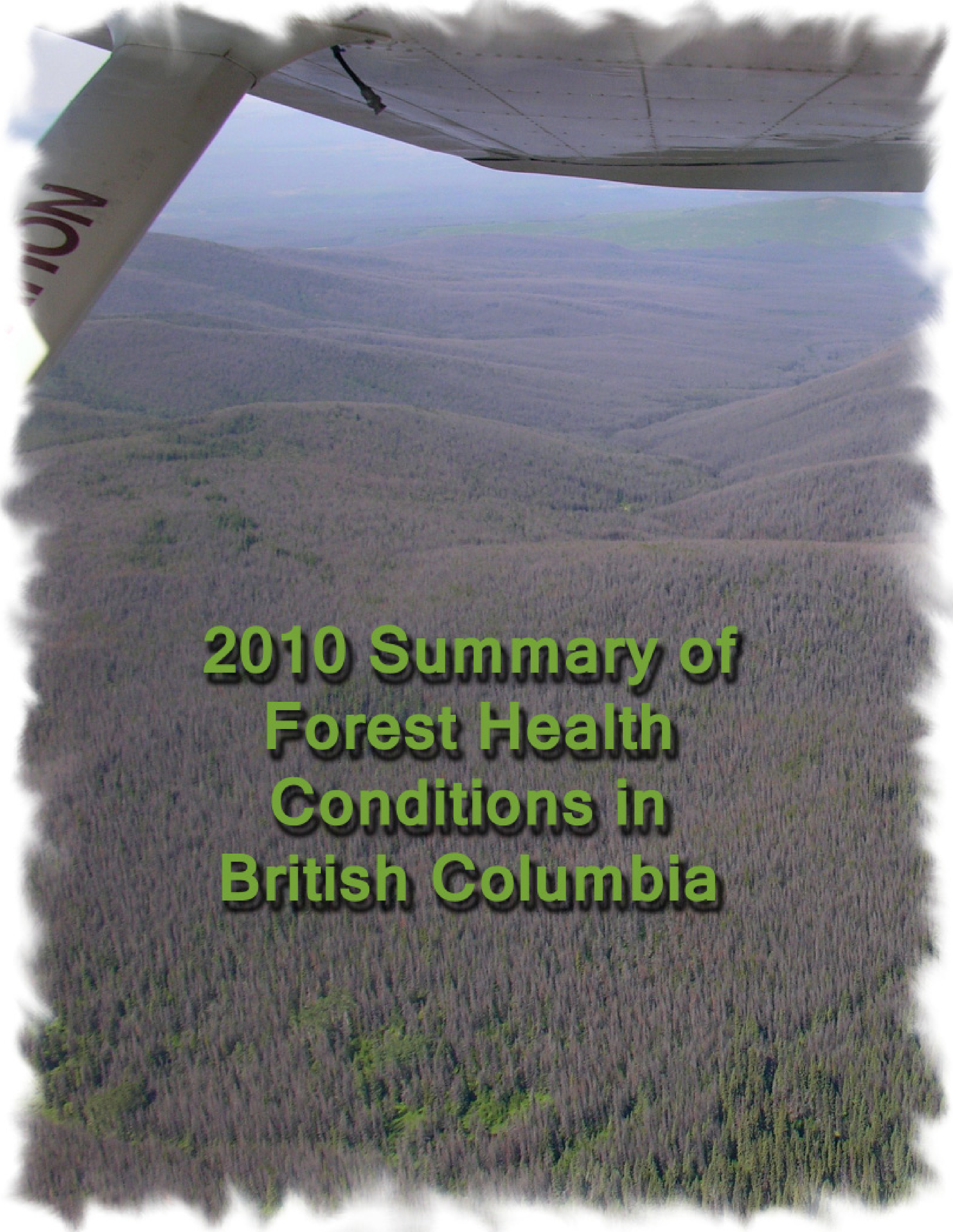


2010 Summary of Forest Health Conditions in British Columbia

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Forests, Mines and Lands

Forest Practices and Investment Branch

Pest Management Report Number 15
Library and Archives Canada Cataloguing in Publication Data

Main entry under title:
Summary of forest health conditions in British Columbia. - -
2001 -

Annual.
Vols. for 2010- issued in Pest management report series.
Also issued on the Internet.
ISSN 1715-0167 = Summary of forest health conditions in British Columbia.

1. Forest health - British Columbia - Evaluation - Periodicals.
2. Trees - Diseases and pests - British Columbia - Periodicals.
3. Forest surveys - British Columbia - Periodicals. I. British Columbia.
Forest Practices Branch. II. Series: Pest management report.

SB764.C3S95 634.9′6′09711 C2005-960057-8

2010 Summary of Forest Health Conditions In British Columbia

Joan Westfall[1] and Tim Ebata[2]

Contact Information

1 Forest Health Forester, EntoPath Management Ltd., 1654 Hornby Avenue, Kamloops, BC, V2B 7R2. Email: entopath@shaw.ca

2 Forest Health Officer, Forest Practices and Investment Branch, PO Box 9513 Stn Prov Govt, Victoria, BC, V8W 9C2. Email: Tim.Ebata@gov.bc.ca

Table of Contents

Summary

The *2010 Summary of Forest Health Conditions in British Columbia* (BC) is a compilation of current provincial forest health aerial overview survey data in conjunction with insect population prediction assessments, ground observations from trained personnel and summary descriptions of special projects, meetings, presentations and publications undertaken by the Ministry of Forests and Range (MFR) entomologists, pathologists and their associates.

Over 11 million ha of BC forests were damaged by forest health agents in 2010. Mountain pine beetle continued to be the primary cause of mortality, though area affected declined to 6.3 million from the peak of 10.1 million hectares in 2007. Infestations were highest in the NIFR, where 5,669,820 ha were affected. The majority (93%) of the attack continued to occur in the Peace, Mackenzie, Fort St. James and Nadina Forest Districts. Mortality in the Southern Interior Forest Region (SIFR) dropped more than four-fold since last year to 559,909 ha. Attack levels decreased in all districts, particularly those in the Cariboo, with the exception of the Rocky Mountain Forest District. Coastal Forest Region infestations declined for the fifth year in a row to only 21,857 ha.

Western balsam bark beetle mortality remained similar to last year with 1.8 million hectares affected across BC. Intensity of attack continued to be assessed as mainly trace (96%) and disturbances were noted over many of the same areas as last year. Spruce beetle damage remained static at 30,096 ha of attack, though several of the disturbance locations changed. After a seven year increase in Douglas-fir beetle mortality to a peak of 100,726 ha last year, infestations dropped precipitously to only 15,789 ha. Most of the decreases occurred in the Cariboo area of the SIFR, while infestations actually increased substantially in the Rocky Mountain Forest District in the SIFR and South Island/ Sunshine Coast Forest Districts of the CFR.

Damage due to insect defoliators was led by a Bruce spanworm outbreak in the NIFR. Attack almost tripled to 1.7 million hectares in 2010. Defoliation expanded from the original infestation in Peace Forest District into Prince George Forest District last year, and continued north and westward into five other districts this year. Another aspen defoliator of note was the serpentine leaf miner which caused double the damage reported last year with 209,604 ha recorded throughout BC. Forest tent caterpillar infestations also damaged aspen with a fourfold increase to 132,626 ha, mainly in the NIFR. In many places these defoliators and some other minor ones were intermixed within a given area but the primary damaging agent was recorded. Birch leaf miner was the other notable deciduous defoliator, damaging 8,418 ha in the SIFR.

Damage by the western spruce budworm, which had been the primary provincial defoliator for many years, dropped by two-thirds to 500,121 ha affected. Most of the defoliation occurred in the Cascades, Central Cariboo, Kamloops, Okanagan Shuswap and 100 Mile House Forest Districts of the SIFR. A total of 42,814 ha of high value stands at risk were successfully treated with the biological pesticide *Bacillus thuringiensis* var. *kurstaki* (*Btk*) in the SIFR. Two other budworms were active this year: western blackheaded budworm damage more than tripled to 93,241 ha, primarily in the CFR's Haida Gwaii Forest District, and two-year-cycle budworm defoliation dropped substantially to 97,084 ha. The two-year-cycle budworm is on an odd year cycle in most of the NIFR where 99% of the 396,855 ha affected occurred last year: in 2010 three quarters of the defoliation was noted in the SIFR where the budworm is in an even year cycle.

The Douglas-fir tussock moth was in the third year of an outbreak with 16,303 ha of damage recorded in the Kamloops, Okanagan Shuswap and Cascades Forest Districts of the SIFR. A control program was employed to treat 7,576 ha with *Btk*, and/or nucleopolyhedrosis virus. In response to 30 male gypsy moths being caught in pheromone monitoring traps in 2009, *Btk* was also used in the Lower Mainland this spring to eradicate these populations. A total of 766 ha were sprayed aerially in Richmond and 25 ha were treated with a ground spray south of Harrison Hot Springs.

Overall, needle and leaf disease disturbances (the disease damage that is most visible from the height of the aerial overview survey) were down in 2010 due at least in part to the relatively dry summer BC experienced in 2009. Dothistroma needle blight continued to be most often detected, though damage was almost a quarter of what was mapped last year with 7,413 ha affected. Aspen and poplar leaf and twig blight damage was down by a quarter to 6,621 ha and pine needle cast damage also decreased by half to 2,984 ha. All this damage was recorded in the NIFR. Conversely, larch needle blight damage increased slightly in the south-eastern portion of the SIFR to 3,317 ha, possibly due to that area experiencing more rain last year than most of the province. Hectares affected by white pine blister rust rose substantially this year to 2,328 ha, mainly due to several large low intensity (trace) polygons being delineated instead of the usual small high intensity disturbances.

Due to another hot dry summer over most of the province, the leading abiotic damage continued to be wildfire, with a total of 302,155 ha burned. Fires were more active in the NIFR this year where 40% of the damage occurred but the majority burnt in the Cariboo area of the SIFR, where 53% of the disturbances were located. The remaining wildfires were in the northeast corner of the North Island – Central Coast Forest District in the CFR. Yellow cedar decline continued to cause 10,984 ha of damage along the BC coastline. Slides damaged 2,393 ha of land, including an 889 ha slide near Pemberton that has been documented as being the second-largest slide in Canadian history.

Other damaging agents such as flooding, windthrow, red belt and western hemlock looper affected scattered, localized stands throughout the province.

2010 Summary of Forest Health Conditions in British Columbia

Introduction

British Columbia (BC) is home to a wide variety of tree species that are affected by many damaging agents including insects, diseases, animals and abiotic factors. These disturbances often vary widely in type, size, intensity and locations from year to year. To adequately capture these changes, an aerial overview survey is undertaken on an annual basis across BC. For the past fourteen years, this survey has been the responsibility of the BC Ministry of Forests and Range (MFR). In the fall of 2010, the Ministry of Forest and Range underwent a major reorganization that included creation of new regions and some new districts. The reorganization will also result in the delivery of the aerial overview survey in 2011 by the Ministry of Natural Resource Operations , with the provincial compilation and reporting conducted by the Forest Practices and Investment Branch, Ministry of Forets, Mines and Lands. Due to these changes occurring after the completion of the 2010 aerial survey, this report will use the previous names for the Ministry of Forests and Range with its regions and districts to permit comparisons with previous years' reports.

The primary objective of this project is to obtain forest disturbance information in a quick and cost effective manner across the forested areas of BC. For every forest health factor encountered, size and severity of damage by tree species affected is recorded. This information is used by government agencies, industry, academia, and the public for many purposes such as: supporting Timber Supply Analysis, contributing to a national database for the National Forest Pest Strategy, setting Government strategic objectives, directing management and control efforts, reporting national indicators for sustainable forest management, and providing disturbance data for research projects.

This annual report reviews damage to BC forests that has occurred over the past year and compares the results to previous years. Hectares of disturbances as discussed in this report were obtained directly from the aerial overview survey results and are summarized by forest districts (Figure 1). Information collected on damage caused by agents that was not visible when conducting this survey was included if conditions changed since the last report. This included diseases such as rusts, cankers and dwarf mistletoes, as well as animal and insect damage that were too subtle to pick up aerially. As this information was collected by other methods it was not added to the overview database. Information on assessments to determine population levels for some insects such as pheromone trapping, egg mass surveys, three tree beatings and overwinter mortality studies was also included where appropriate.

Forest health presentations, projects and publications by MFR entomologists, pathologists and their associates conducted within the past year follow the reports on general forest health damage. This report encapsulates BC forest health conditions from a MFR perspective and does not necessarily include research and management conducted by other agencies.

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)**
DQC · Haida Gwaii Forest District **(Queen Charlotte City)**
DNC · North Coast Forest District **(Prince Rupert)**
DIC * North Island - Central Coast Forest District **(Port McNeill**, Hagensborg)
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 and Range regional and district boundaries as of April 1, 2003.

METHODS

Small fixed wing aircraft (minimum 4 seats) are used to conduct the aerial overview surveys. Two experienced observers sit on opposite sides of the plane, with one beside the pilot to assist in navigation. Disturbances are sketched on customized 1:100,000 scale paper maps which consist of colour Landsat 5 satellite images with some features digitally enhanced. On completion of a flight the two maps are collated onto one mylar which is digitized to obtain the final spatial data. Details of survey methodology and digitizing standards can be found at http://www.for.gov.bc.ca /hfp/health/overview/methods.htm.

Aerial observer recording forest health damage

Flights are conducted when the primary forest health factors are most visible, weather conditions permitting. Survey windows vary by which damage agents are priorities for a given geographic area and how the causal agents have progressed depending on seasonal conditions. Flights in 2010 began July 8th and were completed by September 22nd (Table 1). Conditions were very good across the province until the end of July, when extremely heavy wildfire smoke curtailed most of the flying with the exception of the south-eastern and north-eastern portions BC. Smoke conditions improved somewhat by the third week of August and the last flights were completed by September 22nd. Flying time in 2010 totalled 717.5 hrs.

Survey progress and coverage intensity were monitored by recording flight lines with Global Positioning Satellite (GPS) receiver units (Figure 2). Flights were conducted between 450m to 1000m above the ground, depending on visibility and terrain. Where topography was relatively flat, a grid pattern was flown 7km to 9km apart where disturbances were active and up to 14 km apart where damage was very low. In

Table 1. Flying hours and survey dates by region undertaken for the 2010 provincial aerial overview survey.

Region	Zone	Flight hours	Survey Dates
Southern Interior Forest Region	Cariboo	120.3	July 19th – Aug 30th
	Kamloops	52.0	July 19th – July 29th
	Nelson	88.0	July 17th – Aug 9th
Northern Interior Forest Region	East	272.3	July 8th – Sep 21st
	West	106.5	July 8th – Sep 16th
Coast Forest Region		78.4	July 14th – Sep 22nd
Total		**717.5**	**July 8th – Sep 22nd**

mountainous terrain, coverage was drainage based. Plane speed depended on the extent and variety of damage.

The annual goal is to survey all forested land in the province, weather and funding permitting. This isn't always possible, especially in lower priority areas with historically minimal damage. In 2009 the main drainages of the Cassiar Timber Supply Area (TSA) in the Skeena Stikine Forest District were flown and only minor damage was detected. This year, this portion of the province wasn't flown. Instead, resources were concentrated on the northern half of the Mackenzie Forest District and main drainages in the Fort Nelson Forest District that weren't surveyed last year. In total, an estimated 85% of the province was flown in 2010, up from 82% last year. This percentage was derived with the use of a digital planimeter to roughly determine how much of the entire province was surveyed. This did not factor in whether areas contain non-forested types such as large lakes, grasslands and alpine. All surveyed forests were examined for all visible forest health disturbances, regardless of timber type or land ownership.

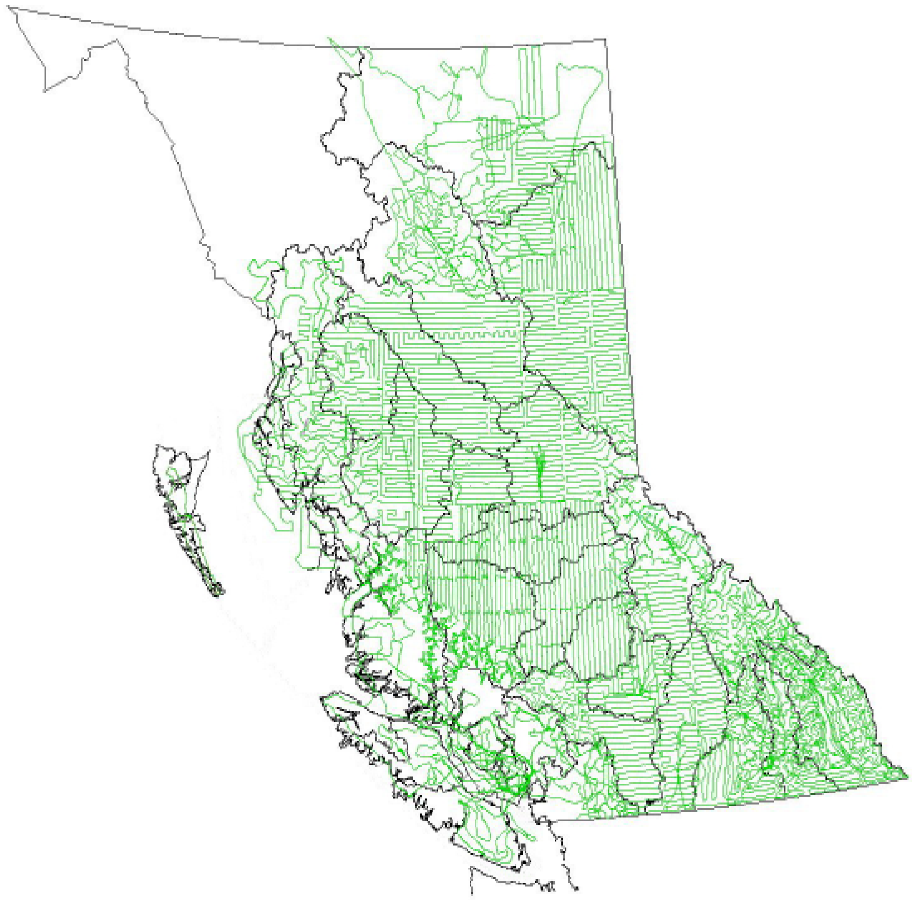


Figure 2. Flight paths flown while conducting the 2010 aerial overview surveys.

Recent tree mortality was identified by observations of distressed foliage colour. Only trees killed within the past year were mapped. Clumps of dead trees up to 50 were recorded as "spots" and mapped as point data. Spots are assigned an area depending on the number of recently killed trees within the spot. Spots with 1 to 30 trees were given a size of 0.25 ha and 31 to 50 trees 0.5 ha at a severe intensity rating. Larger disturbances were mapped as polygons by five intensity classes (Table 2).

Trees with foliage damage (caused by insect feeding, foliage diseases or abiotic factors) tend to cover large areas and all age classes are affected. Therefore, only polygons were mapped and they were assessed for intensity of defoliation based on the amount of foliage damaged in the past year over the entire polygon (three intensity classes, Table 2).

In addition to damage caused by some agents not being visible at the height or time of the aerial overview survey, the collected data has limitations. Hectares affected from past surveys by the same forest health factor cannot be added cumulatively, as new damage can be recorded in all or a portion of the same stands that were previously disturbed. Relatively broad intensity classes and known errors of omission also must be considered when manipulating the data. For example, calculating accurate mortality volume estimations are not possible since the actual number of trees killed (and consequently, volume) is not precise.

Table 2. Intensity classes used during aerial overview surveys for recording current forest health damage.

Disturbance	Intensity Class	Description
Mortality (bark beetle, abiotic, and animal damage)	Trace	<1% of the trees in the polygon recently killed.
	Light	1-10% of the trees in the polygon recently killed.
	Moderate	11-29% of the trees in the polygon recently killed.
	Severe	30-49% of the trees in the polygon recently killed.
	Very Severe	50%+ of the trees in the polygon recently killed.
Defoliation (defoliating insect and foliar disease damage)	Light	Some branch tip and upper crown defoliation, barely visible from the air.
	Moderate	Noticeably thin foliage, top third of many trees severely defoliated, some completely stripped.
	Severe	Bare branch tips and completely defoliated tops, most trees sustaining more than 50% total defoliation.

Western blackheaded budworm damage on Haida Gwaii

Douglas-fir tussock moth infected with virus

General Conditions

The 2010 aerial overview surveys recorded a total of 11,195,135 ha of damage mapped across the forests of BC (Table 3). Mortality caused by mountain pine beetle was still the primary disturbance in the province, though area affected declined from the peak of 10.1 million hectares in 2007 to 6.3 million in 2010. Western balsam bark beetle continued to impact 1.7 million hectares at primarily trace intensity over many of the same areas where attack was noted last year. Area affected by spruce bark beetle mortality remained almost the same as last year provincially with 30,096 ha of attack in the same general areas in the Southern Interior Forest Region (SIFR) but with a substantial decline in the Northern Interior Forest Region (NIFR). Douglas-fir beetle attack dropped to only 16% of the area mapped last year with only 15,789 ha recorded. Ground observations in most areas concur that the Douglas-fir beetle population has decreased sharply.

Leading the insect defoliators, a Bruce spanworm outbreak in the eastern portion of the NIFR continued to grow, almost tripling last year's affected area to 1.7 million. Damage by the western spruce budworm, which has been the main provincial defoliator for many years, dropped to two-thirds of the area affected last year with 500,121 ha defoliated. Two-year-cycle budworm damage also dropped to a quarter of last year's defoliation with 97,084 ha affected. This is largely due to this budworm being in the low defoliation year of its two year cycle in the NIFR, where a large outbreak was recorded last year. A western blackheaded budworm outbreak continued to grow in the Haida Gwaii Forest District and a few other areas were also affected in the interior of the province for a total of 93,241 ha of defoliation. Aspen leaf miner damage expanded substantially with a record of 209,604 ha of defoliation observed throughout many of the aspen stands in the interior. Total hectares affected by the Douglas-fir tussock moth outbreak in the SIFR remained relatively static at 16,303 ha. Birch leaf miner damage grew in 2010, with 8,418 ha mapped throughout the south-eastern portion of the SIFR.

Disturbances due to abiotic factors dropped slightly in 2010 to 324,926 ha. The majority of the damage continued to be caused by wildfires with 302,155 ha affected. Yellow cedar decline damaged 10,984 ha along the coastline and scattered areas of windthrow damage, particularly in the south-eastern portion of the SIFR, affected 3,249 ha. Small areas of flooding and slides were scattered throughout the province, damaging 4,439 ha and 2,393 ha, respectively. Red belt damage, which only occurs sporadically, affected 880 ha in the Fort Nelson Forest District.

Visible damage caused by diseases continued to be less noticeable this year at 25,329 ha, only half the damage recorded last year. This was primarily the result of a reduction in NIFR needle diseases suspected to be due to a generally hot, dry summer last year. Redband needle blight and pine needle cast continued to be observed mainly in the NIFR at the reduced levels of 7,413 ha and 2,984 ha, respectively. Area affected by aspen/poplar leaf/twig blight in the eastern portion of the NIFR also dropped to 6,621 ha of damage. Conversely, larch needle blight recorded in the moister south-eastern portion of the SIFR doubled to 3,317 ha affected. Locations, extent and intensity of damage by host tree species are documented in the next section of this report.

Table 3. Summary of hectares affected by forest damaging agents as detected in 2010 aerial overview surveys in British Columbia.

Damaging Agent	Hectares
Bark Beetles:	
Mountain pine beetle[a]	6,251,586
Western balsam bark beetle	1,772,395
Spruce beetle	30,096
Douglas-fir beetle	15,789
Total Bark Beetles:	8,069,865
Defoliators:	
Bruce spanworm	1,675,014
Western spruce budworm	500,121
Aspen leafminer	209,604
Forest tent caterpillar	132,626
Two-year-cycle budworm	97,084
Western blackheaded budworm	93,241
Unknown defoliators	38,957
Douglas-fir tussock moth	16,303
Birch leafminer	8,418
Western hemlock looper	3,318
False hemlock looper	220
Satin moth	9
Larch casebearer	6
Total Defoliators:	2,774,921
Abiotics:	
Fire	302,155
Yellow cedar decline	10,984
Flooding	4,439
Windthrow	3,249
Slide	2,393
Redbelt	880
Drought	688
Birch decline	128
Misc. Abiotics	11
Total Abiotics:	324,926
Diseases:	
Dothistroma	7,413
Aspen/poplar leaf/twig blight	6,621
Larch needle blight	3,317
Pine needle cast	2,984
White pine blister rust	2,396
Laminated root disease	2,251
Douglas-fir needle cast	260
Armillaria root disease	87
Larch needle cast	2
Total Diseases:	25,329
Animals:	
Bear	82
Porcupine	13
Total Animals:	94
Provincial Total	11,195,135

[a] Includes infestations in parks totalling 482,660 ha.

