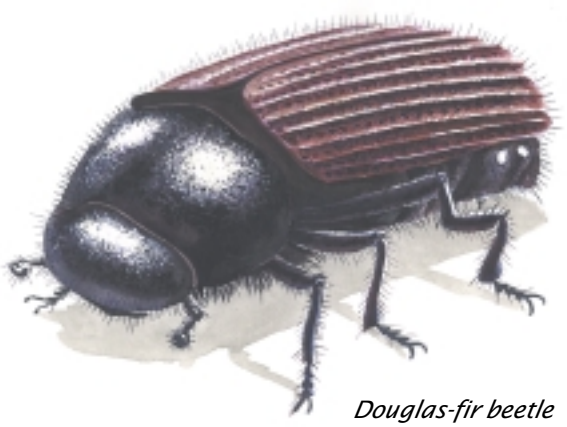
2001 Summary of Forest Health Conditions in British Columbia



Douglas-fir beetle

Introduction

The BC Ministry of Forests is responsible for detecting, recording and monitoring forest insects, diseases and environmental factors in the Province of British Columbia. The majority of this information is gathered at the Regional level (Figure 1) through aerial overview surveys. Surveys consist of sketch mapping forest health disturbances from a fixed wing aircraft at an average scale of 1:100,000. Mapping at this scale allows efficient, economical coverage of the province with an acceptable level of accuracy. The standards employed for overview surveys have been adopted from the Canadian Forest Service Forest Insect and Disease Survey standards. Details of survey methodology are available online at the Resources Inventory Committee website (http://www.for.gov.bc.ca/ric/pubs/teVeg/foresthealth/index.htm).

Unlike the 1999 and 2000 aerial overview, the Cariboo Forest Region and the southern portion of the Lakes District were the only areas to use different methods for collecting aerial survey data in 2001. Earlier provincial summaries used to rely heavily on detailed aerial survey data collected for directing bark beetle management activities.

The 2001 provincial aerial overview surveys were conducted from mid July to the end of September 2001. A total of 897.7 flying hours were required to survey the province (Table 1). The majority of all forested lands were surveyed; the main exception being a portion of the Bulkley-Cassiar District in the Prince Rupert Region, where remoteness, poor weather and a short window of opportunity for surveying did not allow comprehensive coverage of the area.

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 killed trees 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 1. Number of flying hours required by each Region to complete the 2001 provincial aerial overview surveys.

Region	Flight hours
Vancouver	44.6
Cariboo	385.2
Kamloops	48.5
Prince Rupert	168.0
Prince George	173.7
Nelson	77.7
Total	897.7

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

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.

Sketch mapped forest health disturbances were then digitized to BC Ministry of Forests Branch forest health standards, which are available on the Ministry of Forests website (http://www.for.gov.bc.ca/hfp/forsite/Forest_Health.htm).

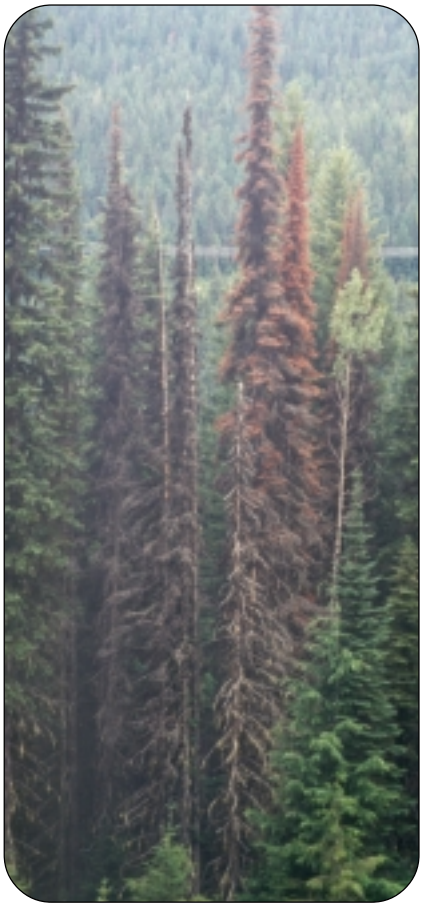
Mountain pine beetle was the most damaging pest in the province in 2001. Other significant damaging agents included: western balsam bark beetle, two-year cycle budworm, spruce beetle, eastern and western spruce budworm, Douglas-fir beetle, forest tent caterpillar, satin moth, and aspen/poplar leaf and twig blight.

Of all the bark beetles, the western balsam bark beetle affected the greatest area in the province. However, the overall impact was much less than that of mountain pine beetle, as balsam bark beetle infestations usually have very low percentages of current attack.

Several other forest health agents caused serious localized damage (Table 3).

Overall, bark beetles and defoliators affected the majority of the hectares recorded in the last three years. Bark beetle activity has increased significantly, due to the mild winters and low mortality rates, while defoliator populations have fluctuated depending on the species (Figure 2).

Pitch tubes caused by mountain pine beetle attack



Balsam bark beetle attacked trees

This report is a summary of the aerial survey results, with additional insect population predictions and special projects information supplied by Regional and District forest health specialists. Certain forest health concerns, particularly diseases such as rusts, cankers, decays and dwarf mistletoes, are not visible from the air. These disturbances are not covered in this report, except where communications or special projects from forest health specialists are noted.

Table 3. Summary of hectares affected by forest damaging agents as detected in 2001 aerial overview surveys in British Columbia.

Damaging Agent	Hectares Affected
Major Bark Beetles:	
Mountain pine beetle[a]	842,977
Western balsam bark beetle	1,072,700
Spruce beetle	99,564
Douglas-fir beetle	14,494
Defoliators:	
2-year cycle budworm	121,260
Western spruce budworm	123,638
Eastern spruce budworm	1,612,314
Forest tent caterpillar	60,415
Satin mot	8,695
Western emlock looper	5,174
Birc leaf miner	4,466
Western black eaded budworm	1,986
Unspecified defoliator	851
Abiotics:	
Wildfire[b]	6,956
Flooding	6,450
Windt row	423
Frost	273
Redbelt	103
Ot er:	
Aspen/poplar leaf and twig blig t	22,601
Pine needle diseases	461
Porcupine	1,457
Bear	1,272
Miscellaneous	347
Provincial Total	4,008,877

[a] Includes infestations in parks totalling 372,570 ha.
[b] Does not include large wildfires mapped by Protection Branch (additional 3,004 ha).

