

An aerial photograph of a forest landscape. A winding road is visible on the right side, and a river flows through the bottom left corner. The forest is dense, with many trees showing signs of stress or death, appearing brown and tan against the green foliage. The title text is overlaid in the upper portion of the image.

# 2011 Summary of Forest Health Conditions in British Columbia



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Front cover photo by Art Stock: Larch needle blight damage near Yahk

# 2011 SUMMARY OF FOREST HEALTH CONDITIONS IN BRITISH COLUMBIA



**Joan Westfall<sup>1</sup> and Tim Ebata<sup>2</sup>**

## Contact Information

- 1 Forest Health Forester, EntoPath Management Ltd., 1654 Hornby Avenue, Kamloops, BC, V2B 7R2. Email: [entopath@shaw.ca](mailto:entopath@shaw.ca)
- 2 Forest Health Officer, Resource Practices Branch, PO Box 9513 Stn Prov Govt, Victoria, BC, V8W 9C2. Email: [Tim.Ebata@gov.bc.ca](mailto:Tim.Ebata@gov.bc.ca)

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## SUMMARY

The 2011 *Summary of Forest Health Conditions in British Columbia* (BC) is a compilation of current forest health data from a variety of BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) sources. The primary source is the provincial forest health aerial overview survey program, with additional information from insect population assessments, ground observations by trained personnel and summaries of special projects, meetings, presentations and publications undertaken by MFLNRO entomologists, pathologists and their associates.

Over 7 million hectares of forested land in BC were damaged by a wide variety of forest health agents in 2011. Mountain pine beetle continued to affect the most area and was the most widespread damaging agent, with 4.6 million hectares of mortality. Damage by this beetle has steadily declined over the past three years, after the outbreak peaked at 10.1 million hectares in 2007. Attack was very low and scattered in the initial outbreak areas of the Cariboo Region and the southern portions of the Skeena and Omineca Regions, where very little susceptible pine remains. Infestation expansions continued only on the leading edges in the far northern and southern areas of the province.

Mortality due to other bark beetles also declined in 2011. Western balsam bark beetle attack dropped to one-fifth the area recorded last year, with a total of 325,711 ha affected. Damage continued to occur in the same general areas but infestations tended to be recorded as spots or small polygons rather than large, light disturbances. Size and intensity of spruce beetle infestations decreased to 19,346 ha, and Douglas-fir beetle attack dropped to only 15,789 ha. This trend is anticipated to reverse in 2012 for Douglas-fir beetle and spruce beetle in several areas of the central interior, where populations have been building in trees damaged by wind, flooding and extensive wildfires.

A variety of deciduous defoliators were abundant in BC this year. Aspen (serpentine) leaf miner affected a record 669,050 ha of primarily aspen stands throughout the host range, though cottonwood trees were also damaged. Forest tent caterpillar damage continued to grow in size and intensity with 453,137 ha affected, chiefly in the Prince George TSA. Other aspen defoliators of note were the large aspen tortrix which infested 51,936 ha, mainly in the Fort Nelson TSA, and Bruce spanworm damage primarily located in Fort St. John and Dawson Creek TSAs, which sharply declined to 9,043 ha. Birch leaf miner infestations also declined to 2,915 ha which were observed chiefly in the Kootenay/ Boundary Region.

Three budworm defoliators were active in the province. The most damaging of the three was the western spruce budworm affecting 616,512 ha in southern BC. High value stands at risk of moderate to severe defoliation were successfully treated with the biological pesticide *Bacillus thuringiensis* var. *kurstaki* (*Btk*). A total of 28,766 ha were treated in the Thompson/Okanagan Region, with a further 20,880 ha sprayed in the Cariboo Region. Two-year-cycle budworm defoliation rose to 178,205 ha with most of the damage delineated in the northern interior of the province, where this budworm is in the peak defoliation year. Western blackheaded budworm was mapped across 41,142 ha, with infestations declining in the Queen Charlotte TSA but increasing in the Kingcome TSA.

Douglas-fir tussock moth infestations in the Thompson/Okanagan Region declined in 2011 to 8,008 ha of current defoliation with a further 8,793 ha of mortality mapped in areas where the outbreak was finished. A control program with *Btk* was conducted on 7,150 ha in the spring. Western hemlock looper infestations are on the rise, as documented by increased moth catches in pheromone monitoring traps and increased defoliation which affected 7,051 ha in the southern interior this year. In response to the growing outbreak, up to 16,500 ha are planned for treatment with *Btk* in 2012.

Needle and leaf disease disturbances were up substantially in 2011, due at least in part to wet weather conditions experienced during much of the growing season. *Venturia* blight affected a record 125,319 ha, particularly in the Northeast and Skeena Regions. Larch needle blight impacted 32,719 ha, primarily in the southern portion of the Kootenay/Boundary Region. *Dothistroma* needle blight damage almost doubled to 14,485 ha since last year, but most of the hectares were mapped in one disturbance on Dundas Island in the North Coast TSA. Large-spored spruce-labrador tea rust damage was mapped during the overview surveys for the first time, with 12,153 ha delineated in the Fort Nelson TSA.

Abiotic damage was relatively low this year, particularly damage due to wildfires which affected only 15,149 ha provincially. This represented a record low in the number of fires, with 11,000 ha occurring in just one fire in the Cassiar TSA. Conversely, wet weather resulted in flooding damage more than doubling over 2010 to 10,701 ha. Windthrow damage increased three-fold to 10,541 ha affected. Redbelt damage was observed on 5,287 ha, of which most occurred in the Fort Nelson TSA. Yellow cedar decline damage was mapped on 5,852 ha with the majority of the disturbances noted in the West Coast Region.

Other damaging agents such as animals, slides, *Delphinella* needle cast and black army cutworm affected localized stands throughout the province.

# 2011 SUMMARY OF FOREST HEALTH CONDITIONS IN BRITISH COLUMBIA

## INTRODUCTION

The forests of British Columbia (BC) are very biologically diverse with a wide variety of climates and tree species. These varied forest types are affected by many different damaging agents including insects, diseases, animals and abiotic factors. Intensity, size and locations of these disturbances often change considerably from year to year. An annual aerial overview survey across BC is therefore conducted to adequately identify the changes in damage in a timely and cost effective manner.

The aerial overview survey has been the responsibility of the BC Ministry of Forests and Range for the past fifteen years. In 2010, forestry became the responsibility of the BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) with new regions and some new districts formed. District and regional boundaries have been changed a few times in recent history, but Timber Supply Areas (TSAs) have remained constant. Therefore, this report will primarily reference TSA units from this year forward (Figure 1).

The information collected from the annual aerial overview survey project is used by government agencies, industry, academia and the public. The many uses for the data include supporting Timber Supply Analysis, contributing to the national database for the National Forest Pest Strategy, setting of Government strategic objectives, directing management and control efforts, reporting national indicators for sustainable forest management and providing disturbance data for research projects.

This report is prepared annually after finalization of the aerial overview data. Damage that has occurred over the past year is summarized and compared to previous years. Hectares of disturbances discussed in the report are obtained directly from the aerial overview survey results. New information on damage not visible during the aerial survey were also reported on, but since this information was collected by other methods it was not added to the overview database. This supplementary information included damage caused by diseases such as rusts, cankers and dwarf mistletoes, as well as some animal, abiotic and insect damage. Information from assessments to determine population levels for specific insects such as pheromone trapping and egg mass surveys was also included where appropriate.

Pertinent forest health projects, presentations and publications from the past year undertaken by MFLNRO entomologists, pathologists and their associates follow the general forest health damage reports. This BC forest health conditions report encapsulates information from a MFLNRO perspective and does not necessarily include research and management conducted by other agencies. In addition, the Southern Interior Region publishes its own more detailed survey summary that is available from their web site: [http://www.for.gov.bc.ca/rsi/ForestHealth/Aerial\\_Surveys.htm](http://www.for.gov.bc.ca/rsi/ForestHealth/Aerial_Surveys.htm).