Mortality caused by Douglas-fir beetles

Damage caused by lightning strike

DAMAGING AGENTS OF PINES

Mountain pine beetle, *Dendroctonus ponderosae*

Provincial situation

Mountain pine beetle infestations peaked in 2007, when just over 10 million hectares were attacked (Figure 3). A substantial drop in 2008 was followed by an increase in 2009. This was partly an artefact of an unusual pattern of needle colour changes that made it difficult to discern recent attack from older mortality, and a larger portion of the most severely attacked areas being surveyed. This year, the predicted decline in area damaged occurred with a total of 6,251,586 ha mapped across the province, down from 8,953,441 ha last year. With the large drop in hectares affected, severity conversely increased slightly, with 2,385,813 ha (38%) trace, 1,815,606 ha (29%) light, 1,513,027 ha (24%) moderate, 519,373 ha (8%) severe and 17,768 ha (<1%) very severe delineated.

Mortality continued to be observed throughout the range of lodgepole pine (Figure 4) but established infestations shrank in size and declined in intensity. In the central portion of BC where the mountain pine beetle has been active the longest, the majority of the mature pine has been killed and new attack was down sharply. The only exception to this occurred in the southeast corner of the NIFR, where beetle from the northern front were blown back into old attack areas, killing much of the remaining suppressed lodgepole pine understory and causing mortality in young managed stands. The largest expansions occurred at the northern boundaries of the outbreak, where the beetle is still moving into previously unattacked stands.

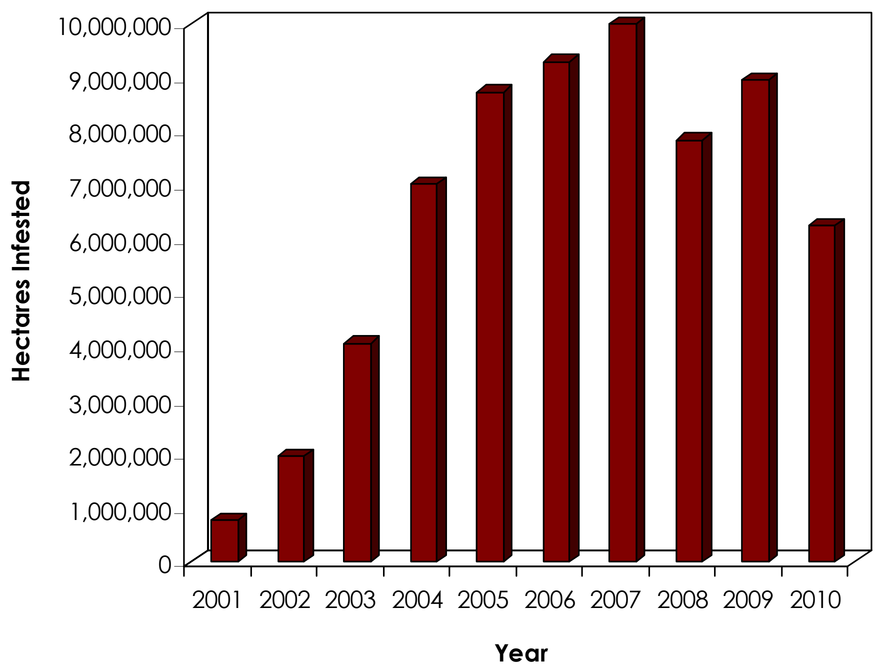


Figure 3. Hectares infested (all severity classes) by mountain pine beetle from 2001 – 2010 in British Columbia.

In addition to the preferred host, mature lodgepole pine, the mountain pine beetle continued to attack secondary hosts. These consisted primarily of ponderosa, whitebark and western white pine along with younger age classes of lodgepole pine. However, the number of hectares where alternate host mortality was detected was down in 2010.

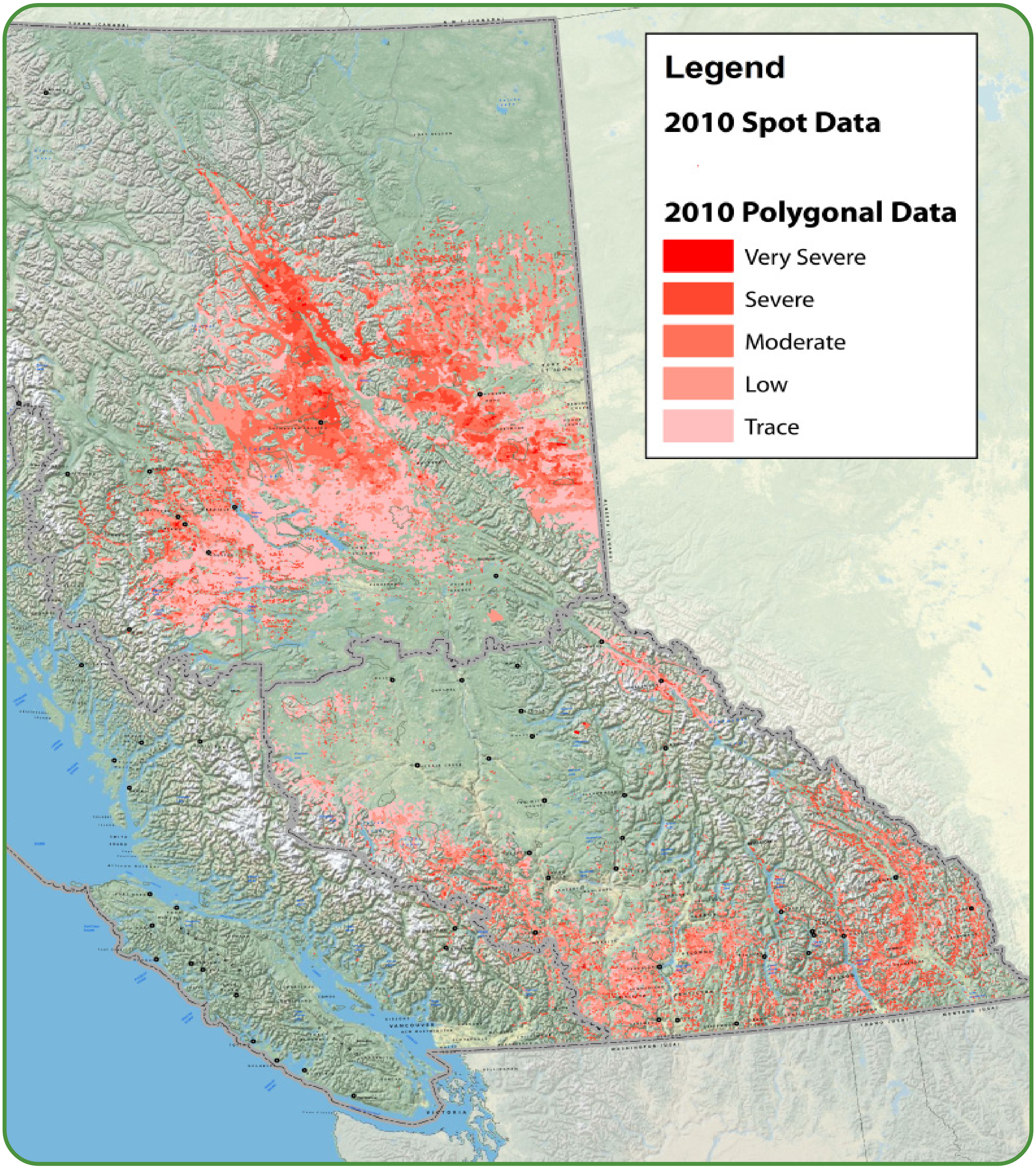


Figure 4. Mountain pine beetle infestations recorded in British Columbia in 2010.

Northern Interior Forest Region damage

Mountain pine beetle damage was recorded across 5,669,820 ha this year, down from a record peak of 6,583,769 ha in 2009 (Figure 5). The NIFR was the only region where some areas still experienced substantial increases in beetle activity in 2010.

Infestations observed in the Peace Forest District increased for the second consecutive year to 1,874,917 ha. Severity rose as well with the moderate category rising from 6% to 28% with a corresponding drop in the trace category by half. Intensity levels were highest along the mid-western portion of the district, particularly around the Peace Arm of Williston Lake. Attack was scattered throughout the district, with the exception of the north-eastern tip where pine is not predominant. In the northwest, infestations have expanded in spots and small trace to light polygons, up past the boundary with Fort Nelson District.

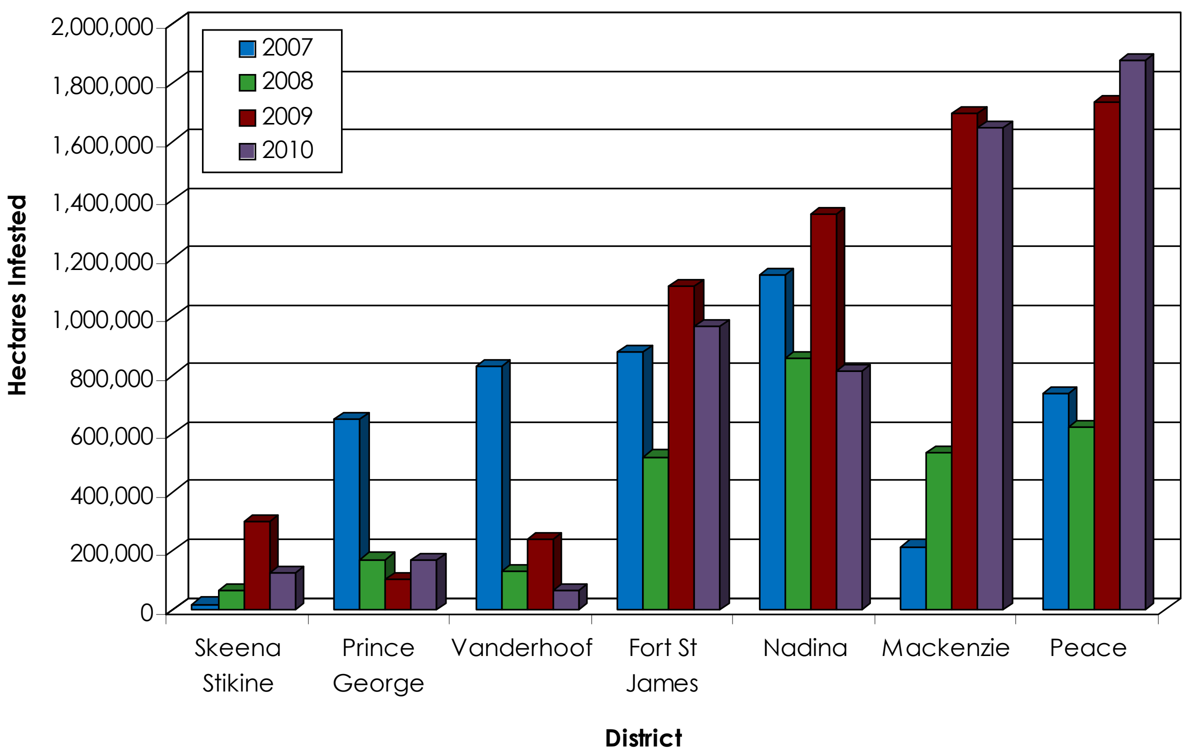


Figure 5. Hectares infested by mountain pine beetle from 2007 – 2010 in the Northern Interior Forest Region (districts with more than 60,000 ha affected in 2010).

Attack levels in the Mackenzie Forest District decreased only slightly since last year to 1,645,575 ha affected, after tripling from 2008. Severity levels have remained relatively stable, with two-thirds of the damage rated moderate or above. Infestations in this district have been moving northward, so attack in the southern half of the province has decreased while the northern reaches have expanded. Part of the noted northern expansion was due to more of that portion of the district being surveyed this year. Mortality was observed to the northern boundary along the Kechika and Gataga Rivers, primarily in small spots and trace to light polygons. Attack levels intensified mid district south of Weissener Lake to Germansen Lake.

Infestations mapped in the Fort St. James Forest District also decreased slightly to 967,831 ha of damage. As in the Mackenzie Forest District, attack began in the south and is moving northward; hence, almost all the new attack observed in the southern half of the district south of Nation Mountain was trace intensity as most of the pine was dead. From Nation Mountain to the north end of Takla Lake mortality is primarily widespread at the moderate level. For the northern portion of the district, newer infestations mainly follow the drainages at trace to light intensity, with the exception of some moderate damage along the northern reaches of the Omineca River. More of the northern part of the district was flown this year than last, and new infestations were recorded in drainages as far north as the Mackenzie Forest District border at Dewar Peak.

Mountain pine beetle mortality near Tumbler Ridge in the Peace Forest District

In the Nadina Forest District, attack levels dropped substantially to 812,947 ha after a record peak of 1,351,012 ha in 2009. Parks and protected areas contained 66,441 ha of the damage, down by half since last year. After sustaining the highest levels of attack in the NIFR for the past five years, mountain pine beetle activity was slowing in this district as most of the mature lodgepole pine was dead. This was reflected in the continually decreasing intensity levels (97% trace to light in 2010) as the remaining scattered pine are attacked. The majority of the higher intensity disturbances were mapped at the north-western corner of the district, where the infestations are more recent.

Mountain pine beetle attack in the Prince George Forest District actually rose slightly to 170,757 ha after a three year decline to only 103,497 ha last year. Most of the mature pine in this district is dead and the local beetle population was very low. However, it is suspected beetle populations were brought in during high wind events from the large infestations to the north, as most of the attack is in the northern half of the district. The majority of the trees killed were suppressed understory trees in old attacked stands and young trees in managed stands.

The relatively new attack in the Skeena Stikine Forest District that reached a peak of 299,416 ha last year dropped substantially in 2010 to only 124,310 ha affected. Large primarily trace infestations recorded last year decreased in size but the remaining polygons increased in severity, as last year almost all (92%) of the disturbances were trace while this year only 18% were delineated as trace, with a corresponding rise in the light category to 68%. Most of the attack continued to occur in the Bulkley TSA (Timber Supply Area) with the highest intensities occurring at the southern edge.

The declining beetle population that remains in the remnant pine of the Vanderhoof Forest District was reflected in the sharp decrease to only 65,544 ha affected this year. Most of the affected hectares were scattered along the northern edge of the district and mortality was very low (96% trace).

After peaking last year at 8,794 ha of damage, infestations in the Kalum Forest District fell to 6,045 ha. Attack was located in approximately the same areas along the Skeena River, Kitsumkalum Lake, Zymoetz River and south of Lakelse Lake but infestation sizes decreased.

The remaining 1,894 ha of attack in the NIFR was mapped in the Fort Nelson Forest District. This is very noteworthy as last year was the first time mountain pine beetle mortality was observed during the surveys in this district, with 24 ha recorded in the southwest corner. In 2010, infestations moved up drainages from southern infestations along the Muskwa and Prophet Rivers. One trace infestation also occurred near Klua Creek and the most northerly damage was recorded along Tuchodi River as far as Tuchodi Lakes.

Southern Interior Forest Region damage

Mountain pine beetle mortality peaked in the SIFR in 2007 with 5.4 million hectares affected. Damage dropped to less than half that area last year and declined to only 559,909 ha in 2010. Infestations decreased in all districts except the Rocky Mountain Forest District.

The Cascades Forest District sustained the highest amount of attack in the SIFR with 137,754 ha affected, though this was less than half the damage delineated last year. Infestations were still scattered throughout the district though they have decreased in size, particularly mid district. Intensity levels were down as well, with light to moderate categories increasing from 55% last year to 84%, with a corresponding reduction in the higher intensities. Populations were most active in the southern half of the Merritt TSA.

The largest declines in area affected occurred in the Cariboo where the majority of the attack has previously been recorded during this outbreak (Figure 6). Most of the mortality (98%) is trace to low intensity, primarily in remnant suppressed, understory lodgepole pine scattered throughout previously killed stands. Host depletion in many areas has likely contributed to the rapid collapse, but many mountain valleys with considerable mature pine remaining have also seen a dramatic decline in population expansion. The highest levels of new attack were generally found at high elevation and often extended into whitebark pine stands.

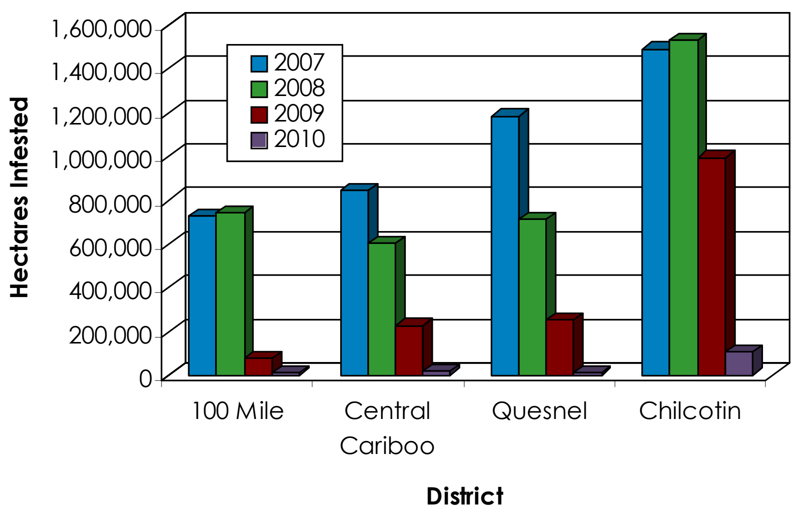


Figure 6. Hectares infested (all severity classes) by mountain pine beetle from 2006 – 2009 in the Southern Interior Forest Region (districts with more than 500,000 ha affected in 2008).

Reductions in attack levels in the Cariboo were the highest in the Chilcotin Forest District, where damage dropped almost tenfold since last year to 103,931 ha. The largest decreases were in the northern portion of the district, with most of the remaining attack located around Kleena Kleene and Chilko Lake east to the district boundary. Figure 7 illustrates the reductions in intensity levels over time as the mountain pine beetle populations have declined.

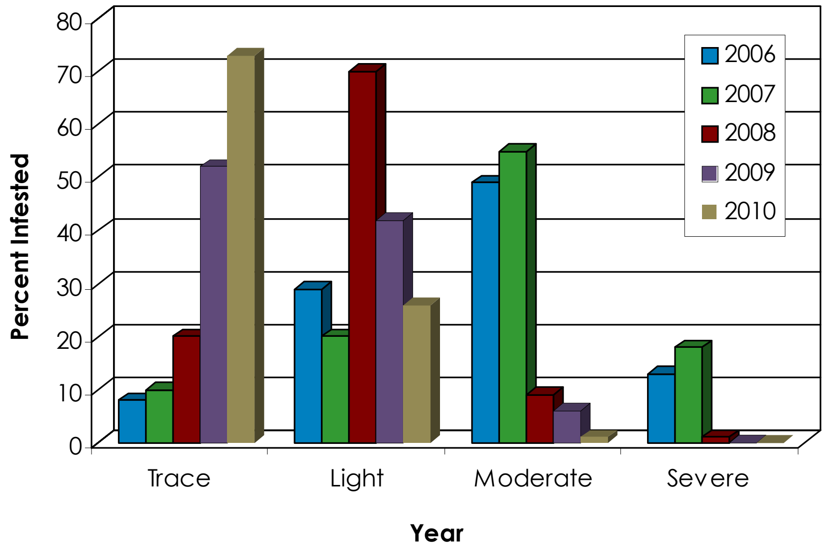


Figure 7. Percent change in severity of hectares infested by mountain pine beetle in the Chilcotin Forest District from 2006 – 2010 (very severe less than 1% all years).

Infestations in the Central Cariboo Forest District dropped from 225,039 ha in 2009 to only 16,671 ha (Figure 6). Small scattered trace to light polygons were primarily delineated in the southwest corner of the district and a few higher intensity infestations were noted south of Quesnel Lake. Attack in the Quesnel Forest District fell by a similar amount from 251,595 ha last year to 9,266 ha. The remaining disturbances were all located in the western tip of the district around Baldface and Tundra Mountains. Infestations in the 100 Mile House Forest District sustained the largest drop in the province last year to 76,848 ha and this trend continued in 2010 with only 9,365 ha mapped. Small polygons were scattered throughout the district in 2009 but almost all the disturbances were along the western boundary this year, particularly along the Marble Range and around Pavilion Mountain.

Attack in the Headwaters Forest District declined by a quarter since last year to 84,654 ha affected. Most of the reductions occurred in the southern half of the district and almost all the remaining attack was noted along the Fraser River through the Kinbasket Lake area and a few side drainages. Okanagan Shuswap Forest District experienced declines of almost 40% to 82,768 ha. The mountain pine beetle in this district is moving from the north to the south and most of the mortality was located in the hills around Okanagan Lake. Intensities are still moderate to severe in the Trout Creek, Hydraulic Lake and Aberdeen Plateau areas.

Mountain pine beetle caused mortality southeast of Nelson in the Kootenay Lake Forest District

Unlike the rest of the SIFR, attack in the Rocky Mountain Forest District expanded slightly (1%) since last year to 52,061 ha. Intensity of attack was proportionally higher than in most districts as well, with half in the moderate to severe range and half in the light to trace categories. Damage levels in the Kootenay Lake Forest District were down marginally to 22,288 ha. Mountain pine beetle disturbances in the Arrow Boundary Forest District dropped by more than half since last year to 19,078 ha. Most of the reductions occurred west of Needles and around Slocan Lake/River area. Infestations in these three districts were scattered throughout, primarily in small polygons and spots.

Attack in the Columbia Forest District was down by a third from 2009 to 12,719 ha. Most of the attack continued to occur in the southeast tip of the district, particularly east of Mount King. Infestations in the Kamloops Forest District declined almost tenfold since last year to only 9,354 ha. The majority of the attack was mapped in small polygons along the western edge of the district.

Coast Forest Region damage

Mountain pine beetle infestations in the CFR declined for the fifth year in a row to 21,857 ha affected. Intensity of attack was lower as well, with 91% of the areas rated trace to light and the remaining 9% moderate to severe. The largest decline occurred in the North Island – Central Coast Forest District where disturbances were reduced to 6,902 ha from 46,194 ha last year. Virtually all of this attack continued to be located in Tweedsmuir Provincial Park. Infestations shrunk in both size and intensity, with the remaining mortality delineated along the north-eastern border of the district.

Attack in the Chilliwack Forest District continued to decline to 10,191 ha, less than half that observed in 2009. A large portion of this reduction occurred in Manning Park, where hectares affected dropped from 17,978 ha last year to only 1,006 ha in 2010. Otherwise, infestations continued to be located in the same general areas but were smaller in size. The majority of the disturbances were located in the north-east tip of the district.

After two years of infestation reductions, attack in the Squamish Forest District doubled since 2009 to 4,611 ha affected. Disturbances remained scattered along the eastern third of the district, with most increases observed east of the Lillooet River and along the Green River.

No other CFR districts sustained attack in 2009, but this year a few spot infestations were observed in the Sunshine Coast Forest District, and one small polygon (149 ha) of damage was delineated in the North Coast Forest District.

Beetle Flights / Larval Development

Throughout most of the province the weather was hot and dry during the mountain pine beetle flight period. Since the majority of the attack areas no longer have suppression status less resources were available to track beetle flights, but overall anecdotal reports indicated the good weather resulted in successful, concentrated flights.

Survey plane wing showing evidence of high altitude aerial dispersal of mountain pine beetle in the NIFR

The NIFR was particularly hot and dry this year. Beetle flights were observed to start the last week of July with the majority of the flights occurring in the first two weeks of August, though new attacks continued into late August. Additionally, a late flight was observed at the end of September in Fort St. James Forest District.

In most of the SIFR beetle flights appeared to be well synchronized, occurring in late July through early August. Resulting attack appears to be particularly successful in the Okanagan Shuswap Forest District along Hwy. 33, near Peachland and around Okanagan Falls. The weather was a little wetter during the flight period in Kootenay Lake Forest District but the rain was interspersed with warm dry weather which allowed for good beetle dispersal. In the Rocky Mountain Forest District the weather overall was wetter and cooler than usual, which did not allow for a concentrated beetle flight.

Tree response to attack

In the NIFR tree colour change in response to attack was generally reported as normal in timing, with very little fall (early) colour change. Although drought conditions were prevalent, it was thought that during the peak of the outbreak, above normal beetle attack densities caused early colour change and now that the outbreak is subsiding, attack densities have returned to normal levels. The drought stress did seem to lead to less pronounced pitch tube development however, particularly in the Kalum and Peace Forest Districts.