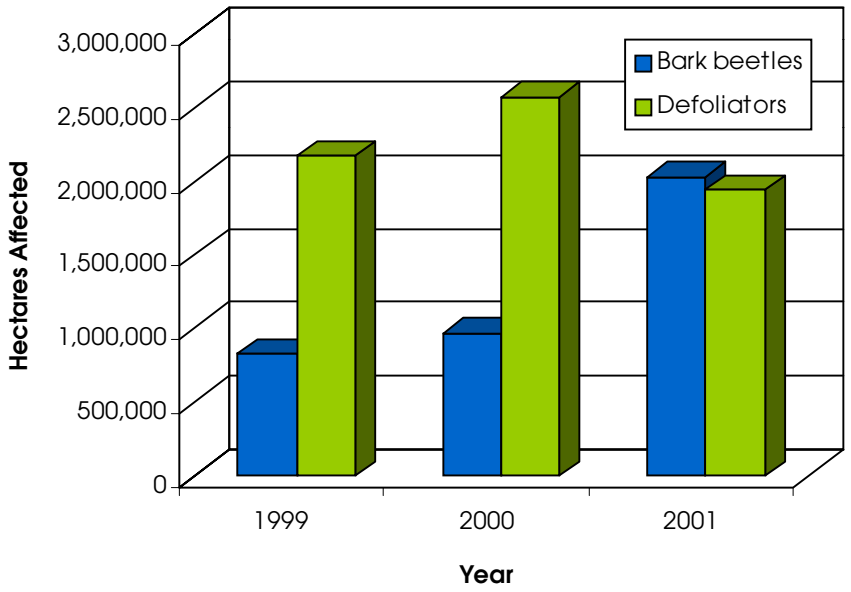


Figure 2. Hectares affected by major bark beetles and defoliators in 1999, 2000 and 2001.

Damaging Agents of Pine

Mountain Pine Beetle, *Dendroctonus ponderosae*

The mountain pine beetle is the most destructive pest of mature pine in British Columbia, and is currently 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.

One of the most extensive mountain pine beetle epidemics in recorded history is presently underway in British Columbia (Figure 3). Beetle populations have been on the rise for several years, due to an abundance of mature lodgepole pine and very favourable weather conditions. The province-wide drought in the summer of 1998 stressed susceptible trees, which were then unable to resist mass attack by mountain pine beetle. Beetle populations increased and 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, which has contributed to the current mountain pine beetle outbreak situation.

Figure 3. Mountain pine beetle infestations recorded in British Columbia in 2001.

Hectares under attack by the mountain pine beetle in BC have increased over five fold from the 1999 level of 164,567 ha to 842,977 ha in 2001. Provincially, this represents eighty-four times as many hectares affected by mountain pine beetle as by wildfire (9,960 ha) in 2001. All Regions except Kamloops and Nelson had increases in attack of at least double from 1999 to 2001 (Figure 4). Of the hectares affected by mountain pine beetle in 2001, 28% sustained severe mortality, 29% moderate, and 43% light mortality.

Prince Rupert Region has had the highest number of affected hectares in BC these past three years, with a dramatic increase of 300% between 2000 and 2001 (Figure 4). The bulk of the attack is located in the Lakes District with 304,314 ha infested, of which 77% is located in Tweedsmuir Park. The Lakes, Morice and Bulkley-Cassiar Districts are at greatest risk for future mountain pine beetle infestations.

Hectares affected by mountain pine beetle in the Prince George Region climbed to 202,824 ha in 2001, which represented a three-fold increase from the 66,439 ha recorded in 2000. The majority of the 2001 attack was recorded in the Fort St. James, Vanderhoof, and Prince George Districts at 43%, 40% and15% of the regional total, respectively. Over 22,000 ha of the infested timber in the Vanderhoof District are in the Entiako Park.

Vancouver Region experienced the largest increase in mountain pine beetle attack last year, up over 500% to 113,265 ha in 2001 from 21,714 ha in 2000. Most of the mortality occurred in the Mid-Coast District (109,574 ha), with 97% of the attack located in South Tweedsmuir Park.

Mountain pine beetle populations in the Cariboo Region also increased at unprecedented rates, from 38,473 ha in 2000 to 103, 792 ha in 2001. Almost 80% of the affected hectares in 2001 were located in the Quesnel District, although infestations were distributed throughout the region.

Kamloops region was less affected by mountain pine beetle than most other Regions in 2001. Only 29,741 ha were impacted. However, this represents a 50% increase from 19,761 ha in 2000.

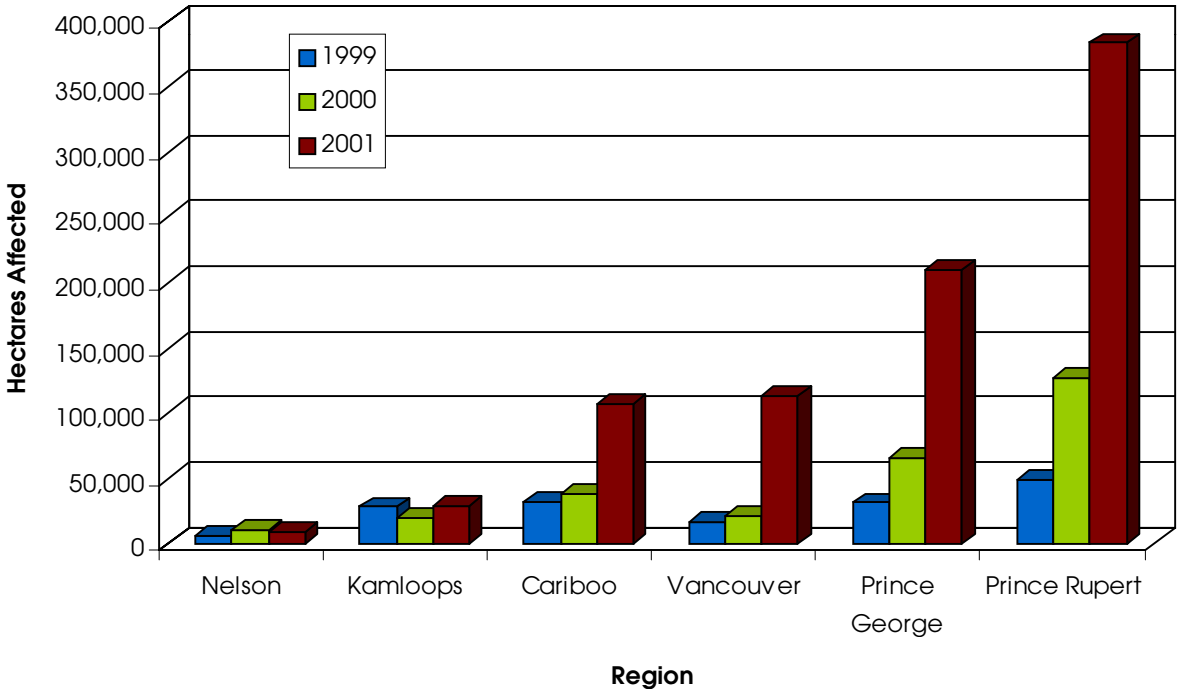


Figure 4. Change in hectares affected by mountain pine beetle from 1999 - 2001 in the six Provincial Forest Regions.