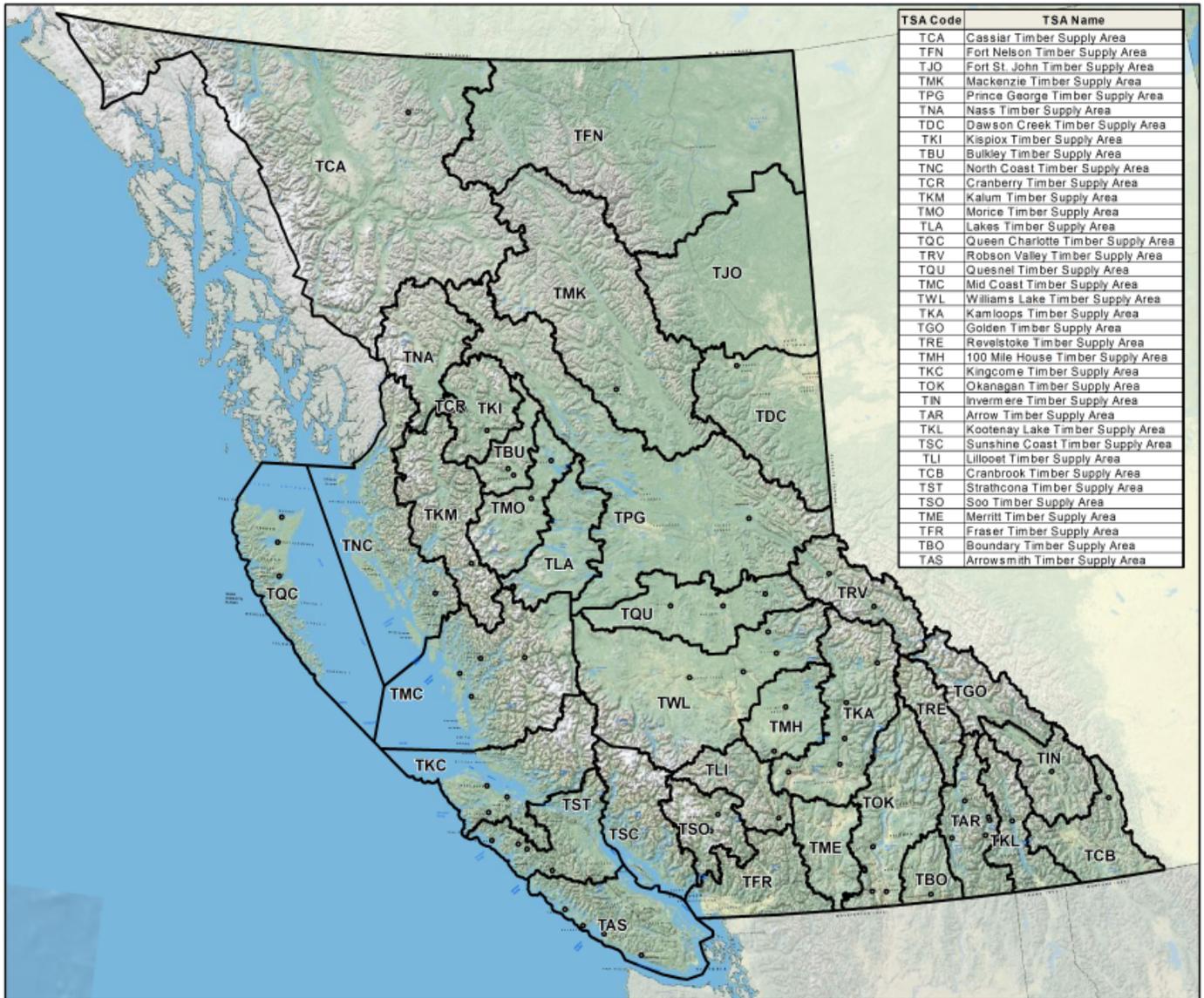


Figure 1. Map of British Columbia outlining Ministry of Forests, Lands and Natural Resource Operations Timber Supply Areas (TSAs).

## METHODS

The aerial overview surveys are conducted by two experienced observers sitting on opposite sides of a small fixed wing aircraft. A minimum of two observers and one plane are employed to cover each region. Forest health damage is sketched on customized 1:100,000 scale maps which consist of colour Landsat 5 satellite images with some features digitally enhanced. After each flight, the two working maps are collated onto one mylar sheet which is then digitized to obtain the final spatial data. 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*

As weather conditions permit, flights are conducted when the primary forest health factors for a given area are most visible. Flights began this year in high priority defoliator areas on July 11<sup>th</sup> and were completed on September 16<sup>th</sup> (Table 1). Unlike the dry summer experienced in 2010 when flights were curtailed by heavy wildfire smoke, 2011 was unusually cold and rainy until at least August over the entire province. The weather was particularly poor in the Skeena Region, where rainy conditions continued throughout the summer into the fall. Temperatures recorded at a weather monitoring station near Smithers showed only 10 days higher than 18°C all year. The Skeena survey crew were on standby to fly until mid-October, but no suitable flight days (without rain, fog or snow) occurred after the last flight on August 26<sup>th</sup>. Hence, a substantial portion of that

region was not surveyed. A total of 701.3 hours of flying time were logged to complete the provincial aerial overview survey in 2011.

Table 1. Flying hours and survey dates by region for the 2011 provincial aerial overview survey.

Region	Flight hours	Survey Dates
Cariboo	125.8	July 11 <sup>th</sup> – Aug 8 <sup>th</sup>
Thompson/Okanagan	53.9	July 22 <sup>nd</sup> – Aug 3 <sup>rd</sup>
Kootenay/Boundary	101.8	Aug 1 <sup>st</sup> – Aug 20 <sup>th</sup>
Omineca & Northeast	269.1	July 18 <sup>th</sup> – Sept 16 <sup>th</sup>
Skeena	70.1	July 19 <sup>th</sup> – Aug 26 <sup>th</sup>
West & South Coast	80.6	July 6 <sup>th</sup> – Sept 19 <sup>th</sup>
<b>Total</b>	<b>701.3</b>	<b>July 6<sup>th</sup> – Sept 19<sup>th</sup></b>

All flight lines were recorded with recreational quality Global Positioning Satellite (GPS) receiver units, to monitor survey progress and coverage intensity (Figure 2). Flights were conducted between 700m to 1400m above ground, depending on visibility and terrain. Over relatively flat ground parallel lines were flown 7km to 14km apart, depending on how active damaging

agents were. In mountainous areas valley corridors were flown. Plane speed, dependent on wind speed and the extent and variety of damage, ranged from 130 to 180 kph. All forests within the viewing area were surveyed for visible forest health disturbances on trees.

Weather and funding permitting, the annual goal is to survey all forested land across the province regardless of ownership or tenure. This goal is difficult to reach unless weather conditions are ideal. Therefore, high priority areas and major drainages in low priority areas (where damage has historically been low) are targeted. If an area can't be flown one year, it becomes a higher priority for surveys the following year. In 2011, all of the Cariboo, Thompson/Okanagan and Kootenay/Boundary Regions were flown, as were the majority of the South and West Coast Regions. For the first time, almost all of the Northeast and Omineca Regions were surveyed, but due to the poor weather only the southern half of the Skeena Region was flown. The percentage flown was calculated using area estimates measured with a digital planimeter. The area estimated did not factor in whether areas contained non-forested types such as lakes, shrubs, grasslands or alpine. In total, an estimated 85% of BC was flown, which was the same percentage as last year. In 2010, more of the Skeena Region was flown but less of the Northeast Region.



Figure 2. Flight paths flown while conducting the 2011 aerial overview surveys.

Tree mortality was identified by the colour of the tree foliage. Only trees killed within the past year were mapped. Clumps of up to 50 dead or dying trees were recorded as “spots” and mapped as point data. When digitized, spots with 1 to 30 recently killed trees were given a size of 0.25 ha and 31 to 50 trees 0.5 ha with an intensity rating of severe. Larger areas of mortality were mapped as polygons by five intensity classes (Table 2).

Trees with foliar damage (caused by insect feeding, foliage diseases or some abiotic factors) tend to cover large areas and all age classes of host trees can be affected. Therefore, polygons were mapped and these areas were assessed for intensity of defoliation based on the amount of foliage damaged in the past year over the entire polygon (three current damage intensity classes, Table 2). Two exceptions were made to include spot data for specific foliage damage this year. Larch needle blight, prevalent in the Kootenay/Boundary Region, often severely affected only individual

or small clumps of trees in a given stand due to the high percentage of non-host tree species. In the Northeast and Omineca Regions, Venturia blight was observed in some cases to be severely affecting only small clumps of trees, despite adjacent trees being the same species.

Foliar damage usually does not cause substantial tree mortality, but after several successive years of damage some trees do succumb. Once a damaging agent has run its course in a given area, cumulative damage resulting in mortality is recorded as grey (Table 2). This occurred in some areas affected by Douglas-fir tussock moth this year.

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.
	Grey	Cumulative foliage damage resulting in mortality, recorded at end of damage agent cycle.

The data collected during the aerial overview survey has limitations. Not all damage is visible either due to the height flown or the timing of the surveys. Additionally, care must be taken in interpretation of the data. Hectares recorded as affected by a given factor during past surveys cannot be added cumulatively since new damage may be recorded in all or a portion of the same stands that were previously disturbed. The relatively broad intensity classes and known errors of omission must also be considered. For example, calculating accurate mortality volume estimations are not possible since the actual number of trees killed (and consequently, volume) is not precise. Despite these limitations, the MFLNRO Forest Analysis and Inventory Branch have utilized the overview survey data to estimate the cumulative and projected volumes of pine killed by the mountain pine beetle (<http://www.for.gov.bc.ca/hre/bcmpb/>).