Tree colour change in the SIFR appeared to be more variable. Foliage turned chlorotic a bit early in the Headwaters and Okanagan Shuswap Forest Districts, but was reported to be normal or a bit late in the Cascades Forest District. Pitch tube development overall was observed to be normal.

Population fluctuations

During the current outbreak brood samples were collected from attacked trees in the early spring to estimate overwinter mortality in various districts, particularly in the SIFR. Data collected included percent mortality of beetles which was used to calculate whether a population was decreasing, static or increasing.

Results from the past two years concurred with the overview surveys that in most areas the mountain pine beetle populations have peaked and are on the decline. Therefore, overwinter mortality studies were not conducted this year except in the Peace Forest District, where they were undertaken by the Canadian Forest Service. A total of 1,618 trees over 70 sites were examined in this district. In contrast to the generally high values obtained in the 2009 survey, cold temperatures in the fall of 2009 and again in late spring of 2010 caused widespread mortality in overwintering populations. Only 16 of the 70 sites indicated increasing populations, generally in areas running northeast of Tumbler Ridge towards Dawson Creek and areas to the northwest of Fort St. John.

Another statistic that was previously collected to predict population changes was the ratio of green attack to red attack (G:R) found during ground surveys in suppression areas. Very few areas were involved in mountain pine beetle suppression efforts this year so reports on this statistic were sparse. In the Rocky Mountain and Kootenay Lake Forest Districts, indications were that the populations are static (average 1:1). The only other area reporting G:R ratios was the Kalum Forest District, where averages are 1.5:1, with a high of 8:1.

Ponderosa, whitebark and western white pine mortality

Infestations in whitebark pine increased substantially this year to a total of 33,460 ha provincially, as mountain pine beetle attack moved upslope out of decimated lodgepole pine stands. Severity of mortality remained relatively stable, with 18,778 ha (56%) trace, 12,144 ha (35%) light, 2,249 ha (7%) moderate, 276 ha (1%) severe and 13 ha (<1%) very severe. The majority of the attack (22,475 ha) occurred in Nadina Forest District, where no attack was observed last year. All the infestations were located in the western portion of the district, primarily in large trace polygons around Morice, Nanika and Tahtsa Lakes and a few smaller disturbances around Burnie Lakes and the Telkwa Range. These infestations spilled over into the Skeena Stikine and Kalum Forest Districts, where 965 ha and 205 ha of whitebark pine were attacked, respectively.

Whitebark pine attacked by mountain pine beetle near Smithers in the Skeena Stikine Forest District

In the SIFR, whitebark pine was damaged to the greatest extent in Cascades Forest District where infestations have remained stable for the third consecutive year at 4,779 ha affected. The majority of this attack continued to be scattered throughout the Lillooet TSA. Disturbances in the Headwaters Forest District declined to 3,026 ha, after a peak of 11,409 ha last year. Most of the reductions occurred in drainages south of the Fraser River, and the remaining infestations are small and scattered throughout the district. Attack in the Rocky Mountain Forest District rose slightly to 1,091 ha while mortality noted in the Kootenay Forest District dropped marginally to 476 ha. Infestations in these districts were small and widely scattered. After no attack was observed in the Columbia Forest District last year, 379 ha of whitebark pine mortality was recorded around the junction of the Columbia Reach and Bush Arm of Kinbasket Lake. The remaining 50 ha of damage in the SIFR occurred in the Arrow Boundary Forest District. An additional 14 ha of attack was recorded in the Squamish Forest District of the CFR.

Until 2010, ponderosa pine was the second most affected pine species in the province. Ponderosa damage peaked in 2008 at 132,929 ha and declined dramatically to 21,406 ha this year. Intensity levels remained similar to last year with 1,075 ha (5%) trace, 14,441 ha (68%) light, 4,780 ha (22%) moderate, 1,048 ha (5%) severe and 62 ha (<1%) very severe. Of the recorded attack, it is suspected that many of the trees continued to be killed by a complex of bark beetles, particularly at the lower elevations.

Almost all of the ponderosa pine attack continued to be located in the SIFR where the majority of this species occurs. Cascades Forest District continued to sustain the highest level of damage, with 16,471 ha mapped. The majority of this attack occurred along the Fraser and Thompson Rivers though infestations were scattered throughout ponderosa pine stands in the Merritt TSA. In the Okanagan Shuswap Forest District a total of 2,987 ha were affected in small disturbances primarily located along Okanagan Lake and a few side drainages. Kamloops Forest District sustained attack in 1,540 ha of ponderosa pine, chiefly around the Spatsum area. Minor infestations (under 125 ha per district) were observed in the 100 Mile House, Kootenay Lake, Rocky Mountain, Arrow Boundary and Headwaters Forest Districts in the SIFR. In the CFR 179 ha were delineated in the Chilliwack Forest District, mainly in one infestation near Boothroyd. A few spots were also noted in the Squamish Forest District.

Western white pine mortality peaked at 3,777 ha in 2008 and declined to only 360 ha in 2010. This is less than half the area recorded last year, though intensity increased somewhat with trace dropping from 98% to 56% and light intensity increasing correspondingly. All infestations continued to be located in the SIFR, with the majority (315 ha) located in scattered small disturbances in the Headwaters Forest District. Okanagan Shuswap Forest District contained 45 ha of attack, and one spot infestation occurred in each of the Arrow Boundary and Rocky Mountain Forest Districts.

Young pine mortality

Young pine mortality in managed stands accounted for 172,268 ha of attack this year, up from 97,308 ha in 2009. Most of the damage occurred in the NIFR, where the beetle population is still active. Along with the mountain pine beetle, various types of secondary bark beetles have also been observed killing some trees in immature stands (Ips beetle attack was particularly noticeable in the Fort St. James Forest District this year). As ground surveys have not been conducted to confirm the precise amount of mortality due to other factors and since more than one beetle is often present in a young attacked tree, damage is simply referred to as young mountain pine beetle mortality.

Young pine mortality on 1400 Rd in Prince George Forest District

Of the provincial total, 164,486 ha (96%) was mapped in the NIFR this year, up almost four fold since 2009. Severity levels fell however, with 67,423 ha (41%) trace, 60,375 ha (35%) light, 28,391 ha (17%) moderate, 7,401 ha (4%) severe and 896 ha (1%) very severe delineated. Prince George and Vanderhoof Forest Districts sustained 39,085 ha and 13,350 ha of attack, respectively. This mortality occurred in areas where the majority of the mature pine was killed several years ago, and beetle activity has dropped to endemic levels. Therefore, it is believed that the attacking beetles were brought in by wind from active populations north of these areas, an average of approximately 90 km and as far as 200 km away.

In the Nadina Forest District mountain pine beetle activity is slowing as the mature pine becomes depleted but 14,164 ha of young pine attack were identified this year scattered throughout the district. Young pine disturbances in the Mackenzie Forest District totalled 7,505 ha with a large concentration along the Nation River though damage continued north as far as Ingenika Arm. In the Peace Forest District, 1,982 ha of attack in young pine were recorded in small polygons scattered throughout the southwest portion of the district. Skeena Stikine and Fort Nelson Forest Districts sustained 312 ha and 194 ha of attack, respectively, and the remaining 2 ha were mapped in Kalum Forest District.

Young pine mortality north of Prince George

Where young managed stands are severely attacked to the point to be declared not satisfactorily restocked, stand rehabilitation treatments are underway through the MFR's Forests for Tomorrow program. In the Prince George Forest District, surveys have indicated that treatment is required on approximately 10-15% of the damaged stands. Under planting efforts have produced mixed results and the preferred treatment in these cases is to remove the dead trees and re-plant. Depending on the stand's proximity to a processing facility, the dead trees may be utilized by being chipped and taken to a plant for pellet fuel production.

Young pine mortality continued to sharply decline in the SIFR, down seven fold since last year to only 7,623 ha affected. Intensity levels remained low with 3,080 ha (40%) trace, 3,884 ha (51%) light, 622 ha (8%) moderate and 38 ha (1%) severe to very severe recorded. Infestations in the Okanagan Shuswap Forest District remained similar to last year with 3,888 ha affected, primarily scattered northwest of Okanagan Lake. A total of 1,163 ha of disturbances were mapped in the 100 Mile House Forest District, with the largest concentration north of Canoe Creek. In Headwaters Forest District 866 ha were delineated, mainly along Canoe Reach of Kinbasket Lake, Holmes River and Castle Creek. Cascades Forest District sustained 654 ha of attack, chiefly in the Merritt TSA. Infestations in the Kamloops, Central Cariboo and Quesnel Forest District totalled 377 ha, 310 ha and 238 ha, respectively. Minor levels of attack (under 65 ha per district) were mapped in the Rocky Mountain, Arrow Boundary, Chilcotin and Columbia Forest Districts.

Secondary beetle attack on young pine

In the CFR, young pine attack was observed in two districts: 149 ha in North Coast Forest District west of Khtada Lake and 10 ha in Chilliwack Forest District.

Dothistroma needle blight, *Dothistroma septospora*

Damage resulting from Dothistroma needle blight infections was recorded on 7,413 ha in the NIFR in 2010 (Figure 8). This is almost a quarter of what was mapped last year and well below the peak of 53,505 ha observed in 2008. The pronounced decrease in damage was anticipated, due to the relatively dry summer experienced over most of the NIFR last year. Overall severity was up slightly however, with 3,272 ha (44%) light, 1,946 ha (26%) moderate and 2,194 ha (30%) severe.

Noted damage was in the same general areas in 2010 as 2009. The Kalum Forest District sustained the highest level of damage with 4,860 ha of mortality. Most of the affected stands were situated along the east side of the Nass River near Jackpine Mountain; some were also scattered east of Meziadin Lake and a few small polygons were located north of Kitsumkalum Lake. The remaining 2,553 ha were observed in the Skeena Stikine Forest District scattered along the Kispiox River, around Kitwancool Lake and near Moricetown.

As part of the *Dothistroma Needle Blight Strategic Plan*, bi-annual helicopter monitoring flights which began in 2002 were conducted again this year. A total of 111 stands that had previously been classified as "Wait and See" (previously affected by Dothistroma but not to a level that required immediate action) were surveyed across the Skeena Stikine and Kalum Forest Districts. Of these blocks, 3 (2%) were assessed as "Action Imperative" (requiring ground surveys in 2011), 39 (35%) were downgraded to "No Immediate Action Required", 63 (56%) remained in the "Wait and See" group and the remaining 6 (5%) were removed for not fitting the criteria. Overall there was substantial damage noted in the stands, but very little was resulting in mortality at this time. The majority (91%) were assessed as still being free-growing (as estimated from the air).

Damage was not obvious enough to be observed during overview flights in other parts of the province. However, ground observations confirmed that infections were still present in the Prince George and Headwaters Forest Districts, particularly in low-lying topographical positions near rivers.

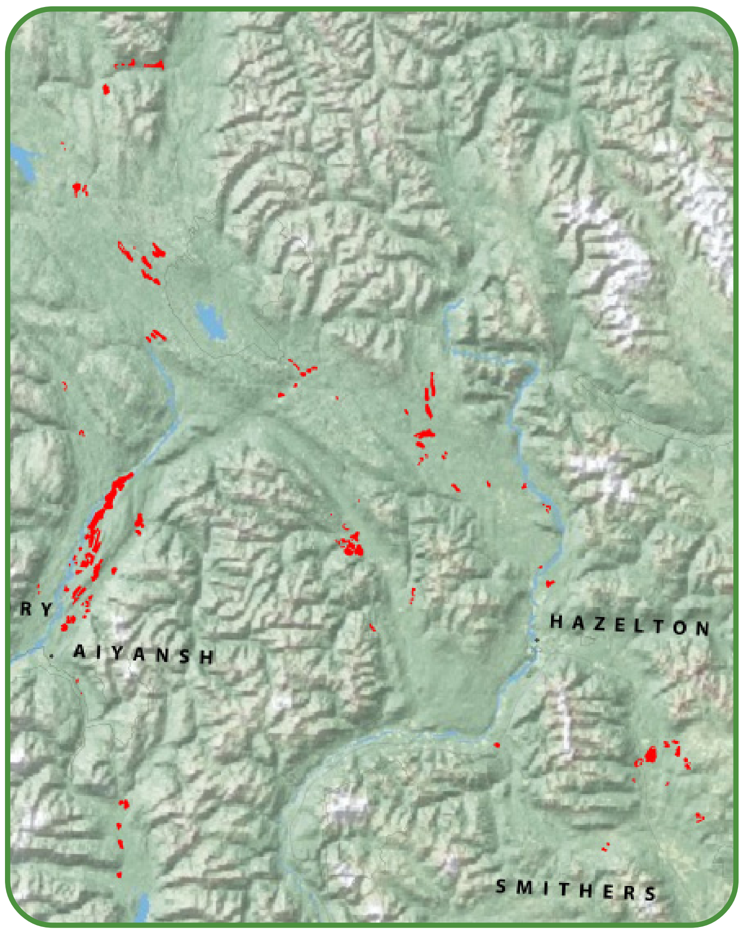


Figure 8. Dothistroma needle blight damage recorded during the 2010 aerial overview surveys.

Pine needle cast, *Lophodermella concolor*

Pine needle cast infections resulted in a total of 2,984 ha of recorded disturbances in 2010 with intensities noted as 1,103 ha (37%) light, 1,632 ha (55%) moderate and 250 ha (8%) severe. This is a decrease of more than half the area affected last year. Peak damage occurred in 2008 when 16,912 ha of pine were defoliated: this followed the same trend as was noted for Dothistroma needle blight damage.

The areas where damage occurred changed substantially in 2010 from 2009. Almost all the disturbances last year were situated in the Skeena Stikine Forest District, where only one polygon of 38 ha was observed this year. Conversely, no damage had recently been recorded in the Vanderhoof Forest District where 1,201 ha were mapped this year, primarily between Murray and Tahultzu Lakes. The remaining 1,725 ha of NIFR pine needle cast disturbances were located in the Nadina Forest District, mainly around Saddle Hill, Pinkut Creek and Tchesinkut Lake.

Pine needle cast damage to young logepole pine in Vanderhoof Forest District

In the SIFR, four small polygons totalled 38 ha of damage in the Cascades Forest District.

White pine blister rust, *Cronartium ribicola*

White pine blister rust damage is not always visible during the aerial overview surveys, particularly if the infections have not killed the tree. However, surveyors often observe scattered damage throughout the range that the host trees grow. These are often recorded as spots or small scattered polygons and amount to less than 200 ha annually across the province.

This year 2,396 ha of white pine blister rust damage was recorded. The reason for the jump in hectares affected was that several large polygons totalling 2,328 ha were mapped at trace intensity in the North Island – Central Coast Forest District. Although the damage occurred primarily as scattered single trees, damage was at a high enough level that recording spot infections was not possible. These disturbances were located in the middle of Vancouver Island along the Nimpkish River north of Vernon Lake.

The remaining 68 ha of damage was chiefly recorded as spots in the South Island, Sunshine Coast and Campbell River Forest Districts of the CFR and the Arrow Boundary, Columbia, Kootenay Lake and Rocky Mountain Forest Districts of the SIFR.

White pine blister rust infection on a young white pine

Damaging Agents of Douglas-fir

Western spruce budworm, *Choristoneura occidentalis*

Recorded Defoliation
Western spruce budworm defoliation mapped across southern BC declined for the third consecutive year to 500,121 ha (Figure 9). Overall severity was down as well with 449,481 ha (90%) light, 50,601 ha (10%) moderate and 39 ha (<1%) severe observed.

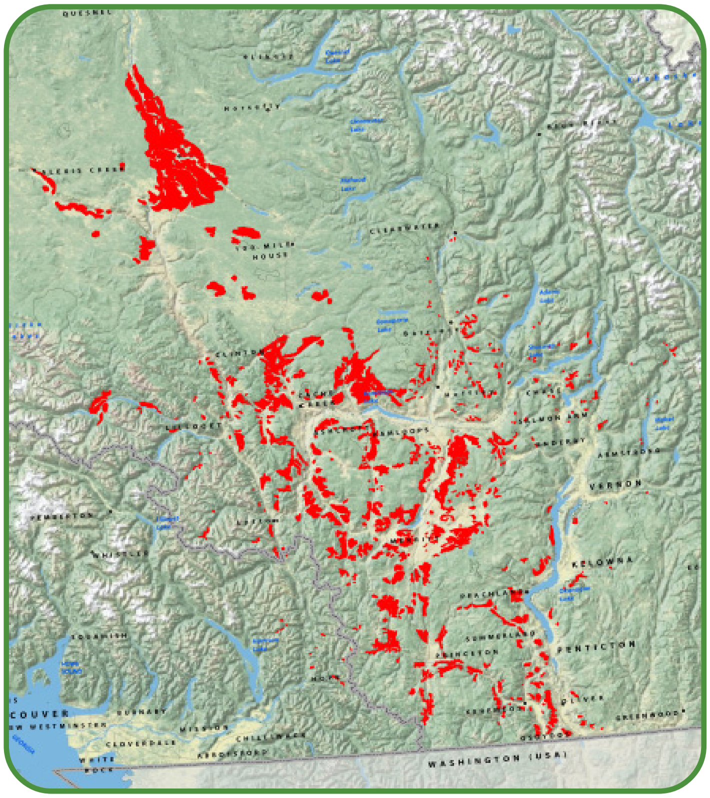


Figure 9. Areas defoliated by western spruce budworm in BC in 2010.

The majority of the damage continued to occur in the SIFR where 499,104 ha were delineated. Infestations in the Cascades Forest District were the highest of all the districts for the first time in many years, though they were down slightly from last year (Figure 10). A total of 146,119 ha were affected with disturbances primarily scattered around Carpenter Lake and throughout the district eastward from the Fraser River. The Central Cariboo Forest District continued to experience substantial areas of defoliation, though visible defoliation dropped by 45% since last year to 137,445 ha. Damage along both sides of the Fraser River and eastward to Knife Creek remained similar to 2009 but large infestations recorded around Riske Creek south past the Chilcotin River were no longer noticeable. The only noticeable increase in the west was delineated in two moderately damaged areas adjacent to the Dome.

Unlike the declines experienced in most of the districts, infestations in the Kamloops Forest District rebounded almost to 2008 levels with 116,255 ha recorded (Figure 10). Stands affected were noted throughout Douglas-fir types in the district, with the largest areas mapped west of the Bonaparte River, around Deadman River, and around Roche Lake. After a peak of 121,383 ha last year, defoliation in the Okanagan Shuswap Forest District declined by two thirds to 40,896 ha of attack. The majority of the infestations continued to be around Okanagan Lake, particularly on the west side, but the size of the areas have shrunk. Damage was also noted around the Shuswap Lake area.

Infestations in 100 Mile House Forest District continued to decline sharply to only 39,279 ha, which is only 40% of the area recorded as defoliated last year. Several infestations, in particular chronic areas around Clinton and Loon Lake, shrank in size and intensity. The most dramatic decreases occurred from Horse Lake to north of Lac La Hache.

Although the infestations only totalled 10,129 ha in the Quesnel Forest District, this is a peak for western spruce budworm defoliation recorded in this district. Defoliation was mapped on both sides of the Fraser River almost to Alexandria and 3,096 ha (44%) were rated as moderate intensity. Conversely, damage receded dramatically in the Chilcotin Forest District, with 8,908 ha of defoliation noted directly along the Chilko and Chilcotin River drainages east from Alexis Creek. This is down from 60,750 ha last year. The remaining damage observed in the SIFR occurred on 73 ha in the Headwaters Forest District. Defoliation also continued to occur in the Kootenay Lake Forest District in a grand fir stand just south of Nelson, though this wasn't observed in the overview surveys this year.

In the CFR, only 1,016 ha were affected in Chilliwack Forest District, scattered along drainages around the Fraser River. This is down from a peak of 43,040 ha recorded for the CFR in 2007.

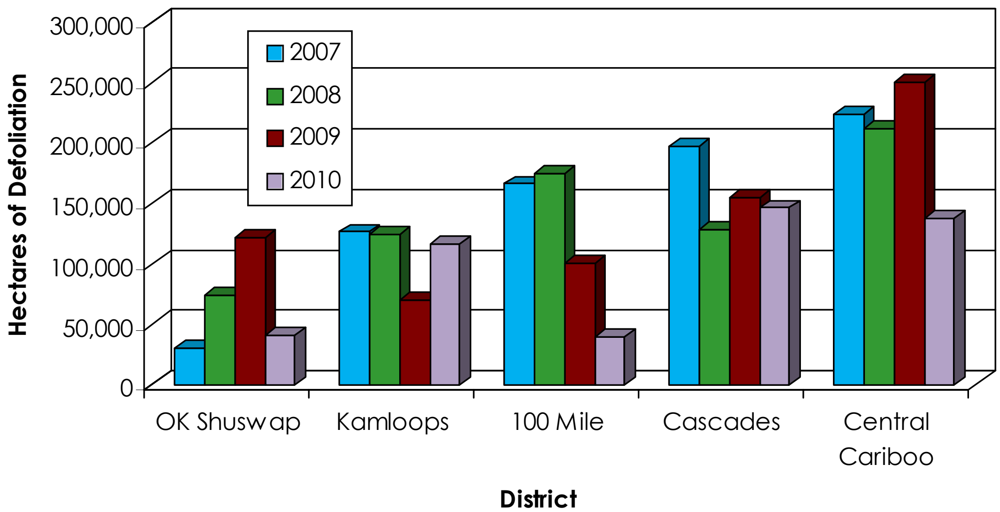


Figure 10. Hectares of western spruce budworm defoliation from 2007 – 2010, for districts with over 30,000 ha damaged in 2010.

Treatment Program

The biological control agent *Bacillus thuringiensis* var. *kurstaki* (Btk) in the formulation Foray 48B® was applied to high value stands in the SIFR to reduce western spruce budworm populations. The product was applied aerially in a single application per stand at a rate of 2.4 litres/ha.

Btk treatment with an AT 802 Air Tractor in the Central Cariboo Forest District

For the southern portion of the program, Lama 315B and Hiller UH12ET helicopters were used to spray 21,699 ha in the Cascades Forest District and 4,879 ha in the Okanagan Shuswap Forest District. Block sizes ranged from 336 ha to 4,200 ha and treatments occurred from June 23rd to 26th.

Application in the northern portion was carried out with two fixed wind AT 802 Air Tractors on 21,115 ha in the Central Cariboo Forest District. Block sizes ranged from 171 ha to 6,317 ha and treatments occurred from Jun 22nd to 27th.

Bud flush and larval growth was carefully monitored to determine optimal application timing. Across some of the treatment areas, bud and larval development varied widely with both elevation and locations to a greater extent than normal, which made choosing the best treatment dates difficult. Pre- and post- treatment egg mass sampling conducted in some treated areas however indicated that substantial population reductions were achieved.

Egg Mass Results

Western spruce budworm egg mass surveys were conducted at 643 sites in eight forest districts in the fall of 2010 (Table 4). The results predicted defoliation for each surveyed area in the spring of 2011 based on the density of egg masses found on a given surface area of foliage ($10m^2$). This prediction is used as a tool for prioritizing areas for treatment. Stands with predicted moderate to severe defoliation are considered for treatment, depending on various criteria such as values at risk, stand recovery capability and previous defoliation.

Table 4. Summary of western spruce budworm defoliation predictions for 2011 based on 2010 egg mass survey results.

Forest District	**Number of Sites by Defoliation Category**				**Total Sites**
	Nil	**Light**	**Moderate**	**Severe**	
100 Mile House	17	72	3	0	92
Cascades	16	130	39	1	186
Central Cariboo	6	51	15	1	73
Chilcotin	5	7	3	0	15
Chilliwack	1	10	2	0	13
Kamloops	23	165	14	0	202
Okanagan Shuswap	0	37	20	0	57
Quesnel	0	1	2	2	5
Total	68	473	98	4	643

Western spruce budworm larva

Since infestations had decreased in many areas the number of sites surveyed decreased as well by 90 from last year. Sites with severe defoliation predicted remain low, with only four sites identified compared to a peak of 28 sites in the 2007 surveys. The number of moderate sites is down slightly from last year to 98, but this still represents a substantial area where damage is expected to occur if treatments are not conducted.

Sites of concern in the northern portion of the SIFR region are in the Central Cariboo Forest District south of Farwell Canyon, north of Soap Lake, around Till Lake, Bald Mountain and Chimney Lake. Proposed treatment areas in the Quesnel Forest District run from the southern boundary along the Fraser River and up to Diamond Island. Sites of concern in the southern portion of the SIFR are relatively scattered, but general areas are Placer Mountain and Princeton in Cascades Forest District, the south Okanagan near Penticton in Okanagan Shuswap Forest District, and the Tulameen, Merritt and Nicola valley areas in Cascades Forest District. A total of up to 50,000 ha are expected to be treated next year, mainly in the SIFR.