Nelson Region has been the least affected by mountain pine beetle these past three years, and the number of infested hectares has actually dropped slightly to 9,611 ha in 2001 from 10,382 ha in 2000. The drop in attack was most significant in Arrow and Cranbrook Districts. However, the number of affected hectares increased in the Invermere District.

Cariboo and Nelson Regions experienced a drop in the number of polygons, but had a corresponding rise in polygon size and number of spot infestations from 2000 to 2001. The decrease in number of polygons with an increase in size represents a coalescing of smaller infestations. The increase in the number of spot infestations indicates that the beetle population is still dispersing into uninfected stands.

Mountain pine beetle infested stand

In the Kamloops Region, the number of spot infestations and polygons has increased since last year, while the average size of the polygons has decreased. Smaller, more scattered infestations reflect a dispersing mountain pine beetle population and these factors combined with the increase in hectares attacked, represent a serious risk to uninfected pine stands.

Recent mild winters have greatly contributed to low mountain pine beetle mortality rates. The weather at other times of the year has also played a role in timing of beetle flight, beetle development, and the ability of trees to resist attack.

In the Prince Rupert, Prince George, and Cariboo Regions, cool and wet spring and fall weather in the last three years has prompted late, extended mountain pine beetle flights. The result has been larvae overwintering in various instars, the majority of which are smaller than usual. Smaller larvae are generally more susceptible to cold temperatures. However, recent winter weather conditions have been too mild to cause significant mortality. Due to late beetle flights, the Cariboo and Prince Rupert Regions have reported a substantial amount of two-year life cycle activity. Trees attacked during the summer and early fall months responded typically by forming pitch tubes as a defense mechanism. However, trees attacked later in the fall were not able to produce resin flow; hence, attacked trees did not exhibit pitch tubes.

In 2001, the mountain pine beetle flight occurred at the normal time in both Kamloops and Nelson Regions. However, many trees were still too weak from drought stress to produce pitch tubes in response to attack. Tree stress in the Kamloops Region was primarily due to the serious drought in 1998. In the Nelson Region, especially the Columbia Trench, it has been dryer than normal for the last four years.

All recorded hectares of mountain pine beetle attack are based on aerial detection of new red trees, which are actually trees attacked approximately one year prior. Currently attacked trees remain green until the onset of 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". Table 4 details green to red ratios observed throughout the province in 2001. Most reported ratios from the districts were higher than 1:1,

and all the regional averages were higher. The highest ratio in the province was reported for some areas of the Vanderhoof District, where the ratio reached 90:1. 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. This ratio is a rough estimate of the average production 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 in 2002, barring a significant cold weather event during the winter.

Dothistroma needle blight on young lodgepole pine

Table 4. Green to red ratios of mountain pine beetle attack observed in 2001.

Region	High	Low	Average
Cariboo	50:1 Quesnel District	1:1 Horsefly District	8.3:1
Kamloops	8:1 Kamloops District average	1:1 Clearwater District average	3.7:1
Nelson	25:1 various drier portions (Columbia Trench)	2:1	7:1
Prince George	Some 90:1 Vanderhoof District	3:1 various locations	8:1
Prince Rupert	40:1 Southern part of Lakes District	1:1	2.5:1

Pine Needle Diseases

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

Pine needle cast affects lodgepole pine of all ages. Only the current needles are infected, but they do not turn red until the following spring. Growth reduction and occasional mortality may result after repeated defoliation, particularly in younger trees. *Dothistroma* needle blight and *Davisomycella* needle cast have similar life histories and damage potential as pine needle cast, but damage is not evident until late summer/early fall, and primarily immature stands are affected.

The Cariboo Region was the only region in the province to have a significant number of hectares infected with pine needle cast in 2001. Ground surveys estimated that 150,000 ha were affected, particularly in the 100 Mile House and Williams Lake Forest Districts. The period of time when dead needles were visible in the spring before wind and rain removed them was very short, and poor weather conditions prevented aerial mapping of the infestations. Minor infestations totaling 156 ha and 62 ha were recorded in Kamloops and Nelson Regions. This is down substantially from the 2000 levels of 6,406 ha and 8,480 ha, respectively.

Up to 5,000 ha of immature pine stands (ground observations) were

infected with a combination of *Dothistroma* needle blight and *Davisomycella* needle cast (identified in samples sent to Brenda Callan of the Canadian Forest Service) in the Prince Rupert Region in 2001. The majority of affected stands were located in North Kalum District, Kispiox District, Cranberry TSA and the Lower Nass. Defoliation was severe enough to cause mortality, and it is estimated that approximately 5% of the stands will require fill planting or complete rehabilitation. Only 243 ha of these needle diseases were picked up during the aerial survey, probably due to the majority of infected needles turning red after surveys were completed. In 2000, one hundred immature pine stands were ground surveyed for these needle diseases in Kispiox District, two-thirds of which were found to be infected. Similar foliar damage in immature pine stands was also observed in the early fall, west of 100 Mile House and south of Jesmond, in the Cariboo Region.

White pine blister rust infection

White Pine Blister Rust, *Cronartium ribicola*

White pine blister rust (WPBR) is an exotic disease that was introduced to British Columbia in 1910. All five-needle pines are susceptible throughout their range (primarily south of 56° N in BC). Stem cankers cause top die-back and mortality through stem girdling.

Whitebark pine is an essential species in the subalpine, where it contributes to watershed protection, ecological succession, wildlife food and cover. Over the last three years, a study by the Vancouver Forest Region has been examining the effects of WPBR on whitebark pine. Ground surveys were conducted throughout the province in timber types containing whitebark pine. During the study, more than 24,000 trees greater than 1.3m in height were examined. Of these, almost 19% were dead; the cause of mortality evenly split between WPBR and other causes. A further 31% of the trees were currently infected, many with stem cankers that will eventually kill the tree (Figure 5).

Interestingly, infection and mortality was not highest in the smallest trees (<5 cm dbh), as is often the case with western white pine, nor the largest trees (>40 cm dbh), but was concentrated in the middle cohort. This does not bode well for the future of whitebark pine, as this generation of trees is largely responsible for seed production. There also appeared to be a trend of increasing infection and mortality from the Coast Range toward the Rockies.