Western gall rust damage is one of the forest health factors that is not visible during the aerial overview surveys

## GENERAL CONDITIONS

A total of 7,271,043 ha of damage were mapped during the aerial overview surveys across BC in 2011 (Table 3). This was a drop of almost one-third since last year, primarily due to the continued decline in mountain pine beetle mortality. Mountain pine beetle damage peaked in 2007 at 10.1 million hectares and dropped to 4.6 million hectares in 2011. Western balsam bark beetle infestations also dropped substantially to just under 326,000 ha of damage, recorded as primarily trace intensity. Spruce beetle mortality decreased by almost a third since last year to 19,346 ha, with most of the reduced infestations located in the same general areas of the southern interior. Douglas-fir beetle attack declined for the second consecutive year to only 8,866 ha affected, which agrees with last year's current attack ground observations.

Total area impacted by defoliators was down slightly from last year to 2.1 million hectares, but some outbreaks decreased while others rose. For the first time since the aerial surveys began, aspen leaf miner became the lead damaging defoliator with 669,050 ha affected. Attack was recorded throughout the range of aspen in BC. After a brief one-year decline, western spruce budworm defoliation rose to 616,512 ha, primarily in the southern interior. Two-year-cycle budworm damage rose as well to 178,205 ha, most of which was located in the northern interior. Forest tent caterpillar damage more than tripled to 453,137 ha, chiefly in the central interior. Conversely the Bruce spanworm outbreak in the Northeast Region which led the defoliator damage last year at 1.7 million hectares, dropped dramatically to only 9,043 ha affected. Defoliation by the large aspen tortrix was substantial for the first time in four years with 51,936 ha recorded, mainly in the Fort Nelson TSA. Particularly at the edges of aspen defoliator infestations, a complex of more than one insect occurred. The primary insect was documented, with minor occurrences noted in the database comments. The western blackheaded budworm outbreak which began two years ago decreased in the Queen Charlotte TSA but increased in the Kingcome TSA with a total of 41,142 ha recorded in the West Coast Region. The Douglas-fir tussock moth outbreak in the Thompson/Okanagan Region is waning, though delineation of mortality where the outbreak was finished resulted in total recorded damage being similar to 2010 at 16,801 ha affected. Conversely, western hemlock looper infestations more than doubled since last year to 7,051 ha of defoliation detected in the southern interior of the province.

Abiotic damage usually far outweighs disease damage, but a large decrease in wildfires this year and a substantial increase in several diseases resulted in diseases affecting almost four times the area that abiotics did in 2011. The majority of the damage was due to *Venturia* blight, which was detected on 125,319 ha in the northern interior of the province. Larch needle blight was prevalent throughout stands in the Kootenay Boundary Region, with 32,954 ha delineated. *Dothistroma* needle blight damage increased somewhat to 14,485 ha, primarily in the Skeena Region, though with the wet 2011 growing season this number is expected to rise sharply next year. Large-spored spruce-labrador tea rust was recorded for the first time in the history of the aerial surveys, with 12,153 ha mapped in the Fort Nelson TSA.



*Venturia* blight damage

Wildfire still led the list of abiotic damage with 15,149 ha affected, but this was down twenty fold from last year. Conversely, all the rain resulted in flooding damage more than doubling to 10,701 ha of damage. Damage due to wind, snow and/or ice tripled to 11,447 ha. Yellow cedar decline and redbelt affected similar areas with 5,852 ha and 5,287 ha noted, respectively.

Various other damaging agents caused minor, localized damage throughout the province as well. Locations, extent and intensity of damage by all forest health factors are documented in the next section of this report by host tree species.

Table 3. Summary of hectares affected by forest damaging agents as detected in 2011 aerial overview surveys in British Columbia.

Damaging Agent	Hectares Affected	Damaging Agent	Hectares Affected
<i>Bark Beetles:</i>		<i>Diseases:</i>	
Mountain pine beetle	4,624,907	Venturia blight	125,319
Western balsam bark beetle	325,711	Larch needle blight	32,954
Spruce beetle	19,346	Dothistroma needle blight	14,485
Douglas-fir beetle	8,866	Large-spored spruce-labrador tea rust	12,153
Engraver beetle	9	Delphinella needle cast	1,331
<i>Total Bark Beetles:</i>	<i>4,978,839</i>	Root diseases**	357
<i>Defoliators:</i>		Pine needle cast	336
Aspen leafminer	669,050	White pine blister rust	232
Western spruce budworm	616,512	Unknown diseases*	13
Forest tent caterpillar	453,137	<i>Total Diseases:</i>	<i>187,180</i>
Two-year-cycle budworm	178,205	<i>Abiotics:</i>	
Large aspen tortrix	51,936	Fire	15,149
Western blackheaded	41,142	Flooding	10,701
Douglas-fir tussock moth	16,801	Windthrow	10,541
Bruce spanworm	9,043	Yellow cedar decline	5,852
Western hemlock looper	7,051	Redbelt	5,287
Unknown defoliators*	5,073	Misc. abiotics	1,748
Birch leafminer	2,915	Slide	1,630
Pine needle sheathminer	729	Snow press	906
Satin moth	604	Aspen decline	374
Larch casebearer	78	<i>Total Abiotics:</i>	<i>52,189</i>
Black army cutworm	67	<i>Animals:</i>	
<i>Total Defoliators:</i>	<i>2,052,343</i>	Bear	404
		Porcupine	88
		<i>Total Animals:</i>	<i>492</i>
<i>Provincial Total:</i>		<i>7,271,043</i>	

\* Unknown refers to damage that could not be confirmed with ground checks.

\*\* Root disease damage is greatly underestimated from aerial overview surveys.

# DAMAGING AGENTS OF PINES

## Mountain pine beetle, *Dendroctonus ponderosae*

### Provincial

Mountain pine beetle mortality peaked in BC in 2007 when just over 10 million hectares were attacked (Figure 3). Infestations continued to decline substantially this year, despite more complete aerial coverage of the attacked areas. A total of 4,624,907 ha were affected compared to 6,251,586 ha last year. Severity declined as well, with 1,566,094 ha (34%) trace, 1,987,401 ha (43%) light, 973,434 ha (21%) moderate, 96,189 ha (2%) severe and 1,788 ha (<1%) very severe delineated. Due to the cool wet weather that occurred provincially until at least August, a substantial amount of the trees attacked in 2010 faded later than usual. As the surveys progressed through the summer, recently turned (chlorotic) trees were observed as late as September. Therefore, it is suspected some attack was missed in the early months of the surveys, particularly in July and the first part of August in the north.

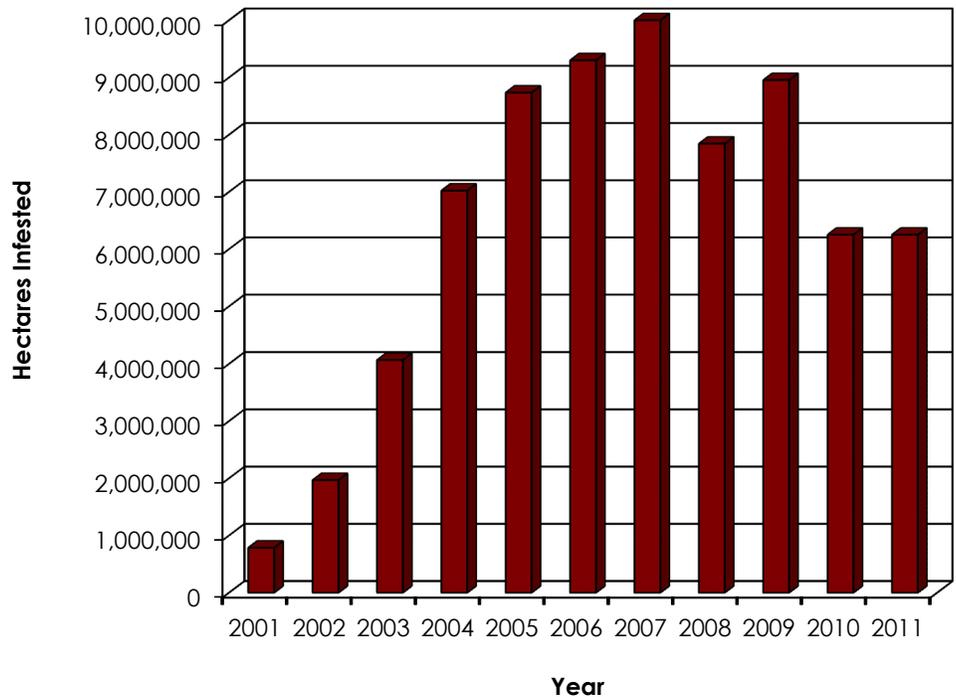


Figure 3. Hectares infested (all severity classes) by mountain pine beetle from 2001 – 2011 in British Columbia.