Douglas-fir tussock moth, *Orgyia pseudotsugata*

A Douglas-fir tussock moth outbreak continued in the SIFR in 2010, with a total of 16,303 ha affected, down from 17,512 ha last year. Intensity levels increased to 1,042 ha (7%) light, 5,102 ha (31%) moderate, and 10,159 ha (62%) severe.

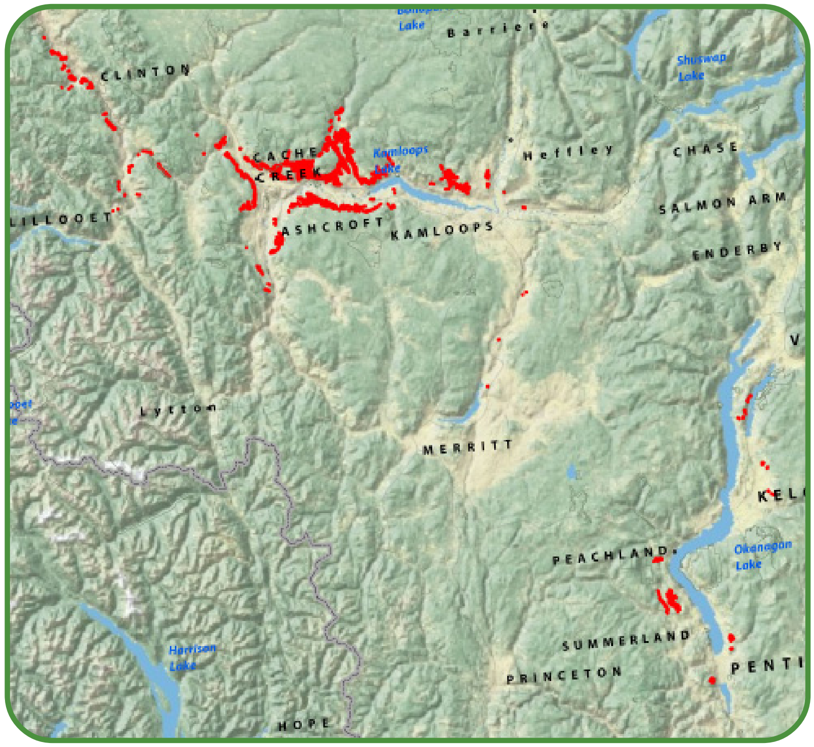


Figure 11. Douglas-fir tussock moth defoliation mapped in 2010.

The majority of the defoliation continued to occur in the Kamloops Forest District, where 14,022 ha were mapped (Figure 11). Infestations moved westward this year, in part due to successful control treatments along the north and south Thompson River. The majority of damage occurred north of Mara Hill, along the Bonaparte River, and around the Thompson River west of Kamloops Lake. Damage in the Okanagan Shuswap Forest District shrank by more than half since last year to 1,148 ha, located around Okanagan and Skaha Lakes with the largest infestation between Peachland and Summerland. The remaining 1,132 ha of defoliation were recorded in the Cascades Forest District, primarily along the eastern boundary of the Lillooet TSA from Pavilion Lake to South French Bar Creek.

Table 5. Average number of Douglas-fir tussock male moths caught per trap, 2003 – 2010 at six trap cluster sites.

Year	District			
	Kamloops (# sites)	Okanagan Shuswap (# sites)	Cascades (#sites)	100 Mile House (#sites)
2003	44.0 (9)	9.2 (8)	10.7 (3)	3.0 (34)
2004	5.6 (9)	6.2 (8)	0.9 (3)	1.5 (36)
2005	13.2 (9)	22.4 (8)	9.8 (3)	0.6 (23)
2006	19.0 (9)	4.2 (8)	1.5 (3)	0.5 (24)
2007	34.9 (9)	5.7 (8)	14.6 (3)	0.9 (24)
2008	67.3 (9)	41.6 (8)	28.6 (3)	2.2 (24)
2009	16.5 (9)	19.0 (8)	25.3 (3)	3.9 (30)
2010	18.5 (19)	9.6 (12)	6.1 (12)	1.7 (30)

Douglas-fir tussock moth populations are monitored annually with pheromone traps placed at specific sites in Cascades, Kamloops, Okanagan Shuswap and 100 Mile House Forest Districts. As outbreaks tend to be cyclical and develop quickly,

Douglas-fir tussock moth egg masses

this monitoring system provides early warning of rising populations so treatments can be initiated before significant defoliation occurs. Previous to 2010 some sites only had single monitoring traps but these proved to be less reliable than the six trap clusters for predicting the current outbreak. This year these sites were discontinued and some new six trap sites were added. The general rise in trap catches at the six cluster sites from 2006 to 2008 mirrored the current developing outbreak quite well (Table 5). In 2009 average trap catches decreased as populations peaked and/or were controlled in many areas. This trend continued in 2010 with the exception of a modest rise in the Kamloops Forest District, primarily from sites in the western portion of the district. Since outbreaks are quite localized, averages per district do not give the entire picture though the trend to lower numbers at this point in the epidemic make sense. Once an outbreak is underway, monitoring trap numbers are less meaningful.

Hiller helicopter applying Btk in Kamloops park

Based on 2009 trap catches and egg mass surveys, aerial control treatments were conducted with Hiller UH12ET helicopters from Western Aerial Applications Ltd. on a total of 7,576 ha (block sizes ranging from 2 ha to 2,186 ha) between June 4th to 18th. Treatment occurred on 4,912 ha in the Kamloops Forest District, 2,499 ha in the Okanagan Shuswap Forest District and 165 ha in the Arrow Boundary Forest District. All of the treatments were conducted by the MFR with the exception of 395 ha done by the City of Kamloops in city parks. Most of the areas (6,129 ha) were treated with two applications of Foray 48B® at 4.0 l/ha. An additional 1,347 ha were sprayed with nucleopolyhedrosis virus and the remaining 100 ha were treated with a combination of both. A control program using just Foray 48B® is planned for the spring of 2011 in areas that still have high populations, primarily west of Kamloops.

Mixing NPV virus with molasses for treatment application

Douglas-fir tussock moth infected with NPV virus

Douglas-fir beetle, *Dendroctonus pseudotsugae*

After seven consecutive years of increases in mortality caused by Douglas-fir beetle, infestations in 2010 dropped to only 15% of the area recorded last year with a total of 15,789 ha mapped across the province (Figure 12). Overall smaller, higher intensity infestations were mapped resulting in an increase in severity levels to 5,633 ha (36%) trace, 6,786 ha (43%) light, 2,287 ha (14%) moderate, 1,067 ha (7%) severe and 16 ha (<1%) very severe.

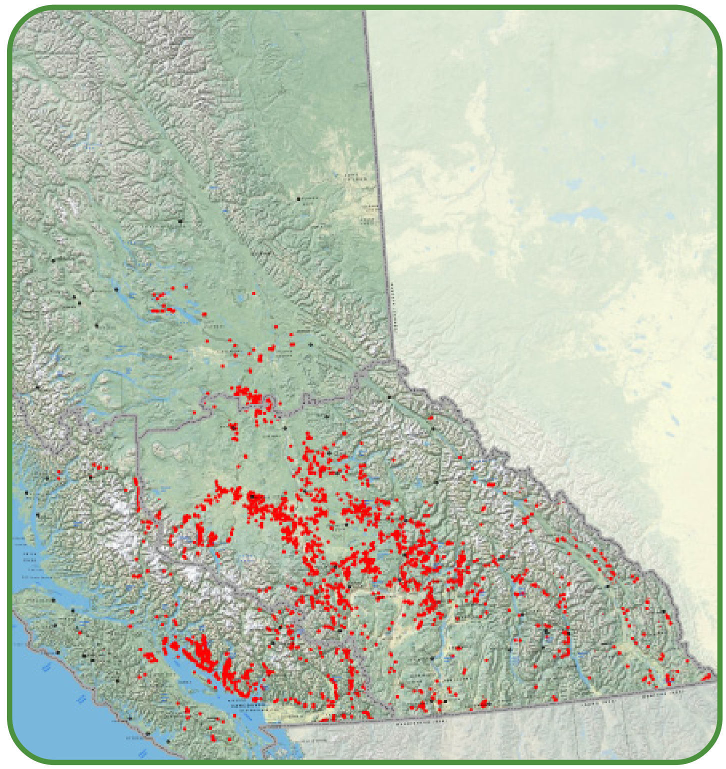


Figure 12. Douglas-fir beetle mortality recorded in BC in 2010.

Unlike the last several years, the Cariboo area did not contain the large majority of the damage in the SIFR. Attack in the 100 Mile House Forest District peaked at 22,684 ha last year but dropped dramatically in 2010 to 2,871 ha affected, of which 86% was recorded at trace intensity. The largest infestations remained around Big Bar, Kelly Lake, Machete Lake and Canim Lake. The Chilcotin Forest District sustained 2,897 ha of attack, down from a peak of 16,212 ha last year. Most of the remaining infestations were small and scattered, with a few large polygons along the Chilko River. Ground probes conducted in the Chilcotin Forest District confirmed the sharp decline with only 37% of the sites that were identified aerially last year having any current attack. The Central Cariboo Forest District experienced the largest drop of all from a peak of 51,248 ha to only 758 ha this year. All sites were very small and scattered with the exception of three trace to light severity polygons in the Gaspard Creek and Dog Creek areas. Unlike the rest of the Cariboo area, infestations in the Quesnel Forest District were never very high (most likely due to a lower percentage of host trees) and have been steadily declining for the past three years. In 2010, 654 ha of Douglas-fir beetle mortality was delineated primarily along the Fraser River at the northern boundary of the district. Due to the low populations, no overwinter mortality surveys were conducted in the Cariboo this year.

For the rest of the SIFR, the largest increase (almost triple last year) and the highest level of infestations occurred in the Rocky Mountain Forest District where 1,287 ha of attack were mapped. Most of the damage occurred in small centers scattered throughout the district, with some larger concentrations north of Grave Lake, beside Whiteswan Lake and along the Kootenay River in the northern portion of the district. Attack in the Kamloops Forest District decreased to almost a third of last year's damage, with 635 ha delineated in small, scattered pockets. The remaining SIFR districts continued to have relatively low levels (<600 ha) of attack. Most of these infestations occurred in spots and a few small polygons scattered throughout the districts.

Infestation levels and intensity of attack increased in the CFR this year, with disturbances more than doubling from 2009 to 3,557 ha affected. The large increase is primarily due to mortality in the South Island Forest District where no attack was observed last year but 1,435 ha of mainly light intensity disturbances were mapped in 2010. Most of the sites were spot infestations, but one large polygon was delineated north of Port Alberni. It was suspected that this infestation developed as a result of weakened or downed trees caused by flooding during a creek washout. Observed attack in the Chilliwack Forest District remained steady with 1,117 ha noted. The largest infestations were along the Fraser River at the northern end of the district and along Mehatl Creek. District staff suspects actual attack hectares may be higher in the Chilliwack valley than mapped, due to substantial blowdown that occurred in 2006. This area was flown fairly late in the season so new attack may have appeared to be old. In the Sunshine Coast Forest District, attack rose from nothing to 735 ha. These infestations occurred in widespread spots along the coast and inlets, with a concentration between Jervis and Sechelt inlets. This attack is thought to be the result of populations building after 2006/2007 windthrow events coupled with drought conditions. The remaining CFR attack remained at relatively static, endemic levels (<180 ha) in the North Island – Central Coast, Squamish and Campbell River Forest Districts.

Douglas-fir beetle mortality exacerbated by flooding, north of Port Alberni in the South Island Forest District

In the NIFR, attack declined to 2008 levels with a total of 844 ha affected. Almost all of the infestations remained in the Prince George Forest District, where 834 ha were delineated, primarily in spot infestations throughout the south-western quarter of the district. The largest concentration continued to occur along the Blackwater River on the southern edge of the district. Funnel trap captures concur with the observed drop in Douglas-fir beetle populations. The only other attack noted aerially in the NIFR was 6 ha in the Fort St. James Forest District in spot infestations along the eastern edge of the district. No attack was detected in the Vanderhoof Forest District this year, but ground observations noted spotty attack was still present in the Bobtail, Fraser Lake and Francois Lake areas.

Douglas-fir felled as trap trees in the NIFR

In areas where Douglas-fir beetle is a concern, control measures are taken. Management involves conducting detailed aerial surveys and ground surveys to determine the population levels and locations. Follow-up treatments are then performed as appropriate for the site and infestation level. Treatments include targeted conventional and small scale harvesting, trap tree placement, deployment of clusters of baited funnel traps, use of anti-aggregation pheromones (MCH) and fall and burn.

The decrease in Douglas-fir beetle populations in many of the BC interior districts is suspected to be a combination of these aggressive suppression activities combined with a natural decline due to fungal disease.

In some areas where the populations were previously too high to utilize control measures, these strategies may now prove effective. In other areas where populations are down to endemic levels, monitoring must still be conducted to ensure beetle activity does not rebound. Substantial areas of Douglas-fir stands have been affected by wildfire in the interior over the past two years. Trees damaged by fire and those downed during the construction of fire guards are ideal breeding habitat for the Douglas-fir beetle.

Douglas-fir needle cast, *Rhabdocline pseudotsugae*

Light needle damage caused by Douglas-fir needle cast was observed on 260 ha in the Chilliwack Forest District. The damage was contained within two polygons between Stave and Alouette Lakes and a third area near Yale along the Fraser River. The stands affected were young Douglas-fir located in areas that ground checks were not possible. Therefore, the casual agent could not be positively confirmed, though Douglas-fir needle cast infections have been identified recently in other areas within the district.

Western false hemlock looper, *Nepytia freemani*

Western false hemlock looper defoliation was observed on 220 ha of Douglas-fir in the Rocky Mountain Forest District. All damage was rated as light, with the majority located in a single polygon along the Kootenay River south of Canal Flats. A few small polygons were also delineated south of Windermere Lake.

The last defoliation by this looper to be detected during aerial overview surveys occurred in 2002, when over 2,500 ha were severely damaged in the Eager Hills outside of Cranbrook.

Laminated root disease, *Phellinus weirii*

A total of 2,251 ha were identified as infected with laminated root disease in the CFR, up from only 192 ha last year. As root disease does not change this radically from year to year, the difference was primarily a factor of the visibility of the damage from the air and local knowledge of the surveyors. This disturbance is very difficult to distinguish from older Douglas-fir beetle damage, which would not be mapped.

Intensity of damage was rated as 1,241 ha (55%) light, 986 ha (44%) moderate and 24 ha (1%) severe. A total of 1,175 ha were located in the Chilliwack Forest District. Most of the areas were noted north of Hope along the Fraser River and on Bowen Island. In the South Island Forest District 912 ha were delineated, mainly in one large infection center on Saturna Island. Damage observed in the Sunshine Coast and Campbell River Forest Districts was 89 ha and 74 ha, respectively. Minor spot infection centers were also found in the North Island – Central Coast and Sunshine Coast Forest Districts.

Damaging Agents of Spruce

Spruce beetle, *Dendroctonus rufipennis*

Provincially, spruce beetle mortality remained static at 30,096 ha of attack, though several of the damage locations changed. Intensity levels were recorded as 5,461 ha (18%) trace, 11,424 ha (38%) light, 11,179 ha (37%) moderate, 1,942 ha (7%) severe and 89 ha (<1%) very severe.

The SIFR contained almost all of the attack in 2010 with 29,943 ha infested. The Central Cariboo Forest District continued to sustain the highest levels of spruce beetle infestations with 16,520 ha affected, almost double that observed in 2009. Damage occurred in the easternmost quarter of the district, particularly south of Quesnel Lake to the district boundary. Licensees have been addressing these areas with large scale salvage harvesting and, where appropriate, employing an extensive trap tree program. One of the largest areas of attack continued south into the 100 Mile House Forest District, where infestations tripled over last year to 9,198 ha. All the attack in this district was situated in the northeast corner around Mt. Hendrix, Boss Creek and Deception Creek.

Infestations in Kamloops Forest District decreased by almost a third since last year to 2,288 ha. The majority of the attack was delineated in the same two areas around Sun Peaks and Silwhoiakun Mountain, with a few small additional polygons near Carin Peak. Cascades Forest District experienced a fivefold decrease to 603 ha, at least in part due to aggressive salvage operations by licensees. The remaining spruce beetle mortality was at the south end of the district around Flat Top Mountain, mid district near Kanaka Mountain and widely scattered south of Carpenter and Seton Lakes. Attack in the Headwaters Forest District declined as well to 561 ha of damage which was primarily located east of Kinbasket Lake near the district boundary. Conversely, disturbances in the Rocky Mountain Forest District increased almost four fold to 518 ha. The infestations continued to be primarily concentrated in the Fenwick Creek drainage, where most host polygons have now been attacked. Salvage harvesting combined with a trap tree program is addressing the spruce beetle attack in the district. Attack in the Okanagan Shuswap Forest District declined sharply by 98% since last year with only 130 ha delineated in small polygons west of the Similkameen River. Spruce beetle infestations in other districts in the SIFR remained at endemic levels (<100 ha).

Mortality caused by spruce beetle in the NIFR continued on a downward trend with only 107 ha delineated, compared to 5,219 ha last year. This drop was due mainly to a decrease in the Skeena Stikine Forest District infestations from 3,428 ha to 82 ha. The decline is in part due to the fact that the Cassiar TSA was not surveyed this year, where a substantial portion of the attack was observed last year. Disturbances in 2010 were located along the Skeena River south of Kuldo Mountain. No infestations were noted

Primarily old mortality caused by spruce beetle in Fenwick Creek, Rocky Mountain Forest District in the Peace and Fort Nelson Forest Districts this year, where 1,158 ha and 413 ha were mapped, respectively, last year. In Prince George, Nadina, Vanderhoof, Fort St. James and Kalum Forest Districts only minor attack (<20 ha each) was observed. However, ground reconnaissance in the Fort St. James Forest District has found current infestations in several areas, in particular the Cunningham, Cloche, Kazchek and Takatoot areas. This is also the case in the Nadina Forest District, where a combination of trap trees, fall and burn and sanitation harvesting is being conducted to control infestations in the Pinkut Lake, Boer Mountain and Maxan Lake areas. A wind event sometime last winter resulted in substantial spruce windthrow at George Creek in the Prince George Forest District, where staff have confirmed the presence of some spruce beetle. Large wildfires in the eastern portion of the NIFR this year are also of concern for spruce beetle where spruce trees were damaged but not killed and where large areas of spruce were felled and left on fire guards.

Spruce beetle populations continued to be very low in the CFR with only 46 ha of attack in the Sunshine, Campbell River and North Island – Central Coast Forest Districts.

Damaging Agents of True Fir

Western balsam bark beetle, *Dryocoetes confusus*

Western balsam bark beetle damage remained similar to last year with 1,772,395 ha affected across BC (Figure 13). This is in contrast to a large drop reported in 2008, which was more a factor of survey differences than a true reduction in mortality. Intensity levels remained similar as well with 1,707,618 ha (96%) of trace, 63,863 ha (4%) light and 914 ha (<1%) moderate to severe delineated.

This bark beetle tends to affect the same stands year after year with chronic, low levels of scattered attack. This is reflected in the high percentage of trace intensity that is always recorded. Where mortality continues to be chronic over time however, cumulative attack can result in severely damaged stands.

The majority of the attack (1,584,632 ha) continued to occur in the NIFR where subalpine fir is most abundant. Infestations rose in the Mackenzie Forest District this year with 334,245 ha affected, up 19% from 2009 (Figure 14). The largest concentration of damage was noted in the southern third of the district, though scattered disturbances were mapped throughout the remaining area. Fort St.

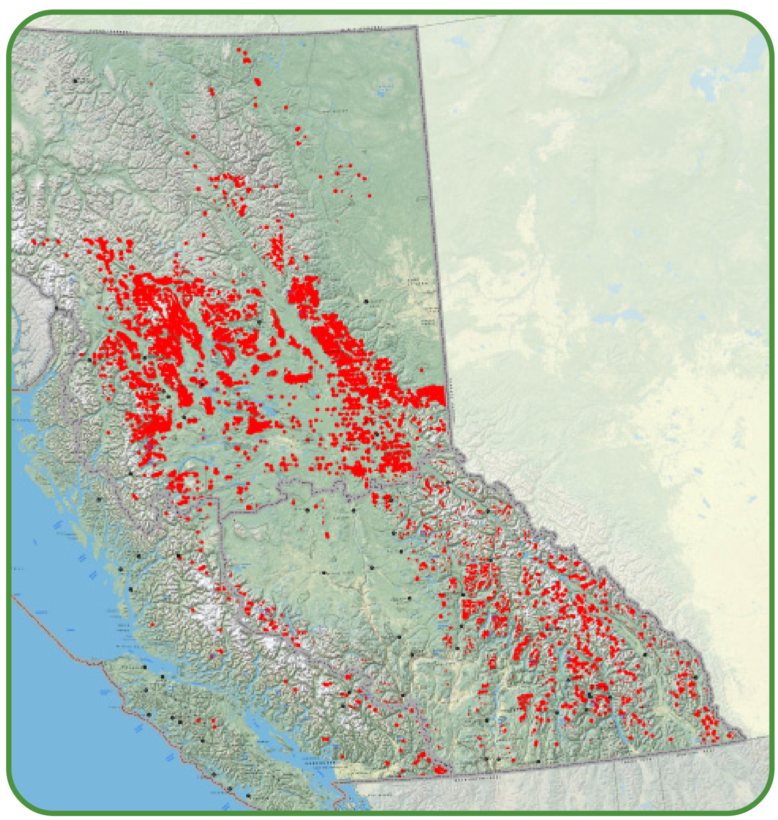


Figure 13. Western balsam bark beetle damage mapped in 2010.

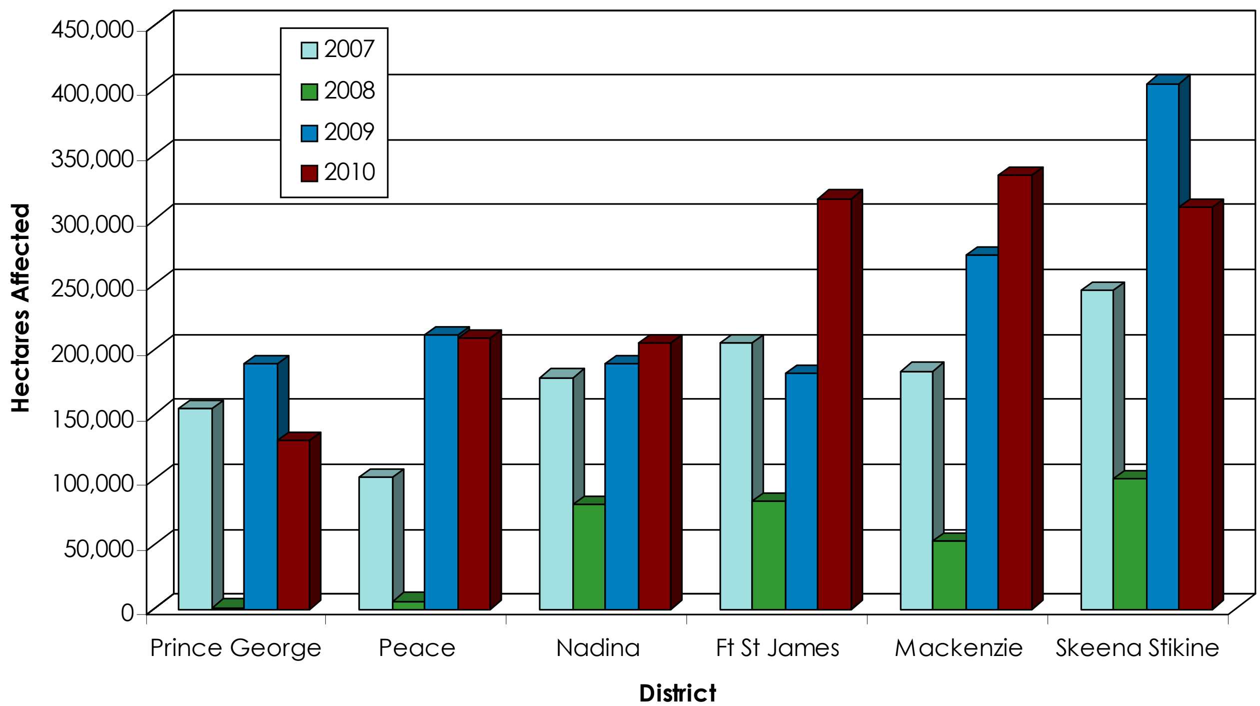


Figure 14. Hectares affected (all severity classes) by western balsam bark beetle in BC from 2007 – 2010, for districts with over 120,000 ha of damage in 2010.