Several recommendations were made for conservation of the whitebark pine including halting all harvest of the species, reintroducing fire into high-elevation ecosystems, collecting seed for nursery purposes, and starting a tree-breeding program.

Much of the damage due to white pine blister rust is not easily defined during aerial overview surveys. Only 45 ha were mapped in 2001 in the Kootenay District.

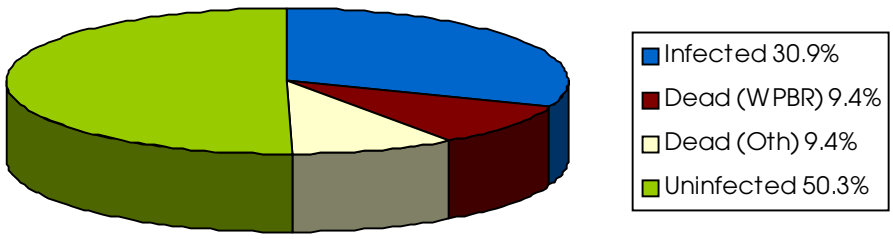


Figure 5. Summary of the condition of whitebark pine trees > 1.3m in height as sampled across the species range.

Damaging Agents of Douglas-Fir

Western Spruce Budworm, *Choristoneura occidentalis*

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

Defoliation by the western spruce budworm has expanded substantially in the last two years, particularly in the Cariboo and Kamloops Regions. Total defoliation by western spruce budworm in the province increased approximately 20 fold between 1999 and 2000. Defoliation again increased in 2001, with a provincial total of 123,638 ha recorded (Figure 6).

Western spruce budworm defoliation of a Douglas-fir stand

An unprecedented 81% of the total defoliation occurred in the Cariboo Region, primarily south of Williams Lake to Meadow Lake, and 108 Mile House, south to Clinton. Most defoliation in the Kamloops Region occurred in Merritt District, with the remainder in Lillooet and Kamloops Districts. The majority of the Kamloops Region defoliation was light, while the defoliation in the Cariboo Region was split between 45% light, 31% moderate and 24% severe. New infestations in the Vancouver Region occurred in the vicinity of Boston Bar and Darcy, and caused mainly light defoliation.

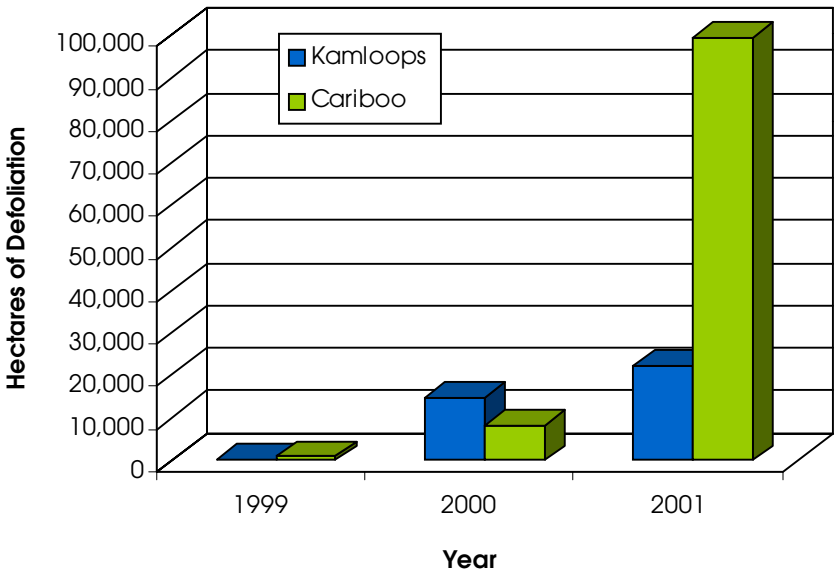


Figure 6. Change in hectares of western spruce budworm defoliation in British Columbia from 1999 to 2001.

Egg mass surveys conducted in the fall of 2001 predict a continued expansion in both hectares and severity of defoliation, particularly in the Williams Lake, 100 Mile House, Merritt and Lillooet Districts (Table 5). The Cariboo Region reported a significant increase in the number of parasitized pupae at egg mass survey sites with moderate to severe 2001 defoliation. Despite

this increase in parasitoid activity, western spruce budworm populations appear to be thriving.

High value stands with moderate to severe defoliation were treated with the biological control agent *Bacillus thuringiensis* var. *kurstaki* (*B.t.k.*). Cariboo Region increased the number of hectares treated from 8,150 ha in 2000 to 17,000 ha in 2001 in the Williams Lake and 100 Mile House Districts. Kamloops Region treated 9,804 ha in 2001 in the Kamloops and Merritt Districts. The treatments were successful, with egg mass counts predicting low defoliation for the year following *B.t.k.* application. The new and expanding 2001 western spruce budworm infestations expected in the Kamloops and Cariboo Regions will require further *B.t.k.* treatments in the spring of 2002.

Table 5. Summary of fall 2001 western spruce budworm egg mass survey results for Districts where moderate to severe defoliation is predicted.

District	No. of sites in each defoliation category				Total number of sites	Average no. egg masses/10m^2 foliage
	Nil	Light	Moderate	Severe		
Kamloops	0	15	3	0	18	29.2
Lillooet	10	24	17	2	53	41.5
100 Mile	1	52	25	6	84	58.3
Merritt	0	47	69	5	121	65.6
Williams Lake	0	17	14	5	36	72.8

Late instar western spruce budworm

Douglas-fir beetle, *Dendroctonus pseudotsugae*

Douglas-fir beetle is an important pest on 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 significant numbers of healthy trees are killed. Drought, fire or significant windthrow/breakage from ice are often the precipitators of outbreaks.

Approximately 14,500 ha were infested with Douglas-fir beetle across the province in 2001 (Figure 7). 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.

The highest number of affected hectares continued to be in the Nelson Region, with almost 4,800 ha infested. There was a significant decline overall from 2000, particularly in the Invermere and Kootenay Lake Districts. Only Cranbrook District showed a large increase, primarily on the west slopes of the Rockies, from Premier Lake south to the U.S. border.

Despite the decline of Douglas-fir beetle in Invermere District, it still has 53% of all Douglas-fir beetle attack detected in the Nelson Region.

Kamloops Region had 4,255 ha affected in 2001, and was the only region where Douglas-fir beetle levels increased significantly. The majority of beetle mortality occurred in Wells Gray Park, although beetle populations expanded in all districts of the Kamloops Region, except Kamloops District.

