However, relative brood success within these two host conditions is not known, nor is it known if an abundance of downed host material will trigger an outbreak, as often occurs with the spruce beetle, Dendroctonus rufipennis. Subalpine fir is most abundant in the ESSF where the highest and most consistent levels of mortality are recorded. Losses due to WBBB are difficult to estimate due to the patchy nature of mortality. The study has focused on elucidating parameters that influence the success of WBBB populations and the progress of tree mortality in stands over time. This has been accomplished by setting up numerous trials and establishing a network of ten large scale, permanent sample plots throughout the range of WBBB. Permanent sample plots are essential to monitor fluctuating forest and pest conditions. After 5 years of intensive annual monitoring, plots will be assessed every 5 years to track damage, growth and yield and longer-term population fluctuations.

Mortality caused by western balsam bark beetle

Forest Health Publications

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"For the Health of our Forests"

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