James Forest District had the largest increase in area of attack since last year, up two thirds to 316,030 ha. Most of the disturbances were located mid district. The increases experienced by both districts this year were in part due to more of the areas being flown than in 2009.

Skeena Stikine Forest District sustained 309,433 ha of mortality, with large polygons recorded throughout the Kispiox and Bulkley TSA's. No infestations were mapped in the Cassiar TSA this year because it wasn't flown; this may account for the drop in total district area affected from 404,836 ha last year. Attack in the Peace remained similar to 2009 with 208,619 ha affected, though large infestations along the south-western border of the district shrank and a new large area east of Onion Lake was delineated. Disturbances in Nadina Forest District rose slightly to 204,487 ha and they continued to be concentrated in the northwest portion of the district. Infestations in the Prince George Forest District fell by a third to 129,249 ha with reductions most noticeable in the northern tip. A total of 50,288 ha were mapped in the Vanderhoof Forest District, which is almost triple the level noted last year. This partially is due to very little current mountain pine beetle attack being left in this district to mask the red subalpine fir trees. The majority of the attack was located in the northern tip of the district. The remaining infestations in the NIFR were observed in the Kalum and Fort Nelson Forest Districts, with 23,446 ha and 8,835 ha affected, respectively.

In the SIFR, infestations dropped by almost a quarter since last year to 183,296 ha. Decreases occurred in all the districts with the exception of the Quesnel Forest District where damage rose slightly to 17,279 ha. The Okanagan Shuswap Forest District continued to be the most affected with 57,419 ha of damage recorded throughout the district. Similar levels of attack were observed in the Headwaters Forest District where 56,622 ha were mapped, with the heaviest concentration in the southern third of the district. All infestations in the Kamloops Forest District were located in the northeast corner and totalled 16,640 ha district wide. Mortality occurred primarily west of Wells in the Cariboo Forest District with 10,797 ha affected. Small infestations were scattered throughout the remaining SIFR districts with less than 6,000 ha affected per district.

Western balsam bark beetle attack in the CFR continued to decline with only 4,467 ha noted in 2010, down from 7,944 ha last year. Despite the overall decrease, infestations in the Squamish District rose to 2,095 ha. North Island – Central Coast Forest District sustained 1,607 ha of attack and 681 ha were affected in the Chilliwack Forest District. The remaining infestations were located in the Sunshine Coast and Campbell River Forest Districts with 73 ha and 12 ha mapped, respectively.

Subalpine fir mortality caused by western balsam bark beetle near Smithers in the Skeena Stikine Forest District

Two-year-cycle budworm, Choristoneura biennis

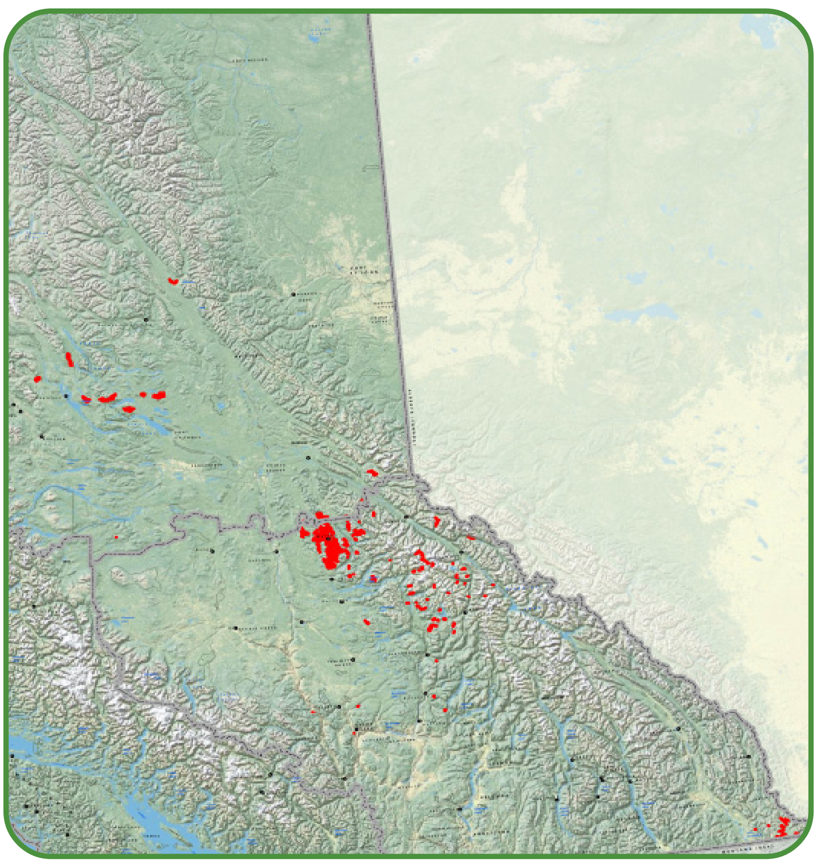


Figure 15. Two-year-cycle budworm defoliation mapped in 2010.

Two-year-cycle budworm affected a total of 97,084 ha across BC in 2010 (Figure 15). This is down substantially from the peak of 396,855 ha last year. Most of the damage last year (99%) occurred in the NIFR where this budworm has peak defoliation in odd years. Last year's damage was the most widespread and severe that has been recorded for at least the last decade. Conversely 2010 is the low year in the cycle and only 26,390 ha were mapped in the NIFR at 25,104 ha (95%) light and 1,287 ha (5%) moderate intensity.

Fort St. James Forest District sustained the most NIFR defoliation, with 14,582 ha affected in the southern portion of the district around Trembleur Lake, Inzana Lake and the Northwest Arm of Takla Lake. Two infestations totalling 3,268 ha were also noted in the Nadina Forest District directly west of the Trembleur Lake damage

Two-year-cycle budworm feeding damage at Mosquito Hills in the Nadina Forest District

in the Fort St. James Forest District. Ground observations in the Nadina and Fort St. James Forest Districts found light defoliation not visible from the air to be very widespread. In the Prince George Forest District, 6,045 ha of defoliation were mapped along the southern boundary: some of this damage may be caused by budworm populations on the even year cycle. The one moderate disturbance of 1,287 ha was located beside Torkelsen Lake and covered all damage in Skeena Stikine Forest District. One infestation on the Ospika Arm of Williston Lake in Mackenzie Forest District caused 1,163 ha of damage, and the remaining 47 ha were located in Vanderhoof Forest District.

In the SIFR, where two-year-cycle budworm is at the peak of its cycle, 70,694 ha of defoliation was detected at 46,689 ha (66%) light and 24,005 ha (44%) moderate intensity. Quesnel Forest District sustained the highest level of defoliation with 46,846 ha of damage located east of the Quesnel River. This attack spilled into the north-eastern portion of the Central Cariboo Forest District to Quesnel Lake with 8,590 ha mapped. Infestations were scattered throughout the Headwaters Forest District and totalled 10,965 ha. Minor damage was also recorded in the 100 Mile House, Kamloops and Cascades Forest Districts at 686 ha, 470 ha and 9 ha, respectively.

A rather unusual outbreak was observed in the Flathead Valley south of Tombstone Mountain in the Rocky Mountain Forest District that covered 3,129 ha of primarily moderate intensity damage. In this infestation, a combination of subalpine fir, spruce and Douglas-fir were affected and it is uncertain at this point if it is two-year-cycle or western spruce budworm, though two-year-cycle budworm is most likely.

Budworm defolition of primarily subalpine fir in the Flathead Valley, Rocky Mountain Forest District

Damaging Agents of Hemlock

Western hemlock looper, *Lambdina fiscellaria lugubrosa*

Western hemlock looper defoliation affected 3,318 ha provincially. This is similar to the hectares damaged last year but the largest infestations occurred in different locations this year. Intensity of attack was lower, with 3,286 ha (99%) light and 32 ha (1%) moderate delineated.

The majority of the disturbances were mapped in small polygons totalling 2,637 ha along the North Thompson River and around Murtle, Clearwater and Azure Lakes in the Headwaters Forest District. In the Columbia Forest District, 358 ha of attack were noted along Revelstoke Lake. The remainder of the defoliation in the SIFR occurred in the Okanagan Shuswap and Kootenay Lake Forest Districts with 35 ha and 5 ha affected, respectively.

Western hemlock looper

In the CFR, 282 ha of western hemlock looper defoliation was noted west of Bella Coola and around Nooskulla Peak in the North Island – Central Coast Forest District. No damage was observed in the NIFR where the majority of the attack occurred last year.

Since outbreaks by the western hemlock looper are relatively cyclical in nature, pheromone traps have been used for several years in chronic areas of the SIFR to monitor populations. Trap calibrations are not complete but increases in trap catches over the past three years, particularly in some areas, suggest an outbreak is developing (Table 6). Average trap catches for the Headwaters Forest District were down this year from a peak in 2009, but still substantial numbers were caught. The highest catches in the entire SIFR occurred at the Murtle Lake Road site, where an average of 968 moths per trap were caught. Defoliation mapped in this area confirmed that populations are high.

In the Okanagan Shuswap Forest District average trap catches remained static, though numbers at Three Valley Lake and Perry River Lower sites were up substantially. Average trap catches in the Columbia Forest District were the lowest of the districts, but were up five-fold from last year. Moth numbers increased at all monitoring sites, with the highest catch of 550 at the Begbie Creek site. In the eastern portion of the Central Cariboo Forest District larval counts obtained from three-tree beatings were carried out in some chronic western hemlock looper areas, but no larvae were found.

Table 6. Average number of western hemlock looper male moths caught per trap at various MFR sites (6-trap clusters per site), 2005 - 2010.

Forest District (# sites)	Year					
	2005	2006	2007	2008	2009	2010
Headwaters (5)	9.2	5.0	19.9	552.7	873.1	550.8
Okanagan Shuswap (11)	8.0	3.7	7.7	202.9	548.4	540.8
Columbia (11)	1.2	4.1	2.9	25.0	69.5	346.5

Western blackheaded budworm, *Acleris gloverana*

Damage resulting from western blackheaded budworm increased from 24,656 ha last year to 93,241 ha in 2010. Intensity levels remained similar with 46,842 ha (50%) light, 22,708 ha (24%) moderate and 23,691 ha (26%) severe.


Western blackheaded budworm larva

Most of the defoliation was located in the CFR's Haida Gwaii Forest District, where 87,497 ha were affected. This is the second year of the outbreak for this district, and almost all the severe defoliation in the province occurred here. Damage expanded substantially this year throughout the islands to the south, particularly on the eastern edge. Defoliation also moved northward on Graham Island to stands around Massett Inlet. Hemlock was the primary host affected.

The bulk of the remaining damage occurred for the second year as well in the NIFR's Kalum Forest District. Infested stands were located just south of the area defoliated last year, around the Mt. Davies area. Saddleback looper was also found during ground checks of one infestation and was suspected to be present in other stands, though the primary defoliator was believed to be western blackheaded budworm. A total of 5,590 ha were affected. Besides hemlock, spruce and cedar were defoliated in this district.

One lightly defoliated area of 155 ha was also delineated along Duck Creek in the SIFR's Kootenay Lake Forest District.


Western blackheaded budworm defoliation in Haida Gwaii Forest District

Damaging Agents of Larch

Larch needle blight, *Hypodermella laricis*

Larch needle blight damage peaked in 2006 with 68,228 ha of damage, followed by a three year decline to only 1,886 ha last year. In 2010 observed disturbances rebounded slightly to 3,317 ha affected, though intensity levels were down somewhat with 2,853 ha (86%) rated light and 464 ha (14%) moderate.

All mapped defoliation was in the south-eastern portion of the SIFR in small infection centers. The districts involved experienced more rain last year than most of the province, which may account for the increase in this needle disease when others in the NIFR are declining. Most of the damage (1,822 ha) continued to occur in Rocky Mountain Forest District west of the Kootenay River in valley bottoms and on ridge tops. The Arrow Boundary and Kootenay Lake Forest Districts sustained 948 ha and 337 ha respectively, scattered throughout the districts mainly in intermediate aged managed stands. A total of 181 ha were affected in Columbia Forest District, chiefly around Bigmouth and Old Camp Creeks. The remaining 28 ha of damage occurred in the Okanagan Shuswap Forest District.

Tree infected with larch needle blight

Larch casebearer, *Coleophora laricella*

Larch casebearer is an introduced defoliator of western larch, first recorded in BC at Rossland in 1966. Since then, the larch casebearer has spread throughout much of the range of western larch in south-eastern BC. A biological control program was initiated in 1969 with the introduction of parasites imported from Europe and they have been effective at reducing populations.

Damage by larch casebearer is not usually noticeable during the aerial overview surveys and has not been recorded since the MFR has taken responsibility for this function. This year one young stand was observed to have 6 ha of light defoliation east of Mt. Bleasdell in the Rocky Mountain Forest District. Other minor defoliation was observed on the ground near this site, as well as at an area between Salmo and Kootenay Pass in the Arrow Boundary Forest District.

Damaging Agents of Cedar

Yellow-cedar decline

Yellow-cedar decline damage was observed on 10,984 ha along the mid coast of BC this year, up slightly from 8,009 ha in 2009. Intensity was somewhat higher as well with 1,106 ha (10%) trace, 5,515 ha (50%) light, 2,581 ha (24%) moderate and 1,783 ha (16%) severe delineated.

The majority of the damage continued to be recorded in the CFR with 10,726 ha mapped. Of this, most (8,006 ha) occurred in the North Coast Forest District. Small affected areas were scattered along the coastline, with larger areas of damage continuing to occur around Observatory Inlet. North Island – Central Coast Forest District disturbances, totalling 2,061 ha, were most prevalent around south Bentinck Arm and north of Knight Inlet. The remaining 659 ha in the CFR occurred in Haida Gwaii Forest District.

The only other yellow-cedar decline mapped this year was in the NIFR Kalum Forest District, where 258 ha were detected. All the damage was located in the southern half of the district, with the highest concentration along Kitlope River and Wahoo Creek.

Damaging Agents of Deciduous Trees

Bruce spanworm, *Operophtera bruceata*

Bruce spanworm defoliation reached a peak of 1,675,014 ha in 2010, which is the third year of an ongoing outbreak in the NIFR (Figure 16). Assessed severity levels continued at similar intensities as last year, with 1,380,212 ha (83%) light, 273,226 ha (16%) moderate and 21,576 ha (1%) severe.

The Peace Forest District continued to sustain the majority of the damage with 1,111, 398 ha delineated, almost double that recorded last year. The bulk of the infestations continued to occur north and south along the Peace River, with the largest increases noted south of Willow Valley down to Halfmoon Creek. Smaller more scattered infestations spread northward past the district boundary into Fort Nelson Forest District, where 546,642 ha of defoliation was mapped. Damage in this district chiefly occurred along major river drainages and continued to the BC border in the north. Defoliation in the Prince George Forest District was down from last year, totalling 811 ha over a few small polygons scattered mid district.

Bruce spanworm larva

All the remaining damage occurred in districts that hadn't been affected by this outbreak to date. Fort St. James Forest District contained 5,893 ha of attack in two main areas: the Skeena/Squingula River junction in the north and around Trembleur Lake in the south. Attack was observed at similar levels in Mackenzie Forest District where 5,595 ha were defoliated. These infestations were more scattered, though the majority occurred along Williston Lake. A total of 4,397 ha of damage were recorded in the Skeena

Stikine Forest District. Most of the defoliation was in the far northeast corner of the Cassiar TSA along the Dease River. A few stands in the Nadina Forest District were affected east of Babine Lake along Fleming Creek, with 248 ha delineated. The remaining 30 ha were located in the Vanderhoof Forest District.

With the large extent of the outbreak this year, only a small percentage of the areas could be ground checked. Where conducted, reconnaissance confirmed that the primary defoliating agent continued to be Bruce spanworm. However, minor populations of other defoliators were also observed in many areas, including forest tent caterpillar, serpentine leaf miner, large aspen tortrix and birch leaf miners. For each general area the primary defoliator was chosen, though other damaging agents were noted when appropriate in the database comments for a given polygon. Bruce spanworm outbreaks usually only last about three years so a decline is anticipated next year, at least in the original Peace infestation.

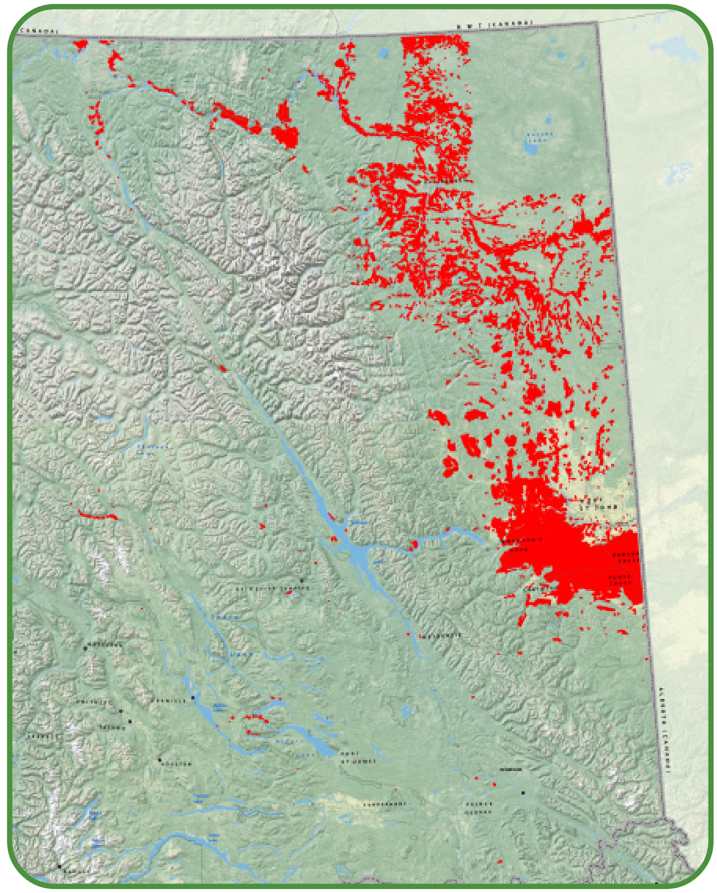


Figure 16. Bruce spanworm defoliation observed in 2010.

Gypsy moth, *Lymantria dispar*

The North American strain of the European gypsy moth has been periodically discovered in BC since 1978 but an aggressive detection and prompt eradication program has been successful in preventing establishment of moth populations. To date, no defoliation has been observed during the aerial overview surveys.

In response to 30 male moths caught in monitoring pheromone traps in 2009, chiefly in the Lower Mainland, an eradication program was conducted in 2010 in two areas. Treatment consisted of three applications of the Btk formulation Foray 48B® that is suitable for use on certified organic farms. The main area in Richmond (766 ha) was treated aerially between April 30th and June 1st (Figure 17). Another 25 ha south of Harrison Hot Springs were treated with a ground spray between May 4th and May 30th.

Monitoring pheromone trap results from the fall of 2010 showed that the program was very successful. Only 12 male moths were caught in BC, which was the lowest total catch since 2001 when 11 moths were trapped. The 2010 trap catches occurred in Harrison (1), Port Moody (1), North Vancouver (2), Comox (4), Nelson (2) and Revelstoke (2). These numbers indicate that a treatment program is not required for the spring of 2011, though sites with positive trap catches will be trapped at a higher density next year to determine if the introductions survived and if so to locate the population epicentres.

Figure 17. Location of 2010 Richmond gypsy moth treatment.

Further information regarding the gypsy moth program and historical records can be accessed at the MFR's gypsy moth website at http://www.for.gov.bc.ca/hfp/gypsymoth/index.htm.

Serpentine leaf miner, *Phyllocristis populiella*

Serpentine leaf miner damage doubled over last year to 209,604 ha across BC (Figure 18). Intensity dropped marginally though to 85,875 ha (41%) light, 64,664 ha (31%) moderate and 59,066 ha (28%) severe.

Area affected increased almost three fold in the NIFR, where 140,933 ha were delineated as attacked. For the third consecutive year the majority (82,844 ha) of the disturbances were located in the Skeena Stikine Forest District. Infestations remained stable along the Babine River, but increased substantially along the Skeena River. Nadina Forest District sustained 23,381 ha of attack with the largest concentrations around Babine Lake. Damage in the Prince George Forest District more than doubled to 20,852 ha with most of the defoliation located around the Willow River and Pinkerton Peak. The Peace Forest District contained 5,138 ha of attack, primarily around Mt. Merrick and Mt. Bergeron. Infestations in the Fort Nelson Forest District totalled 4,874 ha and most of the damage was observed along Elleh Creek. A total of 1,817 ha of defoliation was mapped at the tip of the Northwest Arm of Takla Lake in the Fort St. James Forest District and 1,749 ha were recorded around Williston Lake in the Mackenzie Forest District. Kalum and Vanderhoof Forest Districts contained the remaining NIFR attack with 191 ha and 89 ha affected, respectively.

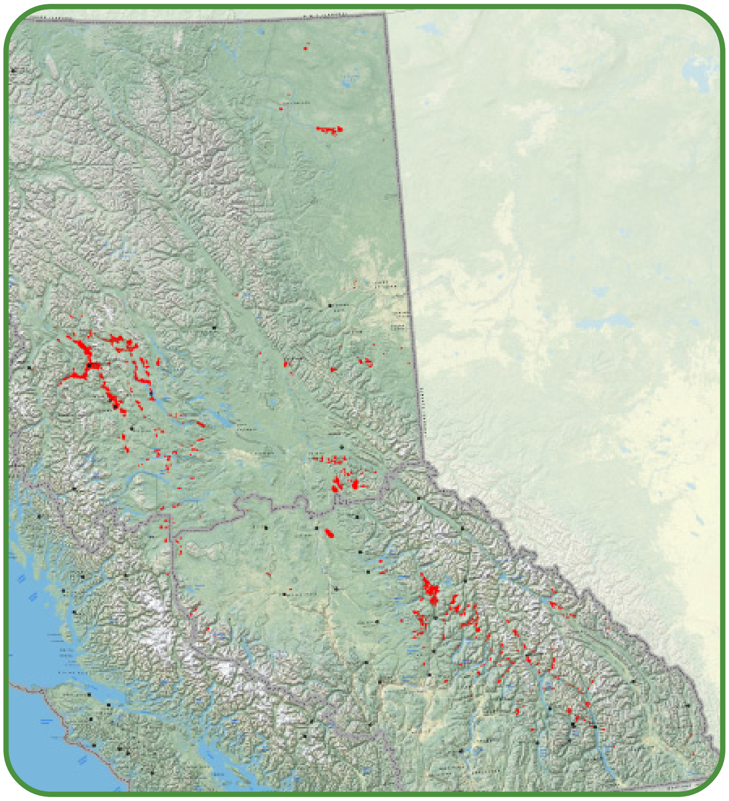


Figure 18. Serpentine leafminer defoliation mapped in 2010.

Damage in the SIFR increased slightly since 2009 to 67,282 ha. Most of the defoliation continued to occur in Headwaters Forest District, where 37,354 ha were attacked. Disturbances were concentrated in the southern half of the district, particularly south of Clearwater Lake. The majority of the 6,646 ha affected in the Quesnel Forest District was mapped in one large infestation along the Quesnel River west of Benson Lake. Infestations in the Columbia Forest District were scattered along the Columbia River and along Revelstoke and Upper Arrow Lakes for a total of 5,841 ha affected. Kamloops and Okanagan Shuswap Forest Districts contained small scattered disturbances totalling 4,932 ha and 4,385 ha, respectively. Arrow Boundary Forest District sustained 3,010 ha of damage in the northern half of the district. Small infestations in the Chilcotin Forest District were widely scattered and amounted to 2,245 ha. Small scattered disturbances totalled 1,268 ha in Kootenay Lake Forest District and the Central Cariboo Forest District sustained 1,106 ha of attack around Horsefly Lake. The Rocky Mountain and 100 Mile House Forest Districts contained the remaining SIFR defoliation with 280 ha and 215 ha defoliated, respectively.

Widespread serpentine leafminer defoliation in the Prince George Forest District

The only attack in the CFR occurred in the North Island – Central Coast Forest District, where 1,389 ha were delineated in the northeast corner around Qualcho Lake.

Serpentine leaf miner damage was scattered throughout aspen across the province. Actual area affected was higher than that recorded during the overview survey as scattered infested trees were difficult to see and to map. Recorded polygons were often limited to areas where the stand composition was high in aspen and the damage was substantial.