Douglas-fir beetle gallery

Douglas-fir beetle levels declined in the Cariboo Region, except in the Military Training Areas west of Williams Lake, and in Horsefly District. Although there was a decrease in hectares infested in most areas, the number of small infestations tripled, indicating an increasing population. Douglas-fir beetle mortality remained relatively constant in the Prince George Region, but dropped to very low levels in the Vancouver Region. The only area where the Douglas-fir beetle increased in the Vancouver Region was in the Fraser Canyon and Nahatlatch River drainages. Prince Rupert Region has a low component of Douglas-fir, and no attack was noted.

In the Kootenay Lake District, a study is underway to determine the best Douglas-fir beetle susceptibility-rating model to apply to Douglas-fir stands within the district. Several previously proposed empirical susceptibility-rating models are being examined for their relative viability by testing them on various ecological variables in study plots. Depending on the results, a new model may be proposed.

Douglas-fir beetle attacked tree

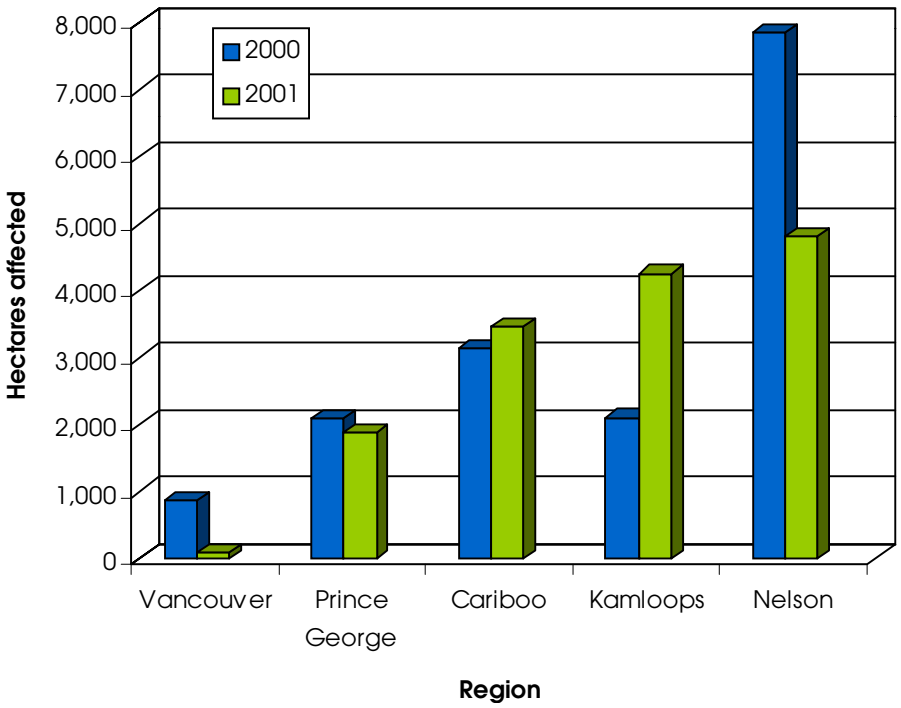


Figure 7. Change in hectares affected by Douglas-fir beetle in BC from 2000 to 2001.

Western False Hemlock Looper, *Nepytia freemani*

The western false hemlock looper is found primarily in the drier portions of southern BC. Its main host is immature 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 or mortality.

One infestation of 115 ha was identified in Cranbrook District in 2001, located adjacent to the Fort Steele highway exchange.

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 Region. Pheromone trapping sites are used to monitor the population in high hazard areas in the Kamloops Region and the southern part of the 100 Mile House District. Trap catches averaged 17.3 moths per trap in the Kamloops Region in 2001, up substantially from an average of 6.0 moths per trap in 2000. The highest increases occurred at trap sites at Veasy Lake, Barnes Lake and Battle Creek in Kamloops District; Spences Bridge in Lillooet District; and Stemwinder Park and Ashnola River in Merritt District. Trap catches were lower in 100 Mile House District, with an average of 2 moths per trap caught at 44% of the sites. However, the numbers of moths caught were on the rise from 2000 to 2001, particularly at the Deadman Creek Valley, Loon Lake and Bonaparte River trapping sites.

Douglas-fir tussock moth larva

In 2001, 49 ha of tussock moth defoliation were mapped during aerial surveys north of Cache Creek in the Kamloops District, just south of the 100 Mile House District border. Sequential egg-mass surveys are being conducted north of Cache Creek to define the severity and extent of expected defoliation in 2002. Depending upon survey results, up to 300 ha may be treated with nuclear polyhedrosis virus (NPV) next spring.

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.

Close to 100,000 ha were recorded as affected by the spruce beetle across the province in 2001. Of this total, 69% of the hectares had light mortality, 27% 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.

Hectares affected by spruce beetle in the Prince Rupert Region more than doubled from 2000 to 2001 (Figure 8). Over 65,000 ha of attack were detected in 3,363 polygons in 2001 for the region, particularly in the eastern districts of Kispiox, Bulkley, Morice and Lakes. This increase could be a sampling artifact, due in part to ground surveys conducted on many of the significant infestations by the aerial surveyors prior to flying, which led to increased confidence in identifying new infestations.

Spruce beetle-infested hectares in the Prince George Region dropped from 76,083 ha in 2000 to 31,166 ha in 2001 (Figure 8). The spruce beetle flight was late in 2001. Therefore, the majority of larvae will overwinter as early instars, particularly in standing trees that were attacked after available windthrow. Levels of infestation dropped in all districts except Fort St. James, where the hectares almost doubled from 9,892 ha to 19,128 ha. The most significant drop occurred in the Prince George district, from 40,827 ha in 2000 to 7,206 ha in 2001.

All four of the southerly regions experienced very low levels of

spruce beetle infestations, compared to Prince Rupert and Prince George Regions. In the Kamloops Region, 1,800 ha of spruce beetle were recorded, primarily in the Lillooet District, near Carpenter Lake and south of Anderson Lake. In the Cariboo Region, spruce beetle levels declined to 1,197 ha, the lowest level in three years. Most of the infestations were evenly split between 100 Mile House and Quesnel Districts. Only 21 ha of spruce beetle damage were recorded in the Columbia District of the Nelson Region. No new spruce beetle mortality was visible from the air in the Vancouver Region, though endemic levels are known to exist in the northeast corner of Squamish District.