Infestations continued to expand primarily on the leading edges of the attack in the northern and southern most areas of the province (Figure 4). Beetle populations are hampered in these areas however by cold weather in the north and mixed stands and topography barriers in the south. Established infestations behind these fronts shrank in size and declined in intensity, as remaining mature host trees were depleted. In the initial attack areas, particularly the Cariboo Region and the southern portions of the Skeena and Omineca Regions, attack was very low and scattered in the few remaining susceptible pine.

Aside from the primary host, mature lodgepole pine, mortality continued at a diminished rate in the younger age classes of lodgepole pine as well as mature ponderosa, whitebark and western white pine. Attack of alternate hosts was minimal for the 2<sup>nd</sup> consecutive year.

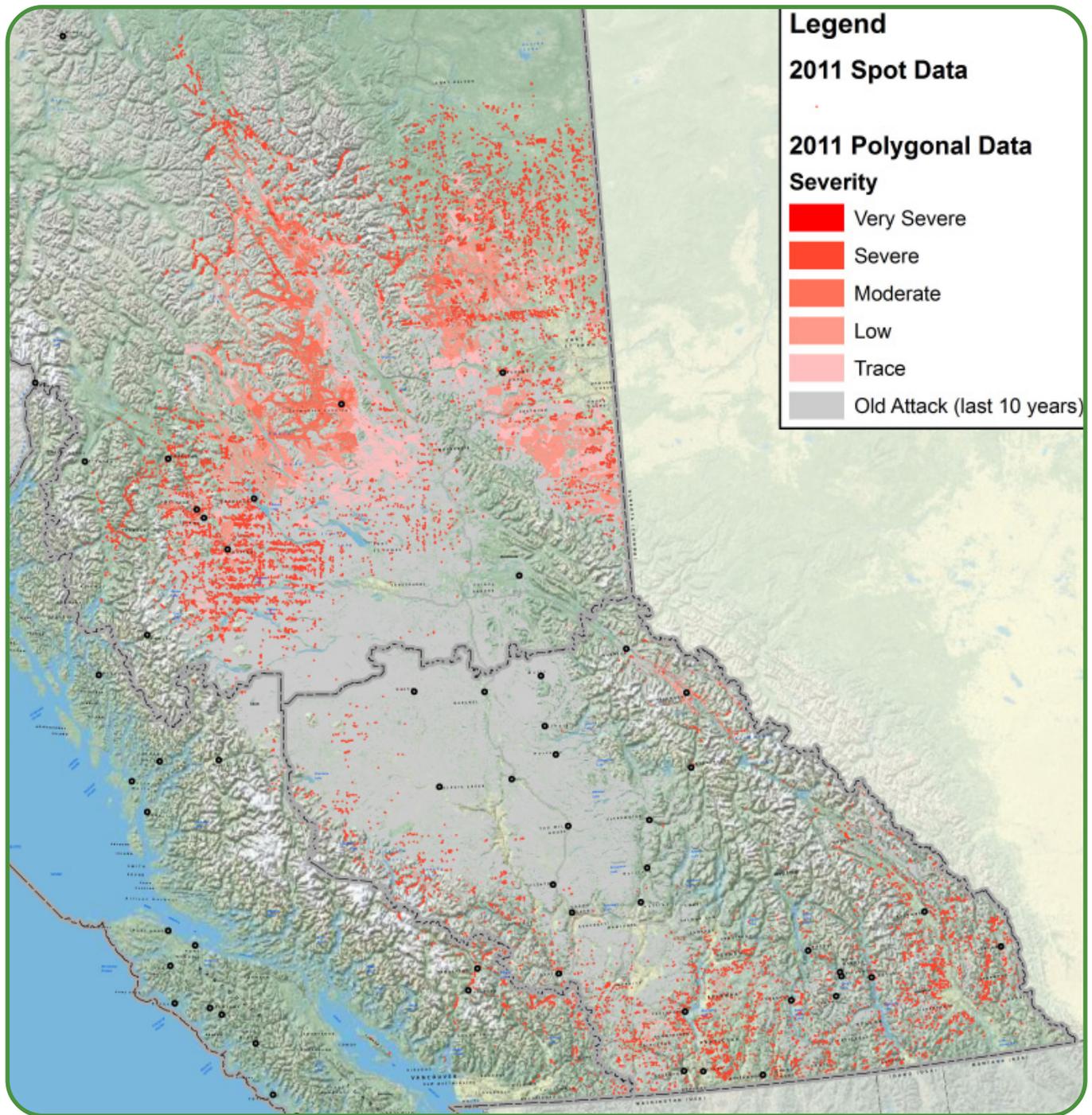


Figure 4. Mountain pine beetle infestations recorded in British Columbia in 2011 with previous attack in grey.

### Northern Interior Damage

The Omineca and Northeast Regions sustained the majority of the mountain pine beetle mortality in 2011 (Figure 5). A total of 4,056,831 ha were affected, which is 88% of the provincial total. Mackenzie TSA contained the highest level of attack with 1,447,831 ha impacted, down from the peak of 1,694,879 ha in 2009. Infestations have dropped dramatically in the southern half of the TSA, while the leading edge of the attack expanded somewhat in the northern third. Intensity levels dropped substantially since 2010 with the severe rating decreasing from 22% to 2% and trace levels rising correspondingly. Conversely, infestations were still very active in the Fort St. John TSA, where attack continued to climb to 1,025,658 ha damaged. Infestations in the southern quarter of the TSA declined, but they grew and coalesced mid TSA, with many new spot infestations identified in the northern third. Only 4% of the attack was rated severe however, and moderate intensity infestations

dropped by half to 16% with a corresponding rise in the trace category. Although the amount of mortality was relatively small in the Fort Nelson TSA, it was important as it represented the leading edge of the BC infestation movement northward. Attack increased 10 fold since last year to 20,357 ha, after being observed for the first time historically in 2009 at 24 ha of damage. Small infestations were recorded throughout the southern tip of the TSA during aerial and ground surveys funded by the Yukon Government with assistance from the Skeena Regional entomologist. These surveys recorded substantial movement of the mountain pine beetle north along the Kechika River drainage. Attack continued up the Kechika River to within 80km of the Yukon border. Ground checks confirmed that the attack was mountain pine beetle but r-value sampling revealed that the populations had very low survival.

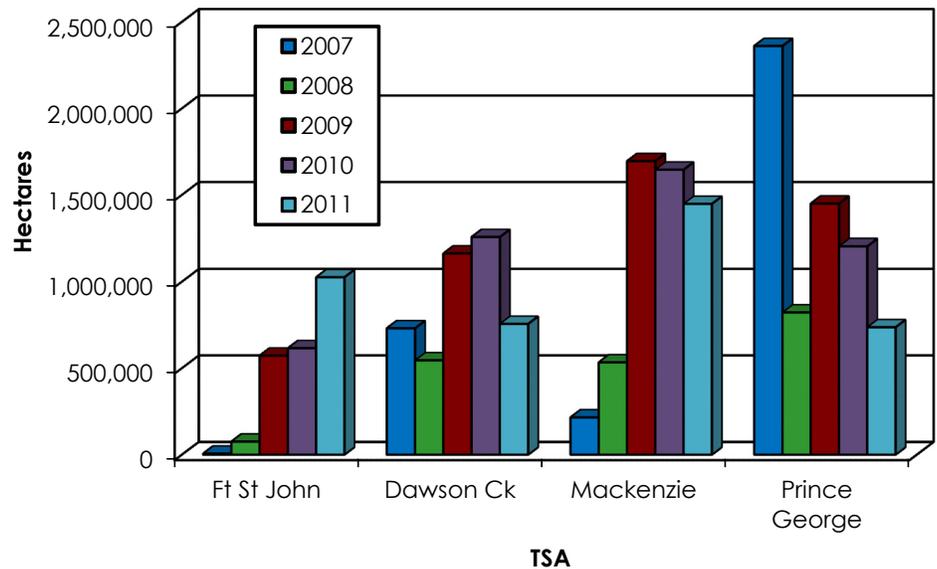


Figure 5. Hectares infested by mountain pine beetle from 2007 – 2011 in the Omineca and Northeast Regions (TSAs with more than 700,000 ha affected in 2011).



Mountain pine beetle mortality NE of Germansen Landing in Mackenzie TSA

In the southern-most TSAs of the Northeast and Omineca Regions, mountain pine beetle attack continued to decline in both area and intensity. Dawson Creek TSA infestations dropped from a peak of 1,258,427 ha last year to 755,854 ha of damage. The majority of the damage was mapped mid TSA and most (98%) was rated as trace to light in intensity. Disturbances in the Prince George TSA dropped to the lowest level in eight years with 736,395 ha mapped. Of this attack, only a few small scattered trace to light polygons were noted in the Prince George Forest District portion of the TSA in the northwest half of the district. The majority of the mortality occurred in the Fort St. James Forest District portion of the TSA, with the highest intensity of attack situated around the northern area of Takla Lake, particularly east of the lake and around West Landing. Infestations in the Robson Valley TSA continued a steady decline to 70,735 ha of attack. Most of the current damage shrank back to the main valley, following along Kinbasket Lake and the headwaters of the Fraser River to McBride.