Forest tent caterpillar, *Malacosoma disstria*

Forest tent caterpillar defoliation increased for the fourth consecutive year across BC to 132,626 ha, more than fourfold what was observed in 2009 (Figure 19). Severity of damage also increased slightly to 72,848 ha (55%) light, 54,034 ha (41%) moderate and 5,743 ha (4%) severe.

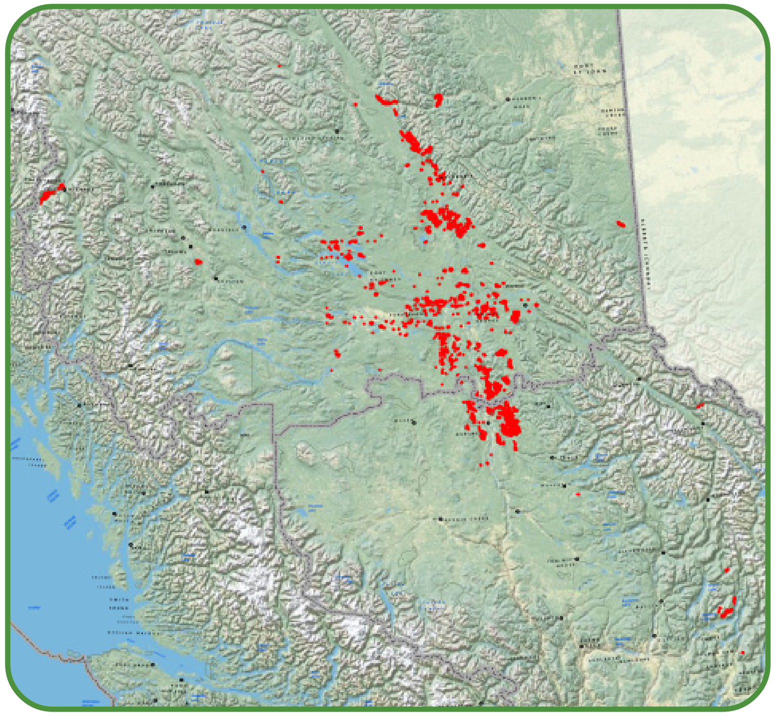


Figure 19. Forest tent caterpillar defoliation mapped in 2010.

Unlike the last two years, the majority of the infestations occurred in the NIFR with a total of 94,766 ha affected. Prince George Forest District sustained 60,529 ha of defoliation scattered throughout aspen stands in the western half of the district. The largest and most severe infestations were located around McLeod Lake. Mackenzie Forest District was the 2nd most affected, with 22,366 ha of damage recorded. The largest infestations were located at the southern edge of the district, with substantial damage also mapped along the southern half of Williston Lake. In Kalum Forest District, a total of 4,993 ha of defoliation were noted along the Nass River around New Aiyansh. Small scattered infestations in the southern half of Fort St. James Forest District covered 3,501 ha. In the northern half of the Vanderhoof Forest District, damage was also noted in small scattered areas totalling 1,391 ha. For the Peace Forest District, two disturbances of 903 ha in total were located northwest of Old Wives Mtn. One infestation of 1,001 ha was observed in the Skeena Stikine Forest District along the Bulkley River at the southern edge of the district. The remaining damage in the NIFR was located in the Nadina Forest District, where 82 ha were mapped.

Severe forest tent caterpillar defoliation beside McLeod Lake in the Prince George Forest District

In the SIFR damage increased by a quarter since last year to 37,844 ha. Most of the defoliation occurred in the Quesnel Forest District, where 34,863 ha were affected. Damage was located mid district, particularly between Quesnel River and Coldspring House. Okanagan Shuswap Forest District sustained 2,200 ha of defoliation west of Shuswap Lake. A further 613 ha were located in the Headwaters Forest District near Overlander Mtn. and

Cayenne Creek. Central Cariboo Forest District contained the remaining attack in the SIFR, with 167 ha mapped.

In the CFR, the infestation along the Nass River from the Kalum Forest District extended into the North Coast Forest District, with one polygon of 16 ha observed.

As occurred with many of the other aspen defoliators, particularly in the NIFR, other minor damaging agents were sometimes found in the same stands but if forest tent caterpillar was the primary defoliator it was recorded as such. Other defoliators were noted when appropriate in the database comments for a given polygon.

Forest tent caterpillar larvae

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

A total of 6,621 ha were affected by aspen and poplar leaf and twig blight in 2010 in the NIFR which represents a reduction by a quarter from last year. Intensity of damage was rated as 5,376 ha (81%) light, 49 ha (1%) moderate and 1,197 ha (18%) severe. Moderate intensity is down from 2009, but severe is up substantially.

Almost all the damage in 2009 was located in the Fort Nelson Forest District, with none observed there this year. This could partially be due to changes in the aerial survey crew, though no obvious damage was noted by ground personnel either. In 2009 the majority of the disturbances (5,850 ha) were located in the Skeena Stikine Forest District, where none was noticed last year but 912 ha were delineated in 2008. Two primary areas were identified: west of Skeena Crossing on the Skeena River and on the Bulkley River south of Moricetown. The survey crew noted that damage actually intensified later in the summer after the flights were finished in this area.

The remaining damage covered less area, but was mainly severe in intensity. In Vanderhoof Forest District, 327 ha were observed at the east end of Francois Lake and in the Kalum Forest District 166 ha were mapped primarily on the Skeena River near Mount Jackman. The remaining 82 ha were detected in small scattered patches within the Nadina Forest District.

Most of the damage occurred in aspen stands, and where it was not widespread it was observed that the infections were very clonal in nature. Ground observations were also made of spotty aspen and poplar leaf and twig blight infections in black cottonwood trees from the NIFR down into Robson Valley in the SIFR, though nothing was obvious enough to be recorded during the overview survey.

Aspen and poplar leaf and twig blight affecting an aspen clone near Smithers

Birch leaf miners

Birch leaf miner (*Fenusa pusilla*) damage impacted 8,418 ha in the SIFR in 2010, up from only 735 ha last year. Intensity was assessed as 3,072 ha (36%) light, 5,313 ha (63%) moderate and 33 ha (1%) severe. Almost all infestations were small and scattered throughout the range of birch.

Blotch leaf miner larvae

Arrow Boundary Forest District contained 2,748 ha of attack with some concentrations of polygons along little Slocan River and around South Fosthall, Wilson, and Seaton Creeks. Infestations in the Okanagan Shuswap Forest District totalled 2,093 ha, primarily scattered around the Cherryville area. Kootenay Forest District sustained 1,797 ha of defoliation, particularly along Duncan River, Campbell Creek and La France Creek. A total of 839 ha were recorded, chiefly around Upper Arrow Lake, in the Columbia Forest District. Kamloops and Headwaters Forest Districts had similar levels of attack with 530 ha and 405 ha mapped, respectively. The remaining 6 ha of damage were observed in the Rocky Mountain Forest District.

In the NIFR two different birch leaf miners were identified by the Regional Entomologists. Ground reconnaissance in the Prince George Forest District of stands containing primarily forest tent caterpillar attack on aspen trees were also found to have approximately 5% of the defoliation on birch by *Profenusa thomsoni*. These stands were mainly east of Prince George. Since this birch leaf miner was a minor component of the stand damage, it was only noted in the database comments for the appropriate polygons. At the north end of the Ningunsaw Pass to Bob Quinn forest service road in the Skeena Stikine Forest District, ground observations of substantial defoliation of birch led to the discovery of a blotch leaf miner in the family *Gracillariidae*. This damage was not seen during the aerial overview survey.

Blotch leaf miner defoliation in the Skeena Stikine Forest District

Birch decline

Birch decline is very difficult to see from the height of the aerial overview surveys so it is not often mapped. Last year for the first time small scattered patches totalling 245 ha were mapped in the southeast portion of the province. These disturbances were not visible this year, though ground observations continued to find evidence of birch decline throughout the southern interior.

In the NIFR however, 128 ha of severe birch decline was noted in 2010 along the Prophet River near Milo Creek in the Fort Nelson Forest District.

Birch decline near Yahk in the Kootenay Lake Forest District

Satin moth, *Leucoma salicis*

After a peak in satin moth defoliation last year in the SIFR of 1,608 ha, recorded infestations dropped dramatically to only 9 ha. The infestations were small but rated as severe intensity and were located in the Okanagan Shuswap and Kamloops Forest Districts at 8 ha and 1 ha, respectively. Although not recorded during the aerial overview survey, ground observations noted small patches of moderate to severe damage along the Columbia River corridor from Harrogate to just south of Golden in the Columbia Forest District.

Satin moth pupa

Damaging Agents of Multiple Host Species

Abiotic injury and associated forest health factors

Wildfire damage remained high in 2010 due to another generally hot, dry summer over much of BC. A total of 302,155 ha burned at a severe level of intensity.

The SIFR sustained just over half the provincial damage, with 161,171 ha affected. Unlike last year, very few were wildland/urban interface fires capable of spreading to structures. Quesnel Forest District wildfires totalled 55,818 ha with the three largest occurring west of Tingley Creek, east of Pelican Lake and around Tsacha Lake. Chilcotin Forest District was the second most affected by wildfire, with 53,549 ha damaged. The majority of the large fires occurred just west of Alexis Creek with the exception of one east of Baldy Mtn. Almost all the wildfire activity in the Central Cariboo Forest District occurred mid district with 43,844 ha burnt. Two fires in the Yalakom area of the Cascades Forest District accounted for most of the 2,812 ha affected in that district. The remaining wildfires in the SIFR were small and scattered, with less than 1,500 ha burnt per district. As occurred last year, many of the SIFR fires involved Douglas-fir trees that were damaged but not totally burnt, as well as trees felled for fire guards. These trees will be highly susceptible to Douglas-fir beetle attack and present the opportunity for populations to build and infest healthy trees.

Convair tanker 44 dropping retardent on a Cariboo wildfire

Wildfire damage increased 40% over last year in the NIFR to a total of 120,715 ha affected. Nadina Forest District sustained the most damage, with 36,914 ha burnt in the southern half of the district, in particular one large fire at Kapp Lake that crossed into the Vanderhoof Forest District. That fire along with one at Stony Creek and Tsacha Lake comprised the majority of the 33,415 ha damaged in the Vanderhoof Forest District. In the Skeena Stikine Forest District, almost all the 33,579 ha affected were located in the Cassiar TSA in three fires: one near the Yukon border at Blue River and two mid TSA near Buckley Lake and Pallen Creek. Mackenzie and Prince George Forest Districts had similar levels of wildfire activity, with 5,678 ha and 5,286 ha of damage, respectively. The remaining NIFR districts sustained less than 3,400 ha of fire disturbances per district. A substantial portion of the trees damaged and/or felled for fire guards in the NIFR were spruce, and this may result in an increase in spruce beetle activity.

Of the 20,269 ha burnt in the CFR, almost all (20,056 ha) occurred in the northeast corner of the North Island – Central Coast Forest District around Sigutlat Lake. The remaining districts in the CFR experienced less than 100 ha of wildfire damage each.

Flooding damage affected 4,439 ha province wide with the majority (91%) continuing to occur in the NIFR. Fort Nelson Forest District sustained 3,015 ha of the damage, primarily in two polygons recorded near Klua Lakes and Little Beaver Creek at trace intensity. The rest of the flooding mortality in the province occurred in small scattered pockets at higher intensity. Kalum Forest District was second most affected, with 399 ha delineated. Damage in the rest of the NIFR was less than 200 ha per district. Flooding disturbances for the remainder of the province amounted to less than 80 ha per district for a total of 316 ha in the CFR and 80 ha in the SIFR.

Recent flood damage caused by slide activity on Blackfoot Creek in the Rocky Mountain Forest District

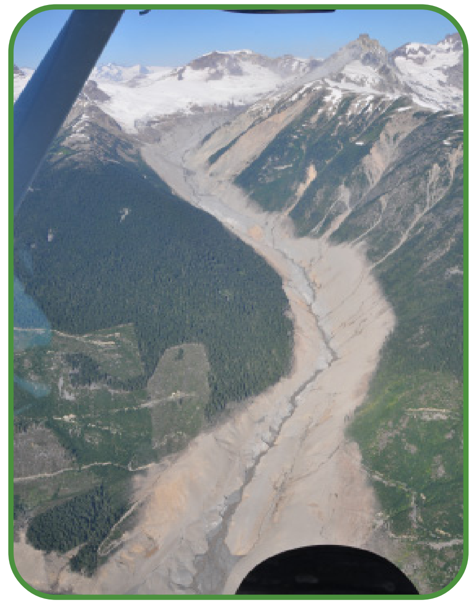
Windthrow damage across BC was very similar to last year, with 3,249 ha recorded. Most of this damage (94%) was rated as severe in intensity, up from only 68% in 2009. All the disturbances were small and scattered, with the largest polygon mapped at 88 ha and most under 5 ha. The majority of the damage occurred in the SIFR, with 2,536 ha affected. Columbia Forest District contained a large portion of the damage, with 943 ha of mortality. Rocky Mountain and Arrow Boundary Forest Districts sustained 681 ha and 318 ha of windthrow damage, respectively, and the remaining disturbances totalled less than 270 ha per district.

In the NIFR, windthrow damage affected 484 ha with 271 ha located in the Peace Forest District. Other small disturbances were less than 100 ha per district. One blowdown event at George Creek in the Prince George Forest District is of particular concern as the damaged tree species was spruce and some spruce beetle activity has been detected from ground reconnaissance. A large windstorm in Mackenzie Forest District that occurred in November 2010 (post aerial survey) caused widespread spruce blowdown on the east side of the trench along the Rockies and half way up to the Peace Reach. An estimated 100,000 to 300,000 m^3 of wood was on the ground and measures will be taken to hopefully prevent a spruce beetle outbreak.

Spruce blowdown at George Creek in the Prince George Forest District

A total of 229 ha of windthrow damage was recorded in the CFR, of which most (216 ha) was located in the Haida Gwaii Forest District. This district also experienced a large storm in October 2010 which resulted in windthrow and landslides, though the extent is not known at this time.

Slides accounted for 2,394 ha of damage province wide (including those caused by avalanches), up almost three-fold since 2009. Almost all (99%) of the damage was rated as severe. The CFR contained the majority (1,747 ha) of the slide activity, with most of the damage located in the Squamish Forest District (1,221 ha). A large-scale landslide at Meager Creek in August 2010 near Pemberton was responsible for 889 ha of this damage, displacing an estimated 40 million cubic metres of earth. According to the Ministry of Environment, this slide is the second-largest in Canadian history next to the 1965 Hope slide. The remaining slides across BC were small and scattered. Haida Gwaii Forest District recorded 251 ha of slide damage, with the rest of the CFR damage totalling less than 100 ha per district. In the NIFR and SIFR, a total of 375 ha and 272 ha were mapped, respectively.

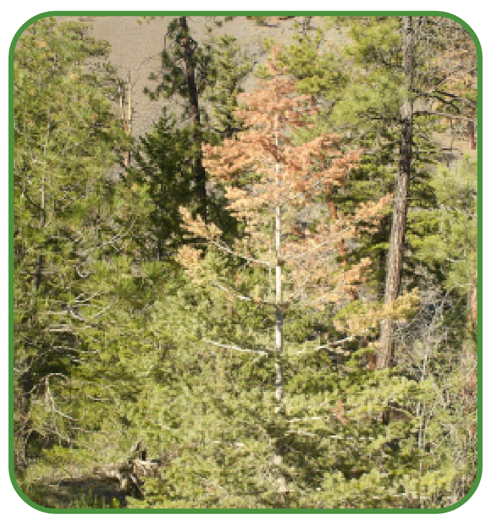


Meager Creek slide

Red belt damage was observed on 880 ha, all of which was rated severe in intensity. This total was down somewhat from last year when 1,185 ha were affected. A large portion of the 2009 damage occurred in the SIFR, where no disturbances were noted in 2010. All the 2010 damage was confined to the Muskwa River area east of Horseshoe Mountain in the Fort Nelson Forest District. This damage was just south of the 506 ha recorded in the district last year.

Red belt damage in Fort Nelson Forest District

Drought damage, despite the second consecutive dry, hot summer, was down dramatically to only 688 ha of chiefly (97%) light intensity damage from 65,817 ha last year. This was primarily due to the vast areas of western redcedar flagging attributed to drought last year not being visible in 2010. This year, tree species damaged were mainly aspen, cottonwood, Douglas-fir and spruce. The SIFR was most affected, particularly in the Cascades Forest District where 388 ha of drought along the Fraser River in the south half of the Lillooet TSA were recorded. Chilcotin Forest District contained the remaining 36 ha of damage. In the CFR all but a few spot disturbances were recorded on 245 ha in the North Island – Central Coast Forest District around North Bentinck Arm. The NIFR, where most of the damage occurred last year, sustained only 19 ha of drought effects in the Kalum Forest District.



Douglas-fir topkill due to drought west of Lillooet

Animal damage

Animal damage impact is underestimated in the aerial overview surveys. Most of the damage is scattered and does not affect the whole tree and/or damage is to very small trees; hence it is not conspicuous enough to be visible at the height flown for the survey.

Black bear (*Ursus americanus*) damage was observed affecting 82 ha in the SIFR this year. In the Rocky Mountain Forest District a total of 69 ha of small disturbances were recorded east of St. Mary's Lake and along the Moyie River. The remaining 13 ha were noted in the Kootenay Lake Forest District near the USA border by Freeman Creek. Results from stand development monitoring surveys in the Arrow Boundary Forest District also found black bear damage in 15-25 year old lodgepole pine stands around the Boundary area of up to 5% per stand. It is also known to be a continuing problem in young to intermediate age class stands in other areas of the province. Fertilized Douglas-fir, lodgepole pine and spruce stands have been noted to be particularly susceptible.

Bear damage in the Rocky Mountain Forest District

Lodgepole pine leader clipped by snowshoe hare

Porcupine (*Erethizon dorsatum*) damage was the only other animal damage to be seen during the overview survey this year, with 11 ha delineated in the Kalum Forest District and 2 ha mapped in the Rocky Mountain Forest District. As with bear damage however, feeding by porcupines is known to be causing ongoing damage in dispersed locations throughout most of the province.

Snowshoe hare (*Lepus americanus*) damage seen in the NIFR this year combined with knowledge of the cyclical nature of hare populations indicate that populations are increasing and should peak relatively soon. However, no surveys were conducted in 2010 to substantiate these observations. In addition to regular population cycles, the mountain pine beetle outbreak has resulted in a large change from mature to younger stands over the landscape which provides improved hare habitat that may increase snowshoe hare populations.

Miscellaneous Damaging Agents

Alder defoliation was observed from the air in the Headwaters Forest District, along the Raush River as well as east of Kinbasket Lake. Damage was severe and affected several hundred hectares of alder. As BC interior alder is classified as a brush species rather than as a tree species, the defoliation was not mapped. Ground confirmation of the damaging agent was not possible due to inaccessibility, but it is likely that the defoliation was caused by an alder sawfly. No defoliation was attributed to the recently introduced green alder sawfly (*Monsoma pulveratum*) although this species has been recorded in several locations throughout BC by the Canadian Forest Service.

Alder defoliation in the Headwaters Forest District

Aspen damage was observed in the Skeena Stikine and Kalum Forest Districts this spring from Hazelton west to Terrace along Highway 16. Damage was clonal in nature, and it is suspected to have been the result of trees breaking dormancy too early then being susceptible to cold weather that occurred in April.

Black banding caused by Botryosphaeria canker

Botryosphaeria canker (*Botryosphaeria piceae*) was identified attacking and killing a small number of Englemann spruce trees on private property near Clearwater. A localized incident has also been reported from a woodlot in the same area. An old report from Funk (1965)[1] previously identified a similar outbreak on spruce near Clearwater. The disease has also been reported on Sitka spruce in the northern coastal area and in the Queen Charlotte Islands.

Symptoms on trees included slight hypertrophy of outer bark and distinct black banding around the circumference of trees. Discoloured banding contained stroma of black, spherical fruiting bodies and pathogen identification on samples was confirmed by B. Callan (CFS-PFC). Most trees had at least two 10+cm wide bands of discoloured bark and most banding occurred

[1] Funk, A. 1965. A new parasite of spruce from British Columbia. Can. J. Bot. 43: 45-48.

within 2 metres of the ground. Disease spread occurs via ascospores and trees appear to be girdled/killed within 1-3 years of the first onset of symptoms in the bark.

While the fungus on Englemann spruce in the Clearwater area is not widespread, further monitoring is needed in order to better understand the infection process of *B. piceae* and disease spread to adjacent spruce in the area.


Elytroderma needle cast infection

Elytroderma needle cast (*Elytroderma deformans*) damage has been particularly noticeable recently in the eastern portion of the Chilcotin Forest District and various other areas in the Cariboo, especially in low lying microsites in young stands. Anecdotal observations report stagnation of heavily infected young lodgepole pine that have been repeatedly damaged. At least part of the "increase" in damage is due to better education of forestry personnel in identification of this disease and from reduction of the masking effect that many consecutive years of pine needle cast (*Lophodermella concolor*) previously had on lodgepole pine stands in the Cariboo.


Shoot moth damage

Shoot moth (*Zeiraphera* spp.) damage was observed from the ground on spruce trees near the highway between Tofino and Ucluelet and near Jordan River on Vancouver Island. Defoliation was light and was not visible during the aerial overview surveys, so the extent of the infestation was unknown.

Unknown defoliation continued to grow with 38,957 ha of damage recorded across the province this year. Intensity was assessed as 16,488 ha (42%) light, 14,314 ha (37%) moderate and 8,155 ha (21%) severe. The majority of the damage occurred in the southern half of the Kalum Forest District (14,037 ha) and extended into the south-eastern edge of the North Coast Forest District (5,521 ha). Hemlock was the primary tree species defoliated, along with some minor spruce and subalpine fir in the stands. Possible damaging agents that are active in the general area included western blackheaded budworm, two year cycle budworm, western hemlock looper and saddleback looper. Unknown defoliation was also observed in several large polygons totalling 17,181 ha in the Fort Nelson

Undknown defoliation of Hemlock in Kalum Forest District

Willow leaf blotch miner damage

Yellow headed spruce sawfly larvae

Forest District. The tree species affected in this district were mainly spruce and subalpine fir that may have been damaged by eastern spruce budworm. Fort St. James and Nadina Forest Districts sustained 1,071 ha and 751 ha of unknown defoliation, respectively. This damage occurred on aspen trees and was suspected to have been caused by forest tent caterpillar. The remaining disturbances were small and scattered throughout the province, with fewer than 200 ha per district. Most of the unknown disturbances were inaccessible for ground checks to determine damaging agents.

Willow leaf blotch miner (*Micurapteryx salicifoliella*) defoliation was noted throughout the range of willow in the Peace Forest District from Hudson's Hope northward and eastward. As with the alder defoliation, this damage was not mapped since willow is not considered a commercial tree species.

Yellow headed spruce sawfly (*Pikonema alaskensis*) defoliation was noted causing serious damage to young domestic and ornamental spruce in a few areas of the NIFR this year. Three consecutive years of damage by this sawfly can result in mortality for spruce up to 8m in height. Reports of defoliation came from the Terrace area in Kalum Forest District and Dawson Creek / Fort St. John towns in the Peace Forest District.

Forest Health Projects

1. Comandra resistance trial

Richard Reich, *Forest Pathologist, NIFR*

This very large trial was established in 2004 as a collaborative effort led by Dr. Sally John, research geneticist, to test putative resistance to comandra blister rust (CBR), which she had previously identified in the Chowsunket progeny test site. The resistance trial tested up to 130 families from the Bulkley #219 orchard on several very high risk sites. Detailed annual assessments have been conducted on the 3 (Thompson, Holy Cross and Endako) fully replicated sites since the rusts became evident in 2006/2007. The CBR infections levels have reached a very high level on 2 of the 3 fully replicated sites, well exceeding the target threshold for evaluation of 50%. Preliminary results show that a low frequency of moderate resistance exists in the tested population, but that the majority of families tested are highly susceptible. Although the rankings perhaps weren't as favourable as hoped, overall this trial has vastly outperformed all expectations. This is in part due to the very careful selection of very high risk sites, and the fortuitous "perfect storm" like weather patterns, which resulted in repeated "wave years" of epidemic infection at the two Nadina district sites.

The utility of this trial was not limited to ranking family resistance. The 3 fully replicated trial sites were mapped for cover and abundance of the CBR alternate host *Geocaulon lividum* in 2007. The risk of infection was found to be directly related to the distance from alternate host. Risk drops approximately by half just several meters away from the alternate host. This highly significant finding may have operational significance for the development of control tactics.