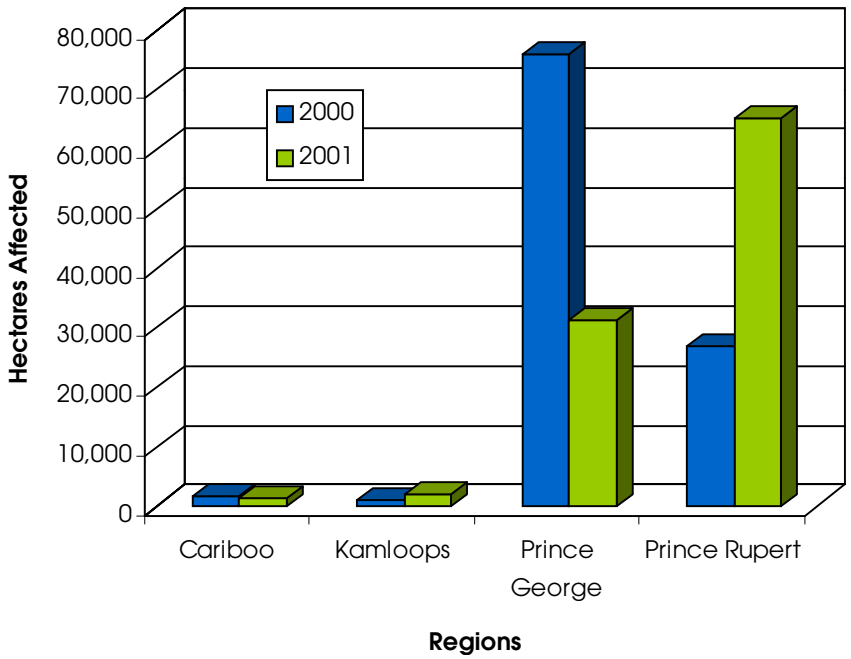


Figure 8. Hectares affected by spruce beetle in 2000 *vs.* 2001, for Regions with more than 1000 ha infested.

Spruce beetle infestation caused by windthrow (top right)

Damaging Agents of True Fir

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

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

Most of the 1,612,314 ha of defoliation in 2001 by the **eastern spruce budworm** in the Prince George Region occurred in the Fort Nelson District, with 8,000 ha recorded in the Fort St. John District. Approximately 80% of the recorded defoliation was light in intensity. Branch samples from affected areas in Fort Nelson District have been collected and early instar larvae emerging from the samples will be counted in order to predict expected defoliation levels for 2002. An economic analysis of the costs and benefits of a treatment program using *B.t.k.* is also underway.

The **2-year-cycle budworm** requires two years to complete its life cycle. Most defoliation damage occurs in the second year, when larvae consume the largest amounts of foliage (referred to as the "on" year). Odd years are the "on" years for 2-year-cycle budworm in the Prince George Region. Consequently, 100,963 ha of defoliation, 90% of it light to moderate, were recorded in the region. Fort St. James District sustained the most defoliation at 93,652 ha.

In the Cariboo and Kamloops Regions, the 2-year-cycle budworm is "on" during even years. Despite this being an "off" year, 20,297 ha of light defoliation were detected during aerial surveys of Quesnel District in 2001, suggesting high budworm populations, which could cause severe damage in 2002. In the Kamloops Region, no defoliation was recorded in 2001. However, egg-mass sampling conducted in 2000 predicted at least 75,000 ha of defoliation in 2002, mostly in the wetter subalpine areas of the Clearwater District.

Severe 2-year-cycle budworm defoliation on balsam fir tree

Spruce stand severly defoliated by eastern spruce budworm

Western Balsam Bark Beetle, *Dryocoetes confusus*

The western balsam bark beetle is the most significant 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. More commonly, less than 5% of a stand is killed in one year.

In 2001, more than one million hectares sustained mortality due to western balsam bark beetle in BC, totaling a greater number of hectares than all other bark beetles affecting forest trees combined (Table 3). However, the impact due to balsam bark beetle is less, because the mortality rate per year is very low. In 2001, 71% of the hectares affected were light attack, 26% moderate, and only 4% were severe. This may still be an exaggeration of attack severity, as dead sub-alpine fir retains the red foliage colour for up to five years. Newly dead trees are a brighter red than trees that have been dead for several years. However, it is common to overestimate the extent of new attack from the air.

The Prince Rupert Region recorded 70% of the provincial total, 739,258 ha, of western balsam bark beetle attack in 2001. Only 253 polygons were noted, resulting in an average infestation size just under 3,000 ha. Infestations were spread throughout all districts, except the North Coast and Cassiar Districts. The number of hectares attacked increased substantially in 2001 from 1999 and 2000 (Figure 9). This increase may be in part a result of differing survey methodologies. 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. 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.

Balsam bark beetle infested stand

Prince George Region was the second most affected region by the western balsam bark beetle between 1999 and 2001 (Figure 9). In 2001, 248,274 ha in the Region were affected by this bark beetle. Over half the attack occurred in the Fort St. James District. Attack levels significantly decreased in the Robson Valley, Mackenzie and Fort Nelson Districts between 2000 and 2001.

The four remaining Regions sustained significantly lower levels of western balsam bark beetle attack than Prince George and Prince Rupert Regions, in part because sub-alpine fir is not as large a component of their forested ecosystems. In the Cariboo Region, the number of affected hectares increased to 42,355 ha in 2001. Attack was scattered in high elevation stands throughout the region with the exception of Williams Lake District, which has very few sub-alpine fir stands. Mortality remained steady from 2000 to 2001 in the Kamloops Region. Most high elevation forests sustained low levels of attack, with the largest increases seen in the Buck Hills/upper Harris Creek area in Vernon and Penticton Districts, and in the Mad River and TFL #18 in the Clearwater District. Attack levels remained low in the Vancouver Region and fell substantially across the Nelson Region (Figure 9).