Mountain pine beetle attack in the Skeena Region dropped almost 60% since last year to 393,483 ha from 943,451 ha affected, though the decreases were not consistent across the TSAs (Figure 6). Although less of the Skeena Region could be flown in 2011 coverage was good in beetle infested areas, hence the drop in area attacked was not due to missed infestations. The most dramatic decrease occurred in the Lakes TSA, where infestations dropped 10 fold to only 38,281 ha. Severity increased however, from primarily trace (97%) to 34%

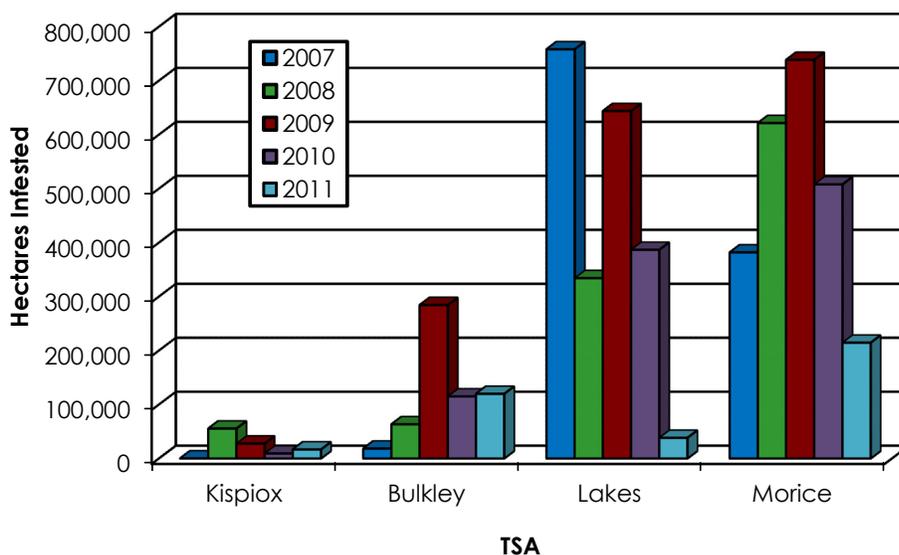


Figure 6. Hectares infested by mountain pine beetle from 2007 – 2011 in the Skeena Region (TSAs with more than 16,000 ha affected in 2011).

light with a corresponding drop in the trace category. Attack remained highest in the Morice TSA with 214,516 ha delineated, though this was down from 507,797 ha last year. Intensity levels were similar to those found in the Lakes TSA, with the highest levels of attack in the northern tip of the TSA. Area affected in the Bulkley TSA remained similar to last year, with 119,793 ha mapped. Mortality decreased in several areas however, particularly in the south, while attack around the Smithers area increased in both size and intensity with 8,000 ha of severe damage delineated. Infestations remained small and scattered along drainages in the Kispiox TSA, with 16,723 ha mapped in 2011. Mortality in the Kalum TSA decreased by almost half to only 3,958 ha. Remaining infestations were primarily light to trace polygons or spots along the Skeena and Zymoetz Rivers. In the southeastern tip of the Cassiar TSA, 203 ha of mortality were mapped and a few spot infestations were identified in the Cranberry and Nass TSA's.

### Southern Interior Damage

In the southern interior, the Cariboo Region has been heavily impacted by the mountain pine beetle outbreak which peaked in this region in 2007 (Figure 7). By 2009 a large percentage of the mature pine in the region was depleted and new infestations sharply declined. This trend continued in 2011 where aside from a few small pockets of current damage, the outbreak appears to be over.

Populations were observed to have collapsed even in areas where mature lodgepole pine has survived. In the Williams Lake TSA 12,541 ha of primarily trace to light attack was delineated. Most of the damage occurred around Tuzcha and Upper Taseko Lakes. Only 1,072 ha of trace to light mortality was observed in the Quesnel TSA in the Baezaeko River area. In the 100 Mile House TSA, only a few small polygons totalling 307 ha were mapped along the Marble Range at the south edge of the TSA.

The mountain pine beetle collapse was not as complete in the Thompson/Okanagan Region, except in the Kamloops TSA where only 985 ha were attacked in small scattered pockets (Figure 8). Disturbances progressed from the northern half of the Okanagan TSA to the south with a total of 44,953 ha affected. The majority of these scattered infestations were trace to light with the exception of higher severities on Aberdeen plateau. Although disturbances are on the decline in this TSA, the southern portion contains substantial areas of pure and highly susceptible lodgepole pine and thus the risk to the remaining pine inventory is high. Small areas of attack were delineated throughout the Merritt TSA, with larger polygons concentrated in the Red and Finnegan Creek area where most of the mature pine left in the TSA is at risk. In total, 32,869 ha were damaged in the Merritt TSA. Disturbances in the Lillooet TSA were down sharply to 9,360 ha of mortality, mainly in the Carpenter and Downton Lakes area.

In the Kootenay/Boundary Region, mountain pine beetle infestations distinctly peaked in 2008 (Figure 9). Due to pine being a lower component of stands in this region compared to other interior regions, hectares affected even at the peak of the outbreak were much lower. A sharp decline followed in 2009, but decreases since then have been slower than in more northern TSAs where the infestations are generally older. Attack was scattered throughout the region in mainly small, light intensity polygons or spot infestations. Invermere TSA contained the most attack with 16,967 ha mapped. Disturbances in the Cranbrook TSA totalled

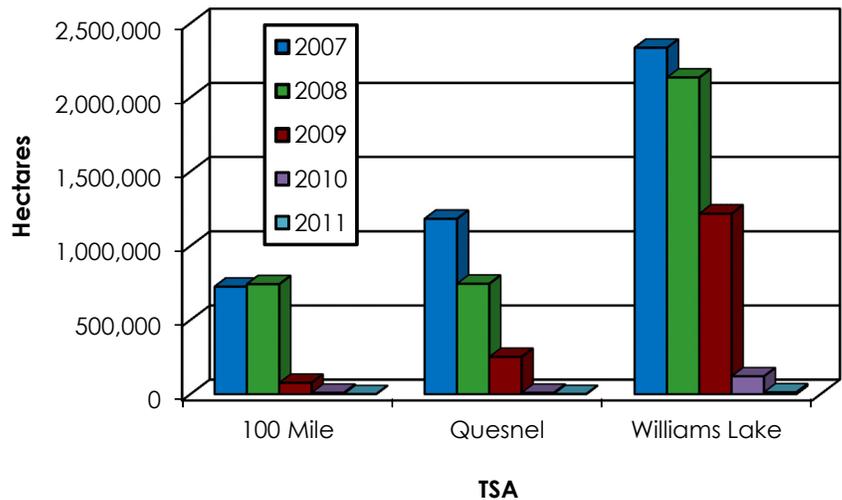


Figure 7. Hectares infested by mountain pine beetle from 2007 – 2011 in the Cariboo Region.

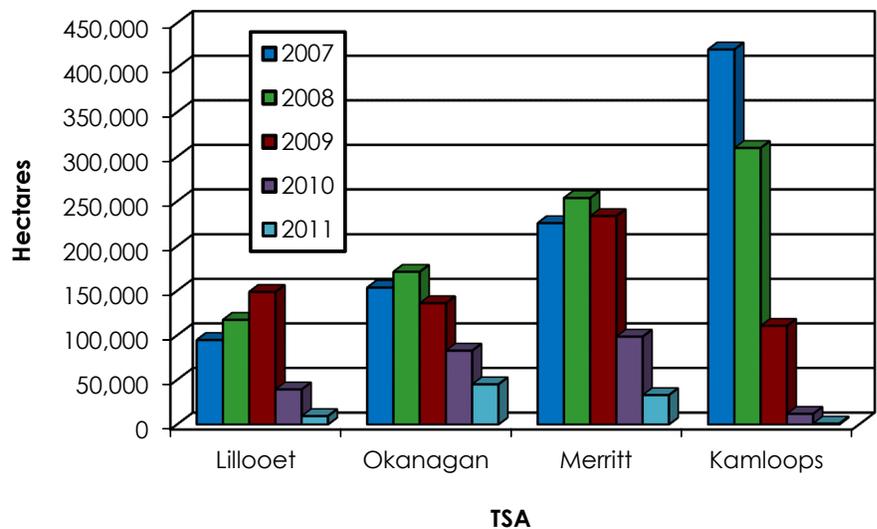


Figure 8. Hectares infested by mountain pine beetle from 2007 – 2011 in the Thompson/Okanagan Region.