Thompson site, October 2010, showing extensive mortality due to comandra blister rust

Another unanticipated result from this trial was the finding that inheritance of resistance to CBR and stalactiform blister rust (SBR) appears to be independently inherited. As incidence of both rusts increased to very high levels over time at the Endako site, the correlation R^2 steadily declined to near zero. This finding is somewhat surprising given the similarity of these rusts in terms of spore morphology, infection process, etc. This knowledge has application for designing screening trials, interpreting their results, understanding mechanisms of resistance trait inheritance, and selecting families for rust resistance orchards.

Although the ultimate goal is to develop a CBR resistance orchard, at the current rate of progress, many additional orchards will need to be screened before this goal is realized using the current approach. Whether more orchards need to be similarly screened on high risk sites, or whether other forms of screening need to be developed is yet to be determined. Pending resource availability, goals for 2011 include annual trial re-measurement, evaluating new prospective screening sites, and field testing an alternative screening technique.

2. FREP stand development monitoring (SDM)

Alex Woods, Forest Pathologist, NIFR

The Stand Development Monitoring (SDM) protocol is designed to provide the MFR with updated information on the productivity and health of free-growing stands 10+ years after declaration. The free-growing declaration is currently the last mandatory entry of stand attributes used in the forest inventory system for stands between that early stage of development and possible harvest decades in the future. Given climate change and its affects already manifest in the forests of BC we may no longer be able hold such a high degree of confidence in our managed stand assumptions and perhaps instead should rely on improved monitoring. SDM will provide data to check both the basic assumption that free-growing stands remain on a productive stable growth trajectory and the assumptions embedded within the growth and yield model used to forecast future stand productivity. Such information is clearly relevant to the sustainable forest management certification process and can be used to validate criterion and indicators. SDM data can ultimately be used to support revision of standards associated with current practices and in so doing support adaptive management of this critical stage in forest management. Such adaptive management techniques will be essential under climate change. Given its direct tie to management practices through the use of operational silviculture records, SDM is uniquely positioned to become both the provincial MFR mid-rotation stand monitoring protocol, as well as the benchmark measure on which to base a systematic approach of adaptive management for those same silvicultural practices.

General Objectives of Stand Development Monitoring

A. To assess the health and productivity of young stands in BC under changing climatic conditions.

B. To review the effectiveness of government policies and reforestation practices that govern managed stand initiation and management decisions.

C. To support sustainable forest management (SFM) certification processes.

D. To develop in-house expertise within the Ministry of Natural Resource Operations (Forest Districts) regarding the health and productivity of managed stands in their respective Timber Supply Areas.

Building on the FREP SDM pilots conducted in 2009 a total of 13 Districts piloted SDM throughout the province in 2010. SDM training sessions were held in post-free-growing stands near Burns Lake, Vanderhoof, Quesnel, Williams Lake, 100-Mile House, Barriere, Revelstoke, Invermere, Nakusp, and Duncan. A core SDM training team consisting of Erin Havard, Ken White and Alex Woods travelled to all of these areas drawing in help from regional and provincial forest health specialists. At the provincial scale Frank Barber of FREP has lead the co-ordination of meetings with headquarters specialist from inventory, timber supply, growth and yield and forest practices to ensure maximum utility of the early stand monitoring data provided by SDM. The SDM protocol has been revised over the 2-year period of pilots by a central team consisting of; Stefan Zeglen, Dave Weaver, Harry Kope, Frank Barber, Kevin Astridge, Chris Mulvihill, Wendy Bergerud, Ken White, Erin Havard and Alex Woods. SDM is planned for full implementation province wide in the spring of 2011.

The following sources provide additional information on the SDM program.

Woods, A. 2010. Stand Development Monitoring (SDM): What have we learned so far, and how can this help us adapt to a changing climate? Presentation on March 18, 2010 in FORREX Online Webinar Series: What's new in Forest Productivity Research. FORREX Forum for Research and Extension in Natural Resources, Kamloops, BC. http://www.forrex.org/program/forest/ESM/PDF/Webinars/Forest_Productivity_Research/PPTs/Woods_18Mar10.pdf

Woods, A. 2010. Forest and Range Evaluation Program Stand Development Monitoring (SDM). Forest and Range Evaluation Program, BC Ministry of Forests and Range, Victoria, BC. FREP Extension Note #10.

SDM training and demonstration session held near Duncan BC, September 22, 2010 with Headquarters, South Island and Campbell River Forest District staff.

3. Mackenzie Forest District hard pine stem rust hazard and risk rating

Richard Reich, Forest Pathologist, NIFR

The purpose of this rust hazard and risk rating is to develop a stand susceptibility rating that informs silviculture prescription development. The ratings are equally valuable for use in the compliance and enforcement system. The hazard plus risk approach developed for the Mackenzie forest district was designed to predict the cumulative rust incidence expected for a given site. An empirical modelling approach was developed involving an intensive survey of a largely randomly selected sample of 102 silviculture openings. In addition to rust incidence, a suite of site and ecosystem variables were collected and evaluated for predictive value. The predictive model identifies the predictive strength of each variable and identifies the best combination of these variables in a predictive equation. The reliability of the predictive model must be validated through testing, and in the interim, a summary table will be used for hazard. The table will reside in the updated Mackenzie District Rust Management Strategy.

4. Operational stump removal for root disease control

Michelle Cleary, *Forest Pathologist, SIFR*

Armillaria root disease remains the biggest pathology concern across the southern interior of BC. Mitigation of damage caused by the fungus (including tree mortality and growth loss on trees that sustain non-lethal infections) can be achieved by reducing the amount and potential of inoculum in the stand via stump removal.

Stumping has been in practice operationally for over two decades. Investment in stumping primarily lies in the hands of the Crown due to the value placed upon the potential impact of Armillaria on rotation production. However, the onus falls on the forest professional to recognize root disease as a problem on the site and to address short and long-term forest health issues in site plans. In the southern interior region, the calculated cost appraisal for root disease control since 1991 was $53,390,549.00 (General Appraisals Report for the SIFR, K. Chantler, July 2010). The range for cost of inoculum removal in the interior is between $600-$1200/hectare, averaging somewhere around $1000 per hectare.

Figure 20 shows the proportion of total area stumped for root disease control since 1991 by district. Some discrepancies are evident in what is generally known about the distribution and impact of root diseases in such districts and the level of practice from licensees when it comes to addressing those concerns (i.e. DKL). In many cases, extent of stump removal operations not only depends on root disease presence, but also the opinion of practitioners around the effectiveness of stumping operations in the long-term. Research on the ecological distribution and impact of *Armillaria ostoyae* and *Phellinus sulphurascens* (= *P. weirii* syn.), studies on host susceptibility and stand level impacts, and results from long-term trials looking at root disease control via stumping have improved our strategies for management of root disease in second growth forests. Examples of such strategies for improving best management practices can be found in the Armillaria root disease Stand Establishment Decision Aid.

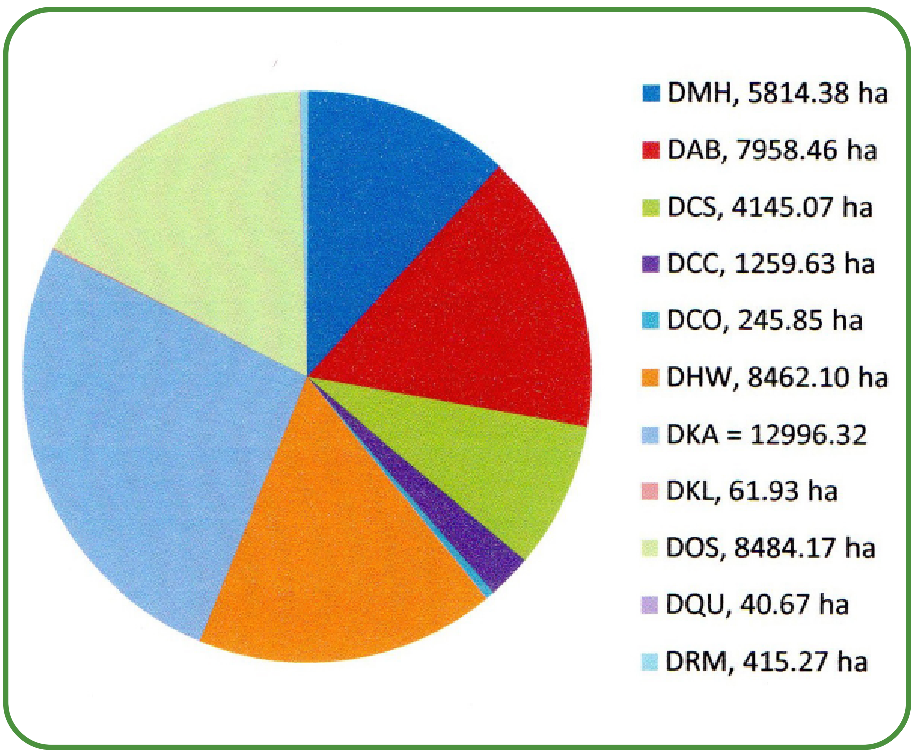


Figure 20. Proportion of Total Area Stumped for Root Disease Control by district in the Southern Interior Forest Region since 1991. Source: RESULTS Query, July 2010. (Note: Total area stumped = 49,684 ha.)

5. Risks to conifers from birch decline

Michael Murray, Forest Pathologist, SIFR

Mature forest stands naturally composed of a mixture of paper birch and conifers are common in the interior regions of BC. Birch can provide both benefits and burdens to associated conifers through nitrogen fixation, competition, and nutrient-rich litter deposition. A particularly important aspect of forest health relates to birch's resistance and tolerance of Armillaria root disease. In fact, birch roots often provide a barrier to disease spread, thus protecting neighbouring conifers such as Douglas-fir and lodgepole pine from infection. When birch are harvested, or killed by other causes, the Armillaria fungus is able to quickly spread along dead birch roots and transfer to conifers. Overall, the incidence accelerates.

During the past decade, extensive die-back and decline of birch trees has been observed in the interior. While the causes are not well-understood, a variety of agents have been observed including bronze birch borer (*Agrilus anxius*), non-native birch leaf miners (*Fenusa pussila* and *Profenusa thomsoni*) and Armillaria. Climatic perturbations may be a pre-disposing factor – and currently under investigation using dendrochronology methods. While surveying stands in the Kootenays impacted by birch decline in 2010, I found pronounced signs of Armillaria on birch trees and associated regenerating conifers. In October, I observed Armillaria mushrooms on 34% of dead birch trees. Since above-ground symptoms are naturally uncommon on birch, it's estimated the actual incidence is much higher.

Armillaria root disease on a recently killed paper birch tree in a birch-conifer stand.

The extensive mortality of birch in birch-conifer stands places conifers at high risk of infection by Armillaria root disease. We can expect larger conifers to become infected initially due to their relatively more expansive root systems. Small regenerating trees, once infected will typically die within several years. Larger trees may survive, but with noticeably reduced growth rates.

6. Septoria Musiva update

Stefan Zeglen, Forest Pathologist, CFR
Harry Kope, Provincial Forest Pathologist, FPIB
Stephanie Beauseigle, University of British Columbia
Richard Hamelin, University of British Columbia

Septoria musiva Peck (teleomorph *Mycosphaerella populorum* G. E. Thomps.) causes leaf blight and, more importantly, stem cankers that often lead to breakage of *Populus* spp. in the Midwest and eastern portions of North America. In 2007 *S. musiva*, was reported for the first time in BC on hybrid *Populus* clones. These hybrids are grown in BC for rapid fibre production, and many are especially susceptible to the disease. The presence of this disease will have an impact on hybrid poplar plantation forestry in BC. Also, the native poplar species black cottonwood (*P. trichocarpa*

Torr. & A. Gray), trembling aspen (*P. tremuloides* Michx.), and balsam poplar (*P. balsamifera* L.) are important riparian species, and the impact of this disease on them is currently unknown.

In 2009, 407 leaf samples were collected at two sampling intervals, in July and then again in October. The sample area stretched from Dewdney, BC in the west to Yale, BC in the north and Manning Provincial Park to the east. The inability to visually differentiate the foliar symptoms of *S. musiva* from those of the native and relatively benign *S. populicola* Peck makes the use of genetic tools to confirm identity mandatory. Similarly, the presence of cankers on stems and branches is often difficult to attribute solely to *S. musiva* since other fungi and some insects cause similar damage. Molecular techniques employed by S. Beauseigle and R. Hamelin were used to positively identify the presence of *S. musiva* from material collected from leaf spots.

The results of the genetic testing of leaf spots collected from sampled poplars are presented in Table 9. *S. musiva* was confirmed in 5 of the samples. When combined with the 2008 survey results, the distribution of these positive results was widely spread across the sample area (Fig. 21) indicating either recently detected multiple introductions, rapid spread from a single introduction, or undetected slow spread over a long period. Improvements to the genomic testing portion of the project should allow us to revisit the collected samples and determine if there are missed positives in the collection. Additional positives will fill out the distribution of the fungus and allow us to better determine the potential for management of this disease.

Table 9. Results obtained from DNA sequencing for samples collected in 2009.

	2009
Number of trees sampled	407
Number of leaf spots sequenced	273
Septoria populicola	243
Septoria musiva	5
Other	25

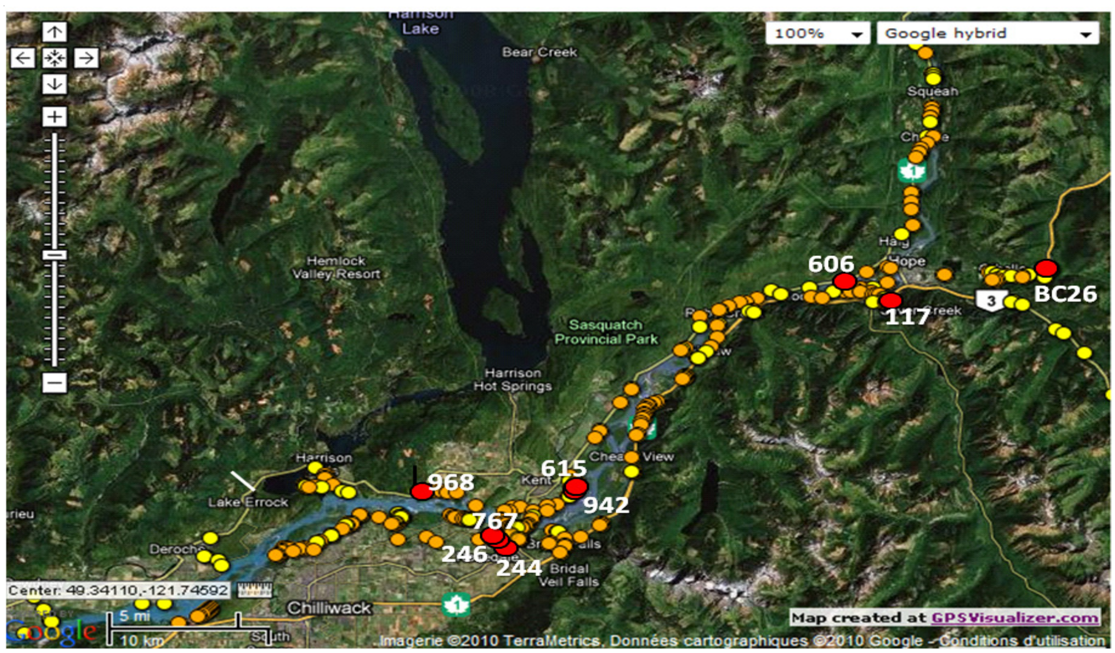


Figure 21. The distribution of poplar trees sampled in the upper Fraser Valley in July (yellow) and October (orange) 2009 with the location of all the *Septoria musiva* positive samples, and their corresponding collection numbers, identified in red.

7. Whitebark pine: trends in the Kootenays revealed

Michael Murray, *Forest Pathologist, SIFR*

The first re-measurements of several long-term whitebark pine forest health monitoring plots revealed that 2 of 3 locations are experiencing increases in dead and dying trees while healthy trees decline (Figure 22). The plots were originally installed in 2003 and 2004: Puddingburn Mountain (Cranbrook), Findlay (Canal Flats), and Bluejoint Mountain (Grand Forks). Since establishing the plots, an epidemic of mountain pine beetle has impacted whitebark pine forests Province-wide. However, based on these results, the non-native white pine blister rust disease is the leading cause of mortality. It's uncertain how representative these three plots are of forest health Province-wide, or even the Kootenay region (enhanced sampling of whitebark pine would yield better insight).

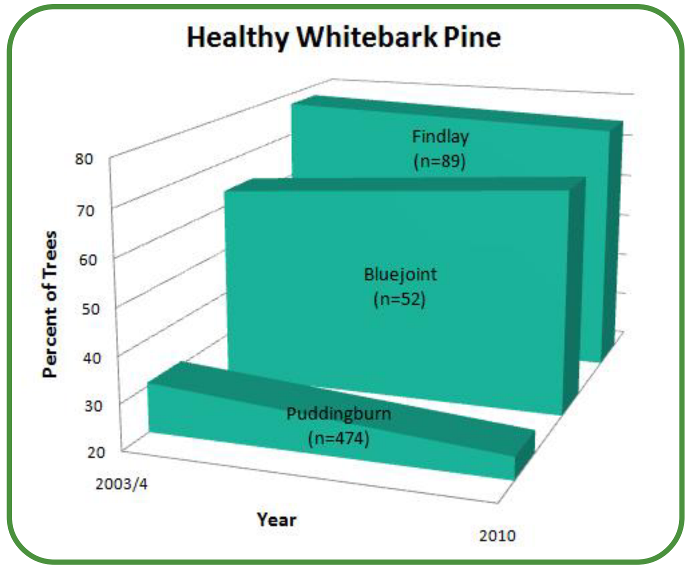


Figure 22. Number of healthy whitebark pine recorded in three forest health monitoring plots 2003 to 2010.

Disease is most pronounced at Puddingburn Mountain where almost three-quarters of trees are infected (Table 10). Of the infected individuals, 63% have more than one canker. This forest is nearly pure whitebark pine and represents a younger stand (primarily <100 years) that has naturally regenerated after a fire. With such high incidence, blister rust is impacting re-establishment of this forest. The stand is bordered by old-growth whitebark pine which is being decimated by mountain pine beetle. Easily accessible from Cranbrook, Puddingburn Mountain is an ideal location for demonstrations, monitoring and restoration of forest health amidst diverse whitebark pine stands. I wish to thank Rocky Mountain District Staff, Liz Goyette and Lyn Konowalyk, for their valuable assistance with surveys.

Table 10. Disease incidence on whitebark pine in the Kootenays, 2010.

Location	White Pine Blister Rust Incidence
Puddingburn Mountain (Cranbrook)	71%
Red Mountain (Nelson)	23%
Bluejoint Mountain (Grand Forks)	18%
Findlay (Canal Flats)	15%

Whitebark pine afflicted with mountain pine beetle at Puddingburn Mountain (near Cranbrook), 2010.

8. Wildlife damage, white pine blister rust, and other important agents in young stands: New findings from Kootenay Lake TSA

Michael Murray, Forest Pathologist, SIFR

An intensive survey of 58 cut-blocks has yielded useful insight on the health of regenerating stands (16-40 years old). This analysis is patterned after similar efforts (e.g. Lakes TSA) which aim to assess the stocking character and forest health of young stands throughout the Province. As part of the Stand Development Monitoring (SDM) protocol, results provide insight for determining how well plantations are progressing after formal free-growing designations.

Whitebark pine killed by bear and mountain pine beetles, Mt. Nelson

The Kootenay Lake TSA is predominantly Interior Cedar-Hemlock (ICH) and Engelmann Spruce – Subalpine Fir (ESSF). A total of 12,121 regenerating trees from 58 plantations were sampled. Within the sampled units, leading species are lodgepole pine, western hemlock, subalpine fir, and Engelmann spruce.

Preliminary findings indicate more trees have been impacted by wildlife damage than by any other biotic agent (Table 11). The incidence on pines is notable. As plantation trees have grown, their greater size has become more attractive to mammals which feed on the cambium. Thus, trees which have passed the free-growing landmark appear more vulnerable.

Table 11. Percent of affected trees in the Kootenay Lake TSA. Only agents which totalled ≥0.01% are provided.

Forest Health Factors	Percent of Trees Observed
Abiotic Damage	4.27
Wildlife Damage	2.40
Vegetative Competition	1.16
White Pine Blister Rust (all conifers)	1.11
All Root Diseases	0.96
Native Rusts (Gall, Commandra, Stalactiform)	0.74
Mistletoe	0.06
Foliar Disease	0.01
TOTAL	**10.7**

White pine blister rust and root diseases are affecting more trees than all other diseases combined. Of note - the high incidence of white pine blister rust compared to root disease. This may partly reflect that root diseases are more challenging to recognize with field surveys.

Forest Health Meetings

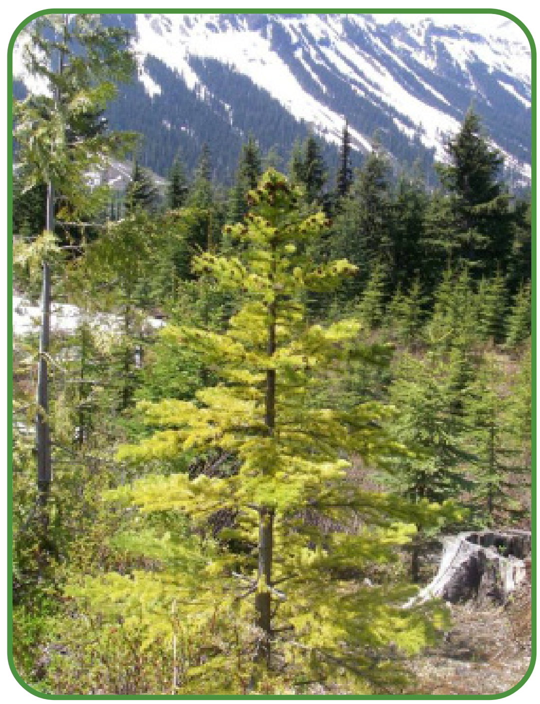
58th annual Western International forest disease conference

Michelle Cleary, Forest Pathologist, SIFR

Venue:
Valemount, October 4-8, 2010

Summary:
The 58th Annual Western International Forest Disease conference (WIFDWC) was held this year in Valemont, British Columbia. Nearly 70 participants attended, about 2/3 of which were from the U.S. We were grateful to have executive participation with Madeline Maley giving an official welcome to the conference and Jim Snetsinger as Keynote Opening Speaker. Special conference sessions were held on White Pine Blister Rust to commemorate its centennial introduction to North America; the economic, social and ecological impacts of diseases on forests; and Armillaria root disease. Field tours included stops to McBride Peak (white bark pine and blister rust), Jackman Flats Provincial Park (mountain pine beetle and lodgepole pine mistletoe), Rearguard Falls and Mount Robson Park (for the spectacular view!) and the east side of Kinbasket Lake (SDM in young stands and Armillaria root disease impacts). A special thanks to Richard Reich and the organizing committee and all presenters including Alex Woods, Stefan Zeglen, Michael Murray, and Lorraine Maclauchlan for helping to make this year's WIFDWC a huge success! Thanks also to Harry Kope, Norma Stromberg-Jones, Heather MacLennan, Kevin Buxton, Deanna Danskin, Erin Havard and the Valemount Fire Protection crew for their assistance with local and logistic arrangements.

Entrance to Mount Robson Park



Spruce showing symptoms of Armillaria infection

Encouraging deployment of western white pine and Sitka spruce in the Coast Forest Region. A look at recent advances in pest resistance.

Craig Wickland, *Regional Silviculturist, CFR*
Scott Dunn, *Resource Management Forester, Campbell River Forest District*

Venue:
Workshop – sponsored by Coast Region FRPA Implementation Team (CRIT) with help from Forest Genetics Council of BC and Interfor, Campbell River, BC, October 19, 2010.

Summary:
The workshop goals were to improve tree species diversity and bring species back into the landscape where they have been in the past. Approximately 40 participants discussed the latest information regarding operational performance of rust-resistant western white pine and weevil resistant Sitka spruce on the BC coast. After reviewing resistance mechanisms and breeding programs for trees that are resistant to these forest heath agents, a discussion on how to overcome barriers to use of this valuable seed source ensued. Suggestions included assessing risk, reducing costs for seed, changing species guidelines (as appropriate) and amending forest health guidelines (e.g. no pruning requirements if rust resistant white pine seed is planted).

The future of high-elevation five-needle white pines in Western North America

Michael Murray, *Forest Pathologist, SIFR*

Venue:
Symposium – sponsored by Parks Canada, US Forest Service, National Park Service, Whitebark Pine Ecosystem Foundation, and other NGOs, University of Montana, Missoula, July 28-30, 2010.