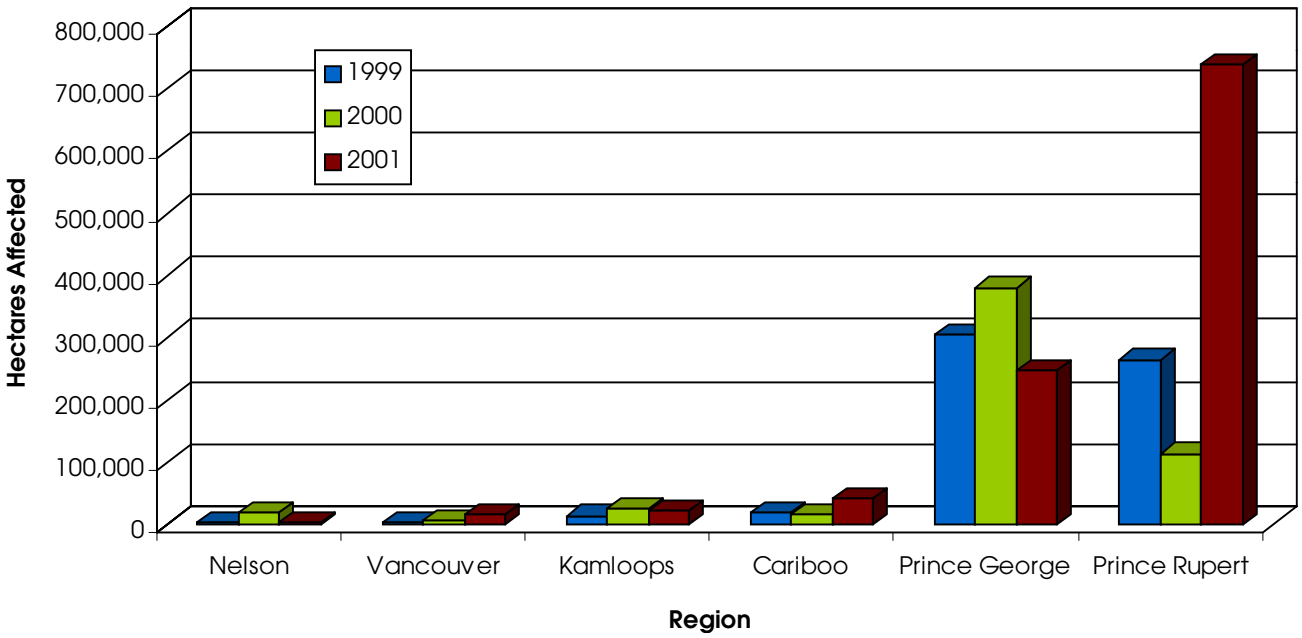


Figure 9. Hectares affected by western balsam bark beetle in British Columbia from 1999 to 2001, by Region.

Balsam Woolly Adelgid, *Adelges piceae*

Balsam woolly adelgid is an introduced species to British Columbia, and is an important pest of true firs. Depending on the intensity of attack and susceptibility of the host, damage can include top-kill, growth reduction, wood quality reduction and mortality. Nearly all mortality occurred on amabilis fir in the 1950's and 60's. It seems that the most susceptible trees were killed at that time. Infested trees are still being killed today, but at a slower rate and over many years.

The first infestations of balsam woolly adelgid were found on the slopes above Vancouver and on southern Vancouver Island. A quarantine zone, which was established for the Lower Mainland, Vancouver Island and Gulf Islands, helped to slow the spread of balsam woolly adelgid, but has not prevented its movement. Infestations have been found in the Chilliwack, Squamish, Sunshine Coast, South Island and Campbell River Districts in the Vancouver Region. The most serious infestation is presently on TFL 44 in the Alberni area, where significant mortality is occurring in old growth forests. Balsam woolly adelgid has now been found as far as the border between Vancouver and Kamloops Regions, at Lillooet and Merritt District boundaries.

Topkill of amabilis fir caused by balsam woolly adelgid

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.

Hemlock looper larva

Western hemlock looper populations increased in four of the six regions in 2001. Visible defoliation increased in the Vancouver Region from 532 ha in 2000 to 2,818 ha in 2001. The infestations were located on the west side of Howe Sound, in the Capilano Reservoir, and eastward to Chehalis River. Aerial overview surveys determined that 2,021 ha were infested in the Prince Rupert Forest Region, although these areas were not ground confirmed. Most of the defoliation in the Prince Rupert and Vancouver Regions fell evenly in the light-to-moderate categories. An infestation of 301 ha of trace-to-light western hemlock looper defoliation was mapped along Clearwater Lake in the Kamloops Region. Larval sampling through tree beatings in areas of historical looper activity generally yielded low numbers in the Kamloops Region; however, moth trap catch averages remained high for the second year, especially around Blue River. In the Nelson Region, 76% of permanent sample plots sampled yielded western hemlock looper larvae with an average of 30 larvae per infested plot, thereby predicting visible defoliation in 2002. Populations were highest between Downie and Pitt Creeks on the east side of Revelstoke Lake. Trace defoliation was noted in this area.

Western blackheaded budworm, *Acleris gloverana* Conifer sawfly, *Neodiprion spp.*

The western blackheaded budworm is a defoliator that occurs throughout British Columbia, which periodically causes extensive defoliation. The preferred hosts are western hemlock and true firs, although spruce and Douglas-fir are sometimes attacked. Trees can be completely defoliated during an outbreak, which can result in growth reduction, top-kill and mortality, particularly in immature stands. Conifer sawfly is sometimes found defoliating in conjunction with the western blackheaded budworm, although it usually prefers older foliage; hence it does not cause as much damage.

After five consecutive years of western blackheaded budworm defoliation in the Queen Charlotte District of the Vancouver Region, the population has collapsed. The height of the outbreak occurred in 1999, with 61,219 ha defoliated. Affected hectares were reduced to 31,391 in 2000, and only 1,851 ha of defoliation (86% severe) were recorded in

Conifer sawfly larvae

2001. It is likely that conifer sawfly contributed to defoliation in 2001, with 87 ha directly attributed to this defoliator.
In the Prince Rupert Region, the Kalum District recorded 136 ha of light to moderate defoliation by the western blackheaded budworm.

Tree beatings at permanent sample plots throughout the Nelson Region yielded western blackheaded budworm larvae at only 36% of the plots, with an average of 6 larvae per infested plot. These numbers were not high enough to expect defoliation in 2002. Conifer sawflies however

Western blackheaded budworm larva

were found in 66% of the plots, averaging 90 larvae per plot. Minor defoliation by the conifer sawfly was noted on the ground at Beaver Creek north of Rogers Pass, Ferguson near Trout Lake and west of Kaslo at Keen Creek. Defoliation is predicted to be visible from the air in 2002.

Damaging Agents of Deciduous Trees

Forest Tent Caterpillar, *Malacosoma disstria*

The forest tent caterpillar is a major defoliator in British Columbia 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.

In 2001, forest tent caterpillar infestations were primarily located in the central interior of BC. Prince George Forest Region sustained 98% of the provincial total with 59,164 ha affected in 205 polygons. Most of the defoliation recorded was light to moderate. The number of affected hectares was down substantially from the 213,934 ha defoliated in 2000. Large areas of aspen stands across Prince George Forest Region and south into Quesnel District of the Cariboo Region were severely defoliated by forest tent caterpillar between 1989-98. Since then, populations have been on the decline.

Forest tent caterpillar larvae

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 south-western 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 some tree mortality.

Defoliation by the satin moth increased substantially in the southern interior in 2001. In the Cariboo Region, 6,575 ha were affected, up from only 211 ha in 2000. Defoliation levels were light in 9%, moderate in 62%, and severe in 27% of these stands, most of which occurred in the Chilcotin District. The area affected in Quesnel District was underestimated during the aerial survey.

In the Kamloops Region, 2,033 ha of primarily light defoliation were detected in 2001. The largest infestations were around Clearwater and the upper end of Adams Lake in the Clearwater District. Defoliation totaled 496 ha in 2000 and occurred mainly in Merritt District. Only 86 ha of light defoliation in 2001 by the satin moth were noted in the Columbia District in the Nelson Region.

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 British Columbia. 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. In 2001, 4,466 ha of light defoliation were recorded in the Kamloops Region. The majority of the infestations occurred in Kamloops District in the vicinity of Louis Creek to Adams Lake, and in Clearwater District near the Mad, Adams and North Thompson Rivers.

Foliage damage caused by birch leaf miner

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 introduced to BC since 1978. Aggressive monitoring and eradication programs have thus far prevented the gypsy moth from becoming established in BC.

Gypsy moth larvae

During the past 22 years, pheromone traps have been monitored throughout the province to detect moths. Eggmass and larval surveys have also been conducted in areas of concern. Where a population is detected and is determined to be on the verge of becoming established, eradication treatments have historically been conducted. In 2001, eleven moths were caught in the pheromone traps, primarily in the lower mainland. The highest trap catches were single moths in three traps in Delta and two moths in Victoria. Eggmass surveys will be conducted in these locations. The only trap catches in the interior were one moth at each of the Grand Forks and Chase sites.

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 British Columbia. Infected young shoots and terminal leaves are killed. Repeated infections can result in growth reduction and stem deformities, particularly in young stands.

The unseasonable cool and wet spring and summers experienced in the Prince Rupert and Prince George Regions for the last three years, have provided optimum conditions for infection by aspen and poplar leaf and twig blight. Prince Rupert Region sustained most of the damage provincially, with 22,169 ha in 237 polygons affected. The majority of the infestations occurred in the Lakes, Kispiox and Bulkley Districts. In Prince George Region, 162 ha of infected stands were observed during aerial surveys in 2001. If the weather patterns of the past three years continue, further expansion can be expected.

Dead shoots and leaves on cottonwood caused by Venturia

Damaging Agents of Multiple Hosts

Climatic Injury

All 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 stressed by climatic injuries are often more susceptible to insects and disease.

Windthrow or blowdown was not recorded as a significant damaging agent in most of the province in 2001. Almost 300 ha of the 423 ha recorded provincially were located in Grand Forks District. The main concern with windthrow and ice damage is the attraction of bark beetles to weakened or downed trees. In 100 Mile House District, Bradley Creek area, ice damage to lodgepole pine in the form of broken tops has lead to a marked increase in mountain pine beetle attack.

Red belt affecting a lodgepole pine stand near Clinton

Mortality caused by flooding was the most significant climate related damaging agent in BC in 2001, affecting 6,450 ha. Nearly 100% of the damage occurred in the three most northerly Regions, due to unseasonably wet and cool spring and summer seasons for the last three years. The Fort St. John and Dawson Creek Districts in the Prince George Region sustained 70% of the tree mortality due to floods.

Red belt, a rare weather driven phenomenon, and frost, affected a total of 366 ha in the Prince George and Cariboo Regions. The effects of a significant occurrence of red belt in 1997 in the Jesmond area northwest of Clinton, are being studied in the 100 Mile

House District. Mature pine trees are dying, due to a combination of weakening by red belt, followed by bark beetle invasion.
Only 3 ha in the Invermere District were directly attributable to drought in 2001. However, the entire Nelson Region has been drier than normal for the past four years, especially in the Columbia Trench. This has resulted in drought stressed trees, which are more susceptible to other forest health pests.

Bear damage to young lodgepole pine

Animal Damage

A variety of animals cause damage to all tree species throughout BC, particularly at the seedling to sapling stage. 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 bark girdling, resulting in dead tops or mortality. Bear and porcupine are most often responsible.

In 2001, black bear damage affected 925 ha of young stands in the Ramsay Arm and Quatam River area of the Sunshine Coast District, Vancouver Forest Region. Almost half of the stands sustained serious damage (over 30% recent mortality). Bear damage was first detected in this area in 1994. Since then, mortality has increased in area and intensity. The only other recorded bear damage was in the Nelson Region, where 347 ha were lightly affected, primarily in the Kootenay District.

American porcupine

Porcupine damage affected 1,287 ha in the Prince Rupert Region, mostly consisting of light attack in the Bulkley District. An additional 170 ha of light attack was recorded in immature stands in the Invermere District in the Nelson Region.

Ministry of Forests, Forest Practices Branch

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

Many thanks to the contributors to this document:

Data and specialized project information:

Forest Practices Branch -	Tim Ebata, Forest Health Project Specialist
	Peter Hall, Forest Entomologist
Cariboo Forest Region -	Leo Rankin, Forest Entomologist
Kamloops Forest Regio -	Lorraine Maclauchlan, Forest Entomologist
Nelson Forest Region -	Art Stock, Forest Entomologist
Prince George Forest Region -	Robert Hodgkinson, Forest Entomologist
Prince Rupert Region -	Ken White, Forest Entomologist
	Alex Woods, Forest Pathologist
Vancouver Forest Region -	Don Heppner, Forest Entomologist
	Stefan Zeglan, Forest Pathologist

Photographs:

Norman Alexander (balsam woolly adelgid)
Brenda Callan - Pacific Forestry Centre (Venturia)
Canadian Food Inspection Agency (gypsy moth)
Robert Hodgkinson - Prince George Forest Region (2-yr-cycle budworm)
Troy Lockhart - Ft. Nelson District (eastern spruce budworm)
Leo Rankin - Cariboo Forest Region (forest tent caterpillar)
Joan Westfall - EntoPath Management Ltd.
Don Wright - Forest Health Specialist 100 Mile House District (spruce beetle, mountain pine beetle pitch tubes)

Drawings:

Soren Henrich - Henrich Design and Illustration

Maps:

Duncan Richards - GISolutions
Resource Tenures and Engineering Branch

Editing:

Julie Brooks - Forest Health Management
Russ Cozens - Forest Practices Branch Forest Health Officer
Tim Ebata - Forest Practices Branch Forest Health Project Specialist