12,163 ha. Boundary and Kootenay Lake TSAs had similar levels of damage with 9,229 ha and 9,058 ha delineated, respectively. Attack in the Golden TSA was primarily located in the southern half of the TSA with 7,011 ha recorded. Arrow TSA had 5,576 ha affected and the remaining 166 ha were observed in the Revelstoke TSA.

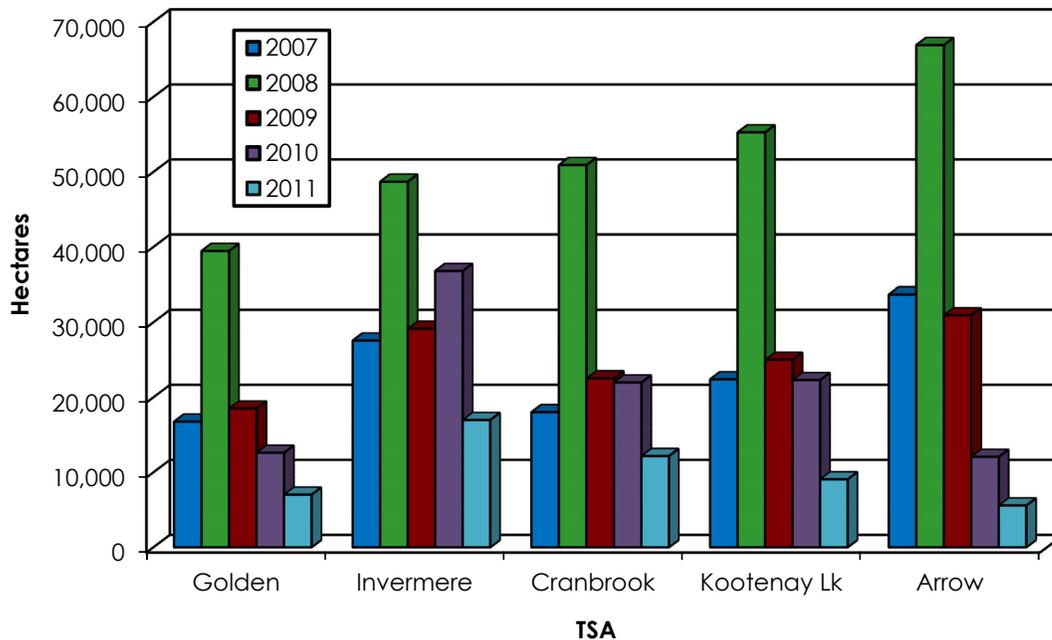


Figure 9. Hectares infested by mountain pine beetle from 2007 – 2011 in the Kootenay/Boundary Region (TSAs with more than 30,000 ha affected in 2008).

### Coastal Damage

Infestation in the coastal regions declined for the sixth consecutive year to 12,336 ha affected. Intensity of attack remained low as well, with 87% of the areas rated as trace to light. Most of the disturbances were located in the South Coast Region. The Fraser TSA contained 8,155 ha of attack scattered throughout the eastern half of the TSA. The mountain pine beetle was most active along the Nahatlatch River. In the Soo TSA 1,365 ha of damage was delineated in small scattered spots and polygons, with a concentration of attack along the Lillooet River. Only 14 ha were mapped in the Sunshine Coast TSA in mainly spot infestations along the eastern edge of the TSA.

The Mid Coast TSA of the West Coast Region contained 2,802 ha of attack along the eastern edge of the TSA. Most of the damage was located north of Mt. Marvin.

### Beetle Flights / Larval Development/ Population Fluctuations

Since most of the mountain pine beetle attack areas no longer have suppression status, fewer resources were available to track beetle biology. Hence, most observations were anecdotal in nature. In general, the cool wet growing season experienced in BC, particularly before August, led to poor beetle development and flights. In the Omineca Region, larvae and pupae development was observed to be retarded, with a resulting late beetle flight mid to late August. During the flight however the weather was relatively good, so it is suspected that the flight was concentrated.

Conditions were similar in the Northeast Region, though August weather wasn't as warm. During ground checks of the mountain pine beetle infestation in Fort Nelson TSA near the Yukon border,

some 2009 attack was found with limited emergence but no brood production was observed in the 2010 attack and no current attack was discovered. The Canadian Forest Service (CFS) collected samples from currently attacked trees across 30 sites in Fort St. John and Dawson Creek TSAs. These samples were assessed to estimate mountain pine beetle population success based on r-values (a value developed from percent mortality of beetles, all life stages included). Relative mountain pine beetle population success was rated as low at 5 sites, moderate at 11 sites, high at 8 sites and extremely high at 6 sites. Sites with the highest success rates were located northwest of Fort St. John and around Tumbler Ridge.

In the Skeena Region the weather was poor for almost the entire summer which resulted in late, dispersed mountain pine beetle flights with resulting poor mass attacks and low beetle survival rates. A short weather window suitable for flights occurred in August, but ground observations showed poor success rates. In the Kalum TSA where suppression efforts are still underway, very little current attack was found except on warmer/drier south aspects. Average Green to Red (G:R) attack ratios on sites surveyed to date are 0.23 to 1. In current attacked trees, district staff did not find larvae.

In the Thompson/Okanagan Region, the weather though cooler than usual was still above threshold levels for reasonable beetle development and in general resulted in a synchronized flight, with a peak flight around the first week of August. The weather wasn't as good in the Kootenay/Boundary Region, which resulted in extended, sporadic flights and poor beetle survival with plentiful pitch outs. G:R averaged 0.2 to 1 in the Cranbrook TSA, and spot infestations surveyed in the Arrow/Boundary TSAs averaged less than one current attack per spot.



*Late fading tree attacked by mountain pine beetle*

### **Ponderosa, Whitebark and Western White Pine Mortality**

Last year mountain pine beetle infestations moved upslope out of decimated lodgepole pine stands and into whitebark pine, resulting in a peak of 33,460 ha of attack. In 2011 whitebark pine mortality decreased in area substantially to 6,471 ha affected. Severity levels remained relatively stable, with 2,979 ha (46%) trace, 3,029 ha (47%) light, 405 ha (6%) moderate and 58 ha (1%) severe. The majority of the attack continued to occur in the Skeena Region. Morice TSA sustained 3,562 ha of disturbances along the Telkwa and Kasalka Ranges. A further 1,394 ha were delineated along the southern edge of the Bulkley TSA. Infestations in the Kalum TSA occurred near Pillar Lake and affected 345 ha, with 172 ha near Tweedsmuir Peak in the Lakes TSA.

In the Kootenay/Boundary Region, most of the whitebark pine mortality (489 ha) was located in the north tip of the Invermere TSA. Cranbrook and Kootenay TSAs both sustained 121 ha of attack, and 60 ha were impacted in the Golden TSA. Small scattered areas of mortality totalled 237 ha in the Lillooet TSA which was the only whitebark pine attack recorded for the Thompson/Okanagan Region. An additional 7 ha were affected in both the Soo TSA of the South Coast

Region and the Williams Lake TSA of the Cariboo Region, with a few spot infestations in other TSAs.

Ponderosa pine mortality continued to decline sharply for the second consecutive year to a total of 7,500 ha affected from a peak of 132,929 ha. Intensity levels were lower as well, with 1,119 ha (15%) trace, 5,412 ha (72%) light, 755 ha (10%) moderate, 179 ha (2%) severe and 35 ha (1%) very severe. Of the recorded attack, it is suspected that some of the trees continued to be killed by a complex of bark beetles that included western pine beetle (*Dendroctonus brevicomis*), particularly at the lower elevations.

The majority of the attack continued to be located in the Thompson/Okanagan Region, where most of the ponderosa pine occurs. In the Okanagan TSA, disturbances affected 3,616 ha in the southern half, particularly in and around the Penticton Indian Reserve. Small scattered infestations were observed on 2,497 ha in the Merritt TSA and 1,265 ha in the Lillooet TSA. Attack in the Kamloops TSA declined drastically to only a few spot infestations. In the Cariboo Region, 91 ha were affected at the southernmost tip of the 100 Mile House TSA on Kelly Creek. Damage was very minor in the Kootenay/Boundary Region. Most of the attack (13 ha) occurred in small spots in the southern portion of the Arrow TSA. Spot infestations also occurred in the Kootenay, Cranbrook and Invermere TSAs, affecting less than 2 ha per TSA. In the South Coast Region, 12 ha of attack were recorded in the Soo TSA.

Western white pine damage also peaked in 2008 at 3,777 ha, and continued to decline this year to only 127 ha. Almost all the attack (126 ha) occurred in two trace polygons in the Kamloops TSA east of Vavenby. Three spot infestations were observed in the Fraser TSA and one spot in the Williams Lake TSA.

### Young Pine Mortality

Young lodgepole pine damage in managed stands peaked in 2008 at 357,017 ha. This year attack declined to 79,660 ha provincially. Intensity of damage was lower as well, at 37,124 ha (47%) trace, 39,243 ha (49%) light, 2,444 ha (3%) moderate, 784 ha (1%) severe and 64 ha (<1%) very severe.



Secondary beetle attack on young lodgepole pine tree

In areas where the mountain pine beetle attack has abated in the mature stands, it is highly suspected that the majority of the young pine mortality is now being caused by a complex of secondary beetles, rusts and Warren root collar weevil. Also confounding the issue in the Nadina Forest District was an unusual top dieback (Project 14). In many young pine mortality cases, the trees were weakened by partial or unsuccessful mountain pine beetle attacks in previous years. The exception to the changing mortality trend is when mountain pine beetles are brought in by wind from distant active populations. This phenomenon occurred in the Prince George TSA last year, but did not reoccur this year. Young pine mortality is generally not ground checked to confirm the causal agent. Since more than one beetle is often present in a young attacked tree, damage has been recorded in

the database as mountain pine beetle, though other factors may be noted in the comments field of the database.

Several surveyors were able to distinguish distinct differences in attack patterns between mountain pine beetle and mortality caused by secondary bark beetles. Typically, mountain pine beetle attack appeared to be associated with active beetle attacks in adjacent mature stands and tended to start around openings in stands and/or stand edges resulting in a substantial number of trees being killed in a given stand. In contrast, mortality in young pine stands caused by other factors tended to occur at lower levels and appeared in a more random pattern, with single attacks or small clusters of mortality.

Most of the young pine damage continued to occur in the northern interior, where the beetle population is still active. In the Omineca Region, the highest amount of attack was noted in the Mackenzie TSA, mostly in the southern half. A record 45,089 ha were mapped as trace to light or as small spot infestations. A follow-up helicopter reconnaissance of 44 young stands in central Mackenzie TSA confirmed this attack pattern as 43 stands were of trace to light intensity with one stand at the moderate level. Very young stands (<24 years), even with adjacent pressure, were not being attacked. However, 25 to 28 year old stands were being damaged. Ground observations concur that most of this mortality is due to mountain pine beetle. Infestations in the Prince George TSA declined sharply to 6,478 ha of attack. Most of this damage was in the southern portion of the Fort St. James District and in the northwestern corner of the Prince George District; however, it is suspected that most of this mortality was not caused by mountain pine beetle.



Young pine stand (23 yrs old) in Mackenzie TSA, unattacked despite adjacent mountain pine beetle attack in mature stand

In the Northeast Region, young pine attack was observed on 5,601 ha of scattered infestations in the western half of the Dawson Creek TSA. A total of 4,814 ha were also attacked near Prespatou in the Fort St. John TSA. Ground observations noted that the young pine attack was caused by mountain pine beetle.

Young pine mortality in the Skeena Region occurred primarily in the Morice and Lakes TSAs where 8,490 ha and 6,162 ha were affected, respectively. In the Lakes TSA where the mountain pine beetle outbreak has run its course, most of the mortality was suspected to be due to secondary causes. A ground survey of 22 sites showed that none of the mortality was caused just by mountain pine beetle: three sites were rust, two were primarily secondary bark beetles, five were top dieback, two were Warren root collar weevil and ten were a mix of various combinations of the above. Secondary bark beetles were collected during the ground survey by the regional entomologist and were identified as *Pityogenes plagiatus*. In Bulkley TSA, 1,163 ha were damaged in small

infestations scattered across the TSA. Most of these sites were adjacent to current mature attack and were suspected to be chiefly mountain pine beetle mortality. A few minor spots were also noted in Kalum and Kispiox TSAs.

In the Cariboo Region a few small areas of young pine mortality occurred. Considering that the mountain pine beetle outbreak has collapsed in this region, it was suspected that most of the attack was caused by secondary beetles but this was not confirmed with ground surveys. Most of the damage (514 ha) was in the Williams Lake TSA in the Churn Creek area. Across the border from this attack were a few small polygons totalling 43 ha in the 100 Mile House TSA.

The remaining young pine mortality was located in the Thompson/Okanagan Region. Ground observers have concluded that the majority of this attack was caused by a combination of mountain pine beetle and secondary beetles. Most of the damage occurred in the Okanagan TSA, even in areas where mountain pine beetle attack is still building in mature stands and beetle pressure is not high. A total of 1,097 ha were attacked, primarily mid TSA. Minor infestations were also scattered in the Lillooet TSA (107 ha), Kamloops TSA (65 ha) and Merritt TSA (34 ha).

Some intermediate aged lodgepole pine stands damaged by mountain pine beetle were also identified. The majority (11,185 ha) occurred in stands of wildfire origin in the Nadina Forest District along the boundary of the Morice and Lakes TSAs. The largest polygons were around Tahtsa and Whitesail Reaches of Ootsa Lake. One 136 ha intermediate pine stand in the Prince George TSA on the northwest arm of Takla Lake was also identified. Several small infestations in the Bulkley TSA totalled 44 ha of attack in the McDonnell Lake and Smithers Landing areas.

In the Peace District on the boundary of the Dawson Creek and Fort St. John TSAs, 253 ha were identified in understory trees. In both these TSAs, it appears that the mountain pine beetles are attacking trees that were missed when the first wave of beetle attack took the larger more susceptible trees.

### **White pine blister rust, *Cronartium ribicola***

Initial white pine blister rust infections that do not kill the entire tree are not visible during the aerial overview surveys. When mortality occurs however, surveyors can delineate scattered damage throughout the host's range. Most of the damage has been historically recorded as spots or very small polygons in the Kootenay/Boundary, West Coast and South Coast Regions at less than 200 ha annually.

This year 232 ha were recorded provincially at 141 ha (61%) trace, 53 ha (23%) light, 3 ha (1%) moderate and 35 ha (15%) severe. Last year a few large trace polygons mapped in the Kingcome TSA of the West Coast Region accounted for the majority of a large jump in white pine blister rust damage to 2,396 ha. Damage continued to occur in this TSA in 2011 in the same general area of the Nimpkish River, but disturbances were greatly reduced in size to 92 ha. The remaining damage in the region occurred in Strathcona and Arrowsmith TSAs at 32 ha and 26 ha, respectively.

South Coast Region sustained 83 ha of damage, of which all but one spot infestation in Soo TSA was recorded in Sunshine Coast TSA, primarily on Texada Island. Kootenay/Boundary Region often contains just a few spots of scattered damage, but none were observed this year.

## **Dothistroma needle blight, *Dothistroma septospora***

Dothistroma (redband) needle blight affected 14,485 ha of lodgepole pine in BC in 2011. The area affected was nearly twice the area recorded last year, but was well below the peak of 53,505 ha observed in 2008. Most of the damage (14,223 ha) was assessed as moderate, with the remaining 263 ha recorded as light.

The majority of the damage has historically occurred in the Skeena Region and this trend continued in 2011. The North Coast TSA contained 14,105 ha, all of which was mapped on Dundas Island. Aside from this disturbance, Dothistroma needle blight damage was very low across the rest of the province. This corresponded with generally dry growing seasons in 2009 and 2010, which resulted in low infection rates. The remainder of the damage in the Skeena Region was mapped in two disturbances: one of 97 ha on the Kinskuch River in the Nass TSA and the other 38 ha west of Dragon Lake in the Kalum TSA.

For the first time since 2007, a small amount of Dothistroma needle blight damage on young lodgepole pine was observed in the Thompson/Okanagan Region. Disturbances were small and scattered. A total of 173 ha were affected in the Okanagan TSA, primarily east of Sicamous and near Cherry Creek. The remaining 72 ha were located in the Kamloops TSA, mainly in the North Thompson and around Tumtum Lake.

Other minor Dothistroma needle blight infections were observed in low lying areas during ground reconnaissance, but this damage was too light to be seen during the aerial overview surveys. Damage is anticipated to increase dramatically in 2012 due to the very wet 2011 growing season.



*Dothistroma needle blight damage near Tumtum Lake in Kamloops TSA*

## **Pine needle cast, *Lophodermella concolor***

Pine needle cast damage continued a steady decline from a peak of 16,912 ha in 2008 to only 336 ha of light intensity this year. All of the damage was recorded in the Prince George TSA between Knewstubb and Tatelkus Lakes in seven young lodgepole pine stands.

Often the majority of pine needle cast damage in BC is recorded in the Skeena Region, but no disturbances were noted in 2011. As with other pine needle diseases, observable damage is expected to increase in 2012.

## Pine needle sheathminer, *Zellaria haimbachi*



*Pine needle sheathminer defoliation*

Occasionally outbreaks of pine needle sheathminer occur in predominantly young lodgepole pine stands, though ponderosa and sometimes white pine are also attacked, as are older trees. The last documented outbreak occurred from 1986 to 1990 in various small infestations within the Thompson/Okanagan, Kootenay/Boundary and South Coast Regions. Ground observations also noted a few hundred hectares of damage west of 100 Mile House in the Cariboo Region in 1996. Since then, no noticeable defoliation has been recorded.

This year pine needle sheathminer damage occurred in several stands of young lodgepole pine. The causal agent was confirmed with ground checks. As the pine needle sheathminer preferentially feeds on new growth, damage was greatest at the tops of trees, though some back-feeding into older growth was observed where the populations were highest.

A total of 729 ha were affected in BC, with severity assessed at 166 ha (23%) light and 563 ha (77%) moderate. One 348 ha polygon of moderate defoliation was mapped near Purden Lake in the Prince George TSA of the Omineca Region. The only previous record of defoliation this far north was on two plantations in 1975.

In the Thompson/Okanagan Region, 270 ha were damaged. In the Okanagan TSA 240 ha were defoliated near Fly Hills, Aberdeen Lake and Mission Creek. Kamloops TSA sustained 29 ha of attack in three polygons near Black Pines north of the City of Kamloops. The regional entomologist reared a sample taken from the southern infestation and noted that substantial parasitism was already occurring. This corresponds with the short length of historical outbreaks.

All the recorded damage in the Cariboo Region was in the Quesnel TSA, where one 112 ha stand was moderately defoliated west of the City of Quesnel. Additional scattered defoliation of young pine was noted from the ground in the 100 Mile House TSA from Sheridan Lake to Lac des Roche along Highway 24.



*Pine needle sheathminer damage west of Quesnel*

# DAMAGING AGENTS OF DOUGLAS-FIR

## Western spruce budworm, *Choristoneura occidentalis*

### Recorded Defoliation

After a three year decline, damage due to western spruce budworm increased by 19% since last year to 616,512 ha affected provincially (Figure 10). Intensity of defoliation increased as well, with 487,921 ha (79%) light, 122,473 ha (20%) moderate and 6,199 ha (1%) severe damage being delineated in 2011. Defoliation also continued to be observed further north and into more high elevation stands than previously recorded.

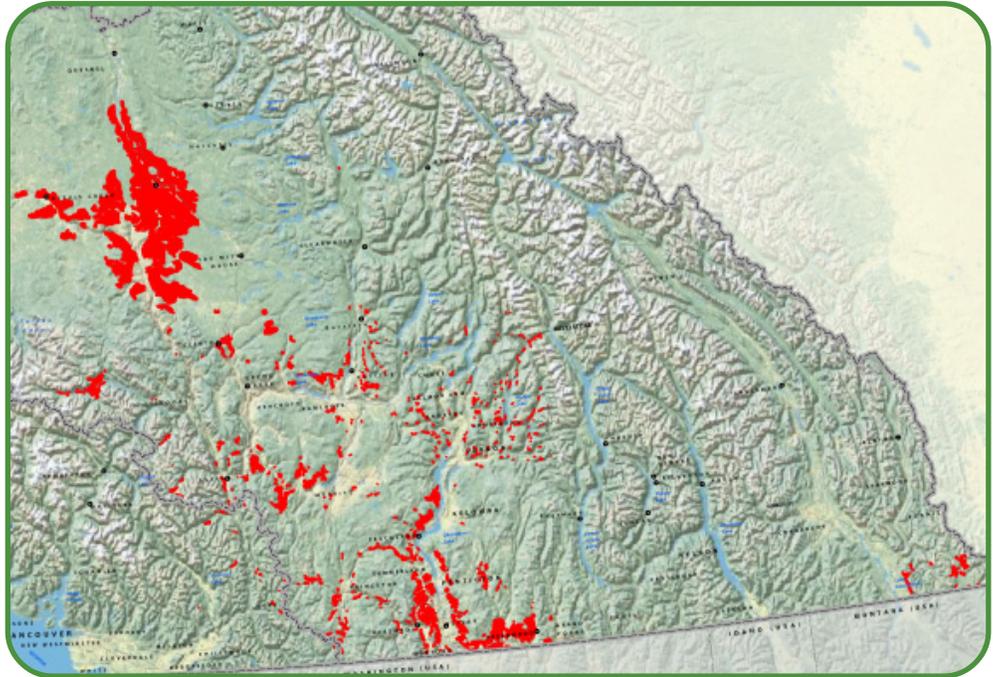


Figure 10. Areas defoliated by western spruce budworm in BC in 2011.

Defoliation more than doubled in the Cariboo Region, where 419,860 ha were affected. The majority of the increase occurred in the Williams Lake TSA, where infestations almost tripled to 399,719 ha of damage after a sharp decline last year (Figure 11). Expansions occurred primarily around Riske Creek, Alexis Creek and Alixton Lake south. Defoliation grew to 62,265 ha in 100 Mile House TSA, chiefly along the western boundary with Williams Lake TSA. Quesnel TSA sustained 17,876 ha of damage in the south along the Fraser River, with minor movement northward past Alexandria.

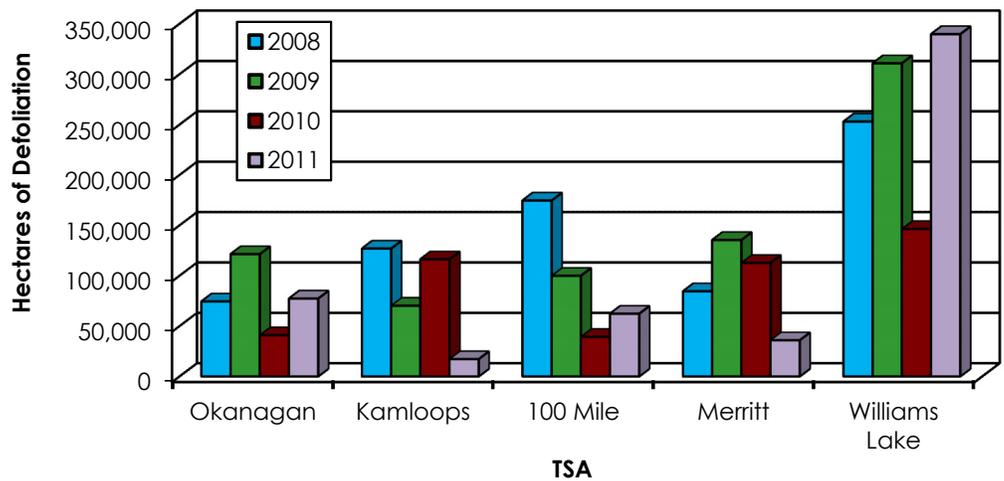


Figure 11. Hectares of western spruce budworm defoliation from 2008 – 2011, for TSAs with over 35,000 ha damaged in 2010.



*Western spruce budworm larva mining a bud*

Conversely, damage in the Thompson/Okanagan Region decreased by half to 146,907 ha. Most of the decline occurred in the Kamloops TSA where defoliation shrank to 17,187 ha, which is the lowest level of damage recorded since 2005 (Figure 11). Damage was concentrated in the southern half of the TSA, particularly along Tranquille River and around Paul Lake. However, infestations in the Okanagan TSA almost doubled to 77,301 ha, after a sharp decline last year. Most of the damage occurred on the west side of Okanagan Lake and extended south of Penticton to the United States border. Also of interest in this TSA were small scattered infestations on dry exposed ridges within the Interior Cedar-Hemlock (ICH) Biogeoclimatic Zone, where western spruce budworm has not historically been mapped before.

This included areas around Mabel Lake, Sugar Lake, upper Shuswap Lake and the highway to Revelstoke. Damage in the Merritt TSA dropped to 35,931 ha, with defoliation remaining in the southern third and west of Nicola Lake in the north. Lillooet TSA sustained 16,488 ha of damage, chiefly around the Gold Bridge area.

Western spruce budworm infestations increased dramatically in the Kootenay/Boundary Region to 47,549 ha of attack. In many areas, defoliation ranged in elevation from the lowest Douglas-fir stands up into sub-alpine fir forests. Last year no defoliation was recorded in this region, though it was noted that a 3,129 ha infestation in the Flathead Valley of the Cranbrook TSA recorded as two-year-cycle budworm may have included western spruce budworm. A total of 7,167 ha were recorded as western spruce budworm in the Cranbrook TSA this year in the Flathead Valley, Wigwam River and Grassmere area. The Grassmere infestation has been confirmed to be western spruce budworm, but the Wigwam and Flathead Valley areas are suspected to have a mix of both budworms in the mixed species stands. Polygons where suspected mixtures of the two budworms occurred were identified in the database as western spruce budworm with two-year-cycle budworm mentioned in the comment field (total of 4,885 ha). Infestations in the southwest corner of the Boundary TSA were particularly active, defoliating 40,104 ha. The remaining 277 ha were observed on the western edge of the Revelstoke