Summary:
About 250 people participated in this past summer's first-ever conference dedicated to high-mountain five-needled pines. The pines (whitebark, limber, foxtail, southwestern white, Rocky Mountain bristlecone, and Great Basin bristlecone) are sensitive to forest health agents, especially white pine blister rust and climate change. Recognizing this, the conference objectives were to network people and promote understanding and improved management. Michael Murray (MFR) and Elizabeth Campbell (formerly of MFR) served on planning committees to help organize nearly 100 presentations and a field trip. The program was comprised of a keynote address, seven plenary presentations, 82 special session presentations, 23 technical papers, and 21 poster presentations. Two-thirds

White pine blister rust fruiting structures among lichen on whitebark pine near Cranbrook.

John King (MFR Research Branch) describes whitebark pine research on McBride Peak to participants of the WIFDWC gathering in Valemount

of presentations focused on whitebark pine, 20 percent on limber pine, and five percent on the other four high-elevation five-needle pines.

The third day of the conference entailed a field trip to the Missoula Snowbowl ski area. Participants visited eight stations scattered across the mountainside. At Station 1, Bob Keane (USFS) gave an overview of his whitebark pine restoration project at the ski area. Station 2 featured Holly Kearns (USFS) and John Schwandt (USFS) presenting the latest findings on blister rust-pine interactions, including resistance, host species, and spread. At Station 3, Mary Frances Mahavolich (USFS) and others described the whitebark pine genetic restoration program in the Inland Northwest. At Station 4, Shawn McKinney (NPS) presented the latest findings on pine/nutcracker/squirrel interactions, and changing climatic conditions. At Station 5, Dan Reinhart (NPS) facilitated a discussion on operational and philosophical challenges to restoring whitebark pine ecosystems in wilderness, backcountry, and roadless areas. At Station 6, Glenda Scott (USFS) described operational whitebark pine regeneration strategies, from cone collection to regeneration success. At Station 7, Jane Kapler Smith (USFS) directed an interactive discussion of educational opportunities in high-elevation pine ecosystems. Finally, at Station 8 John Waverek (USFS) discussed prescribed burning as a tool for restoring whitebark pine ecosystems. Four optional field trips—one guided and three selfguided - were offered after the conference adjourned.

A proceedings document featuring about 35 papers and 20 abstracts will be published by the USFS Rocky Mountain Research Station. It's expected in mid-2011 and will be available online (http://www.treesearch.fs.fed.us/) and mailed for free to anyone in BC.

Pine needle rust (Coleosporium asterum) on lodgepole pine near Nelson.

Forest Health Presentations

Annual observations of conspicuous canker activity on whitebark pine (2003 to 2007)

Michael Murray, *Forest Pathologist, SIFR*

Venue:
Symposium – The Future of High-Elevation Five-Needle White Pines in Western North America (sponsored by Parks Canada, US Forest Service, National Park Service, and NGOs), University of Montana, Missoula, July 28-30, 2010.

Abstract:
Rust-induced mortality is becoming well-documented across the natural range of whitebark pine. However, at a finer scale (i.e. individual tree), the biological interactions taking place between the infected host (whitebark pine) and disease are not well-studied. The objective of this study was to track the most apparent signs of canker activity on mature whitebark pine in Crater Lake National Park, Oregon over a 5-year study period. The magnitude and duration of inactive periods were documented. Further insight regarding possible differences between canker locations (branch vs. stem, location in study area) was also sought. For this study, activity was indicated by one or more symptoms: conspicuous resinosus, sporulation, rodent-gnawing, or bark discoloration. A total of 52 cankers from 46 trees were tracked. Overall, 42 percent of cankers changed their status (active vs. inactive) at least once. Cankers were significantly more active in 2003 and 2006 (x2, Yates correction, $P<0.05$). Branch cankers were observed to be more active than stem cankers in all years except 2003, although not with significance ($U=5$; $P<0.05$). The east-side tended to have lower activity, however, the disparity between sides was not significant ($U=8$, $P<0.05$). The reliability of outward signs of activity closely reflecting fungal virulence is not well-documented in literature. The disease may continue to thrive, and possibly spread beneath the bark without conspicuous symptoms. Notwithstanding, no cankers re-activated after three years of inactivity. Additional studies could explore the utility of this potential threshold in determining when a canker is no longer infected with inoculum. Overall, half of all inactive cankers failed to re-activate. Thus, classifying a tree as having blister rust based on the existence of a single canker which appears inactive would risk overestimating disease incidence.

Are managed stands in BC meeting expectations? If not, why not? And what are the implications?

Alex Woods, *Regional Pathologist, NIFR*

Venue:
Western International Forest Disease Work Conference, Valemount, BC, Oct 4-8, 2010.

Abstract:
After free-growing is declared, possibly as early as age seven, stands are not likely assessed again until after age 60. Growth and Yield (G&Y) models are then used to project yield post free-growing and these model outputs drive managed stand assumptions in Timber Supply Reviews (TSRs). There currently is no government lead formal re-evaluation of managed stands post free-growing in BC. We need to know how well our managed stands are doing. We are depending on them but

we all know that forest health agents can have considerable influence on future productivity. The overall objectives of SDM is to look back at previous stand condition as determined at free-growing and see if stands are on assumed growth trajectories. We also want to determine current yield in a manner that can be compared to G&Y model projections and to quantify species specific impacts due to damaging agents. The SDM protocol has been developed and piloted throughout BC for two years. Given what has been found so far in the five intensive examinations that were used to develop SDM, I suggest the following could be some of the implications of managed stands not meeting expectations across BC:

- Losses to timber supply
- Unrealized genetic gain
- Certification of sustainably managed forests
- Carbon sequestration less than expected

Each of these possible implications of the results of SDM work were discussed in more detail.

Effectiveness of low-dose application rates of TM-Biocontrol-1, the natural virus of the Douglas-fir tussock moth, *Orgyia pseudotsugata* McDunnough

Lorraine Maclauchlan, Regional Entomologist, SIFR
Iral Ragenovich, Entomologist, Pacific Northwest Region USDA Forest Service

Venue:
2010 SERG meeting, St. John's, Newfoundland, February 8-10, 2010.

Abstract:
Douglas-fir tussock moth, *Orgyia pseudotsugata* McDunnough (DFTM), outbreaks occur on a periodic cycle throughout the western U.S. and B.C. causing significant defoliation of Douglas-fir and true firs. With the extensive loss of low elevation Ponderosa pine to mountain pine beetle, there is strong pressure to reduce damage by the DFTM in southern B.C. One of the recommended and most environmentally acceptable suppression options for DFTM is use of the naturally occurring nucleopolyhedrosis virus (NPV). This project was initiated in collaboration with the USDA to evaluate the effectiveness of low-dose application rates of TM-Biocontrol-1, a registered formulation of NPV. If a lower dosage rate than the registered rate is successful, this would extend the useable amount of this limited resource currently in stock. With limited virus remaining in stock and the reduced potency from storage over time, there is a need to extend the life of existing or new supplies.

The trial was a replicated study comparing reduced rate(s) of virus to the recommended adjusted rate (Lot 7 TM-Biocontrol-1 @ 3.08 g/ha). The four treatments tested were:

- ¼ registered rate (3 blocks @ 15 ha each)
- ½ registered rate (3 blocks @ 15 ha each)
- Registered rate (3 blocks @ 15 ha each)
- Control (3 blocks @ 15 ha each)

Preliminary results show slight differences in percent larvae killed by virus among treatments with the lowest mortality in the control blocks, ranging from 24% - 37% mortality. There was little difference in percent larval mortality between the ¼-rate and ½-rate treatments, averaging 88%

and 83% mortality respectively with the Reg. rate mortality slightly lower at 65%. Larval rearing and virus level determination yielded 57%, 63% and 67% larval mortality in the ¼-rate, ½-rate and registered rate, respectively. There was little effect on defoliation due to virus treatment, with total tree defoliation lowest in the registered rate and control blocks. Due to the time required for the virus to take effect, initial larval density is the primary factor. In conclusion, lower than registered rate application of TM-Biocontrol-1 caused similar rates of mortality in DFTM. The rate of mortality may differ slightly and timing of application may be more critical with lower applications than with the full registered rate application.

Is the health of British Columbia's forests being influenced by climate change? If so, was this predictable?

Alex Woods, Regional Pathologist, NIFR

Venue:
Joint Annual Meeting and Conference of the Canadian Phytopathological Society with the Pacific Division of the American Phytopathological Society. University of British Columbia, Vancouver, BC, June 20 – June 23, 2010.

Abstract:
Over 14 million hectares of lodgepole pine dominated forests in BC have been severely impacted by the current mountain pine beetle epidemic. Simultaneously, a Dothistroma needle blight epidemic in northwest BC has been responsible for killing thousands of hectares of pine plantations and has even resulted in the death of mature trees, which is unprecedented. Both of these globally significant forest pest epidemics have been linked to climate change. The beetle epidemic has grossly exceeded the scale of all previously recorded outbreaks in large part due to a lack of cold winters. In this sense the link to global warming is relatively straightforward and foreseeable. Of all climate change projections, the prediction of an increase in winter temperatures has been associated with as high a degree of confidence as any. The Dothistroma needle blight epidemic and its link to climate change was not so predictable. Based on weather records over the past four decades, short term increases in mean summer precipitation correlate closely with historical records of Dothistroma outbreaks in the northwest. The current most severe outbreak has occurred during a prolonged period of above average summer precipitation. An increase in summer precipitation would more typically be thought of as beneficial for forests, but that increase in moisture has improved the conditions for a pathogen that has outweighed any benefits. Similar trends of increasing incidence and severity for other forest pathogens in BC appear in areas that have been receiving increased summer precipitation. Conversely, in the southern interior of the province decreased summer precipitation and increased drought conditions are resulting in stressed trees which can favour root diseases. Early indications are that climate change will have profound effects on forest health. Some effects will be more predictable than others.

Impact of climate change on forest pathogens

Alex Woods, *Regional Pathologist, NIFR*

Venue:
Climate Change & Plant Disease Management Conference, Évora, Portugal, November 10-12, 2010.

Abstract:
This conference was the first international meeting specifically planned to tie plant disease science to climate change. All 34 attendees were invited to be a part of the development of a manuscript on the subject for the first edition of a new high impact scientific journal. The majority of the attendees were agricultural plant disease scientists. I was one of three forest pathologists attending the meeting and was one of the six attendees who were invited to speak. I was asked to represent the subject of forest pathology in relation to climate change.

To see the presentation PowerPoint file please contact Alex.Woods@gov.bc.ca.

Influence of nursery and stocktype on incidence of white pine blister rust

Stefan Zeglen, *Forest Pathologist, CFR*
Peter Ott, *Biometrician, Forest Analysis and Inventory Branch*
Jeff Fournier, *Pesticide Officer, Ministry of Environment*

Venue:
58th Annual Western International Forest Disease Work Conference, Valemount, BC, October 5-8, 2010.

Abstract:
White pine blister rust (*Cronartium ribicola*) is such a frequent mortality agent of five-needle pines that the threat of this disease has drastically reduced the planting of western white pine in coastal British Columbia (BC). To determine if the choice of seed source or cultural factors could be used to lower the risk of infection, we designed a trial to examine four variables – seed source (seedlot), stock type, nursery source and the application of an early low-branch pruning treatment. Five seed sources were used, three from putatively resistant parent trees (one canker-free and two slow canker growth) from Texada Island, BC and the other two wild-collected control lots. Seedlings from these five seedlots were raised as either of two stock types - one year plug stock transplanted for a second year into bare soil or as two year plug stock - and all were raised at two different nurseries, one in a high-hazard rust area and the other in a low hazard rust area. Five years after planting half of the subject trees were pruned to reduce the risk of developing rust infections. This design provided a total of 20 different treatment combinations of the four variables that could be tested. The trial was halted prematurely after nine years due to sale and destruction of the test site. Analysis of the data revealed that pruned trees had less infection but that the advantage was small (5%) four years post-treatment. Interactive effects complicated interpretation of the impact of the remaining three variables but it was clear that the canker-free seedlot was superior to both control seedlots. Another result suggests that bare root stock grown at the interior nursery may be less prone to rust than the other combinations but the evidence is not definitive.

Limber and whitebark pines of British Columbia

Michael Murray, *Forest Pathologist, SIFR*

Venue:
Symposium – The Future of High-Elevation Five-Needle White Pines in Western North America (sponsored by Parks Canada, US Forest Service, National Park Service, and NGOs), University of Montana, Missoula, July 28-30, 2010.

Abstract:
A brief overview of the fundamentals of both species was presented. The distribution and associated communities were described. Government agency roles were compared. The overall knowledge on blister rust and mountain pine beetle incidence was described. The provincial conservation framework, official listings, and current timelines were explained. Some current management and research projects were highlighted including: seed collecting, assisted migration, and monitoring. Blister rust screening, although warranted, is not currently implemented.

Status of defoliators in British Columbia and new hazard and risk rating systems

Lorraine Maclauchlan, *Regional Entomologist, SIFR*

Venue:
2010 Western North American Defoliator Working Group, Coeur d'Alene, Idaho. December 7-8, 2010.

Abstract:
Many defoliators were active throughout British Columbia in both conifer and deciduous forests in 2010. Of note, western spruce budworm was mapped over approximately 504,000 ha and Bruce spanworm over 1,683,000 ha. Douglas-fir tussock moth is in its third year of this outbreak cycle and covered 17,956 ha. Two concurrent spray programs were conducted in 2010 for the tussock moth (6,615 ha treated with *Op*NPV and *Btk*) and budworm (47,687 ha treated with *Btk*). New hazard rating systems are being developed for the budworm and tussock moth in BC. Southern BC has been treating defoliators (budworm, tussock moth and western hemlock looper) for over 20 years. The budworm spray program has ranged from under 5,000 ha to over 75,000 ha annually and there is pressure to further increase this program due to mid-term timber supply concerns and climate change. Prior to the late 1980's there was no clear defoliator strategy and application of treatment was haphazard and often objectives were not met. Since that time a comprehensive strategy has been developed but this must continually be updated and improved to reflect the changing dynamics of these insects. These hazard rating systems will help address the following key concerns:

- Target high priority stands
- Target incipient populations
- Minimize damage to forests by identifying most susceptible areas
- Recognize change – including impacts, range and population dynamics

Possible elements of a hazard rating system for the western balsam bark beetle, Dryocoetes confusus Swaine

Art Stock, *Forest Entomologist, SIFR*

Venue:
Terry Shore Memorial Symposium, Joint Annual Meeting of the Entomological Society of Canada and the Entomological Society of British Columbia. October 31st – November 3rd, 2010. Vancouver, BC.

Abstract:
Tree and site characteristics were compared between subalpine fir stands with and without western balsam bark beetle infestations. Significant differences in age, density, latitude, and slope were found between infested and uninfested stands. A discriminant function analysis model using slope, density, and age predicted 77% of the unattacked stands and 71% of the attacked stands correctly. The results suggest that site and stand characteristics may be useful for developing a susceptibility rating of subalpine fir stands to western balsam bark beetle attack. Thanks to contributing authors Terry L. Shore, Allen M. Brackley and Stuart P. Taylor.

The mountain pine beetle story: path of the outbreak and future opportunities

Lorraine Maclauchlan, *Regional Entomologist, SIFR*

Venue:
The Western Forest Disease Working Group, Valemount, BC, October 6, 2010.

Abstract:
Changes in forests come primarily in the form of "disturbances," which can be defined as discrete events in space and time that disrupt the successional development of a forest stand, ecosystem, or landscape, by affecting its population structure and changing resources, substrate availability, or the physical environment. Landscapes, host condition and abundance, climate, fire and insect population dynamics have all played vital roles in the extent and severity of the current mountain pine beetle (MPB) outbreak in British Columbia. These factors, and many others, all coalesced in a unique spatial and temporal array to allow this insect to reach a critical mass on the BC landscape that exceeded all other recorded MPB outbreaks. MPB-induced tree mortality strongly influences forest dynamics, both as a natural thinning agent and by changing the fuel loading in stands, thus affecting fire behaviour. This MPB outbreak is so extensive that only the severe depletion of the host resource will cause the collapse of the population. The most concentrated and extensive sources of high susceptibility host are now depleted. This abundant host resource that fuelled the early years of this outbreak was located to the largest extent in the central interior from Vanderhoof south to 100 Mile House. With these vast areas of dead pine the landscape is very disjointed from the beetle's perspective. The outbreak is in the "decline phase" in the all but the periphery of the outbreak area such as the far north, eastern and southern portions of B.C. In these last refugia of pine the beetle will once again display more typical outbreak dynamics and natural mortality factors will start to govern the population.

Tree declines: examining three species in BC's southern interior

Michael Murray, *Forest Pathologist, SIFR*

Venue:
Columbia Mountains Institute Annual Researchers' Meeting, Selkirk College, Castlegar, BC, May 12, 2010.

Abstract:
During the past several years, a number of tree species have suffered pronounced death or injury with multiple agents evident. Paper birch has been denuded in the Kootenays with bronze birch borer and Armillaria root disease most obvious. Whitebark pine is dying from mountain pine beetles, blister rust, and fire. Western redcedar is the most recent victim and agents have not been identified yet. Although known mortality agents are native, except blister rust, trees may be more prone to outbreaks owing to underlying environmental stress. Forest declines are typified by three elements: a complex-causal relationship; environmental stress; and two or more mortality agents. A milieu of factors can be challenging to analyze and eventually boil-down to any single cause of tree death. Why are one or more pests successfully killing multiple tree species in such large numbers within a short period of time? This die-off may be linked to climate perturbations inducing stress. Tree stress is evident in growth rings. A dendrochronology lab is being set up at the Kootenay Lake Forestry Center. A ring analysis system includes a velmex stage, high-resolution video, and precise ring measurement. During 2009, a collection of increment cores and cross-sections began. To date we have almost 200 samples from 16 sites between Revelstoke and Yahk. Two-thirds of samples are from birch. Preliminary examination of rings indicates many trees have suffered stress during the past 5—20 years. Weather records extending back 100 years are also being examined. Field sampling continues.

Update on forest health in the SIFR

Lorraine Maclauchlan, *Regional Entomologist, SIFR*

Venue:
The Southern Interior Beetle Action Coalition (SIBAC), Kamloops, BC, December 3, 2010.

Abstract:
A dramatic decline was observed in the total amount of mountain pine beetle red attack mapped in the Southern Interior Region in 2010, down from 546,844 ha in 2009 to 262,942 ha in 2010. Mountain pine beetle is still quite active in the Okanagan Shuswap and parts of the Cascades Districts however. Of note is the incidence of attack in young pine which increased from levels detected in 2009. Spruce beetle and Douglas-fir also declined in 2010 but localized hot spots remain. The western balsam bark beetle declined overall but remains at high population levels in many areas with just over 112,000 ha mapped in 2010. Many defoliating insects remain at high or increasing level in the south. Hemlock looper is steadily increasing and we may see considerable defoliation in 2011. Western spruce budworm declined slightly in part due to its more dispersed habitat in the south and the aggressive spray program in 2010 (over 47,600 ha treated with *Btk*). The Douglas-fir tussock moth defoliated 17,956 ha in 2010, only a slight increase from 2009. The 2010 spray program for tussock moth involved the use of *Op*NPV, *Btk* and combinations of the virus and *Btk* over a total of 6,615 ha in the Okanagan and west Kamloops areas. It is expected that 2011 will be the last big year for tussock moth before the population collapses in most areas.

Forest Health Publications

Alfaro, R.I., Hantula, J., Carroll, A., Battisti, A., Fleming, R., Woods, A., Hennon, P.E., Lanfranco, D., Ramos, M., Müller, M., Lilja, A. and Francis, D. 2010. Forest Health in a changing environment. (Box 7.1 Lessons from a Dothistroma needle blight epidemic in northwestern British Columbia, Canada) 113 - 134 in Mery, G.; Katila, P.; Galloway, G.; Alfaro, R.I.; Kanninen, M.; Lobovikov M. and Varjo, J. editors. Forests and Society – Responding to Global Drivers of Change. International Union of Forest Research Organizations (IUFRO), Vienna, Austria.

Cleary, M. (Ed). 2010. Proceedings of the 3rd Western White Pine Management Conference. June 17-18, 2008, Vernon, British Columbia. BC Ministry of Forests and Range, Kamloops, British Columbia. 116pp.

Cleary, M. 2010. Traumatic resin duct formation in the phloem of western red cedar and other resistance mechanisms effective against Armillaria root disease. Proceedings of the International Symposium - A Tale of Two Cedars: Western redcedar and yellow-cedar. University of Victoria, Victoria British Columbia, May 25-28, 2010. U.S.D.A. Forest Service Pacific Northwest Research Station, Portland, Oregon, PNW-GTR-828, October 2010. 53-56.

Murray, M.P. and Tomback, D.F. 2010. Clark's nutcrackers harvest sugar pine seeds from cones. Western North American Naturalist 70(3):413-414.

Murray, M.P. 2010. Will whitebark pine not fade away? Insights from Crater Lake National Park (2003-2009). Park Science 27(2): 64-67. http://www.whitebarkfound.org/Murray-Park-Science-2010.pdf

Sturrock, R.N., Frankel, S.J., Brown, A.V., Hennon, P.E., Kliejunas, J.T., Lewis, K.J., Worrall, J.J. and Woods, A.J. 2011. Climate change and forest diseases. Plant Pathology 60: 133-149.

Woods, A. 2010. Forest and Range Evaluation Program Stand Development Monitoring (SDM). Forest and Range Evaluation Program, BC Ministry of Forests and Range, Victoria, BC. FREP Extension Note #10.

Woods, A.J., Heppner, D., Kope, H., Burleigh, J. and Maclauchlan, L. 2010. Forest health and climate change: A British Columbia perspective. Forestry Chronicle 86: 412-422.

Zeglen, S., Pronos, J. and Merler, H. 2010. Silviculture management of white pines in western North America. Forest Pathology 40: 347-368.

Ministry of Forests, Mines and Lands

Acknowledgements:

Many thanks to the contributors to this document:

Data and project information:

MFR Forest Practices and Investment Branch -	Harry Kope, Provincial Forest Pathologist
Ministry of Natural Resource Operations	
South Area:	
Kootenay-Boundary Region -	Art Stock, Forest Entomologist
	Michael Murray, Forest Pathologist
Thompson-Okanagan Region -	Lorraine Maclauchlan, Forest Entomologist
	Michelle Cleary, Forest Pathologist
	Kevin Buxton, Forest Health Specialist
Cariboo Region -	Leo Rankin, Forest Entomologist
North Area:	
Ominica Region -	Robert Hodgkinson, Forest Entomologist
	Richard Reich, Forest Pathologist
Skeena Region -	Ken White, Forest Entomologist
	Alex Woods, Forest Pathologist
Coast Area:	
West Coast Region -	Stefan Zeglen, Forest Pathologist
	Craig Wickland, Regional Silviculturist
University of British Columbia	Tom Sullivan, Agroecology Professor
Consultants -	Alta Vista Management
	BA Blackwell & Associates Ltd.
	Industrial Forestry Service Ltd.
	JCH Forest Pest Management
	Nazca Consulting
	Pro-Tech Forest Resources Ltd.
	Purcell Resources Inc.
	TimberWright Contracting
	Wildlife Dynamics Consulting

Photographs:

Aaron Bigsby (Meager slide, Douglas-fir beetle mortality)
Alex Woods (SDM training)
Art Stock (bear damage)
Barb Zimonick (NPV virus mixing)
Barry Mills (aerial observers
Chris Bailey (red belt, willow leafminer)
David Rusch (lophodermella)
Don Wright (drought damage, alder defoliation)
Janice Hodge (satin moth pupa)
Jennifer Burleigh (shoot moth)
Joan Westfall (various remaining)
Ken White (birch leafminer, yellow headed spruce sawfly)
Lorraine Maclauchlan (Douglas-fir tussock moth larvae and egg masses, western hemlock looper, secondary beetle attack)
Michael Murray (whitebark pine, white pine blister rust, larch needle blight, birch decline, Armillaria on paper birch, pine needle rust, WIFDWC gathering)
Michelle Cleary (Botryosphaeria canker, Mt. Robson Park)
Neil Emery (spruce beetle, budworm defoliation Flathead Valley, flooding)
Richard Reich (Comandra resistance trial, Armillaria on spruce)
Robert Hodgkinson (Douglas-fir beetle trap trees, ground young pine, blowdown, forest tent caterpillar larvae)
Sean McLean (unknown defoliation)
Stephanie Haight (Bruce spanworm)
Taiho Krahn (serpentine leafminer)
Tom Foy (pine needle cast)

Maps:
Duncan Richards - HR.GISolutions (various)
Resource Tenures and Engineering Branch (Forest Districts map)

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Forests, Mines and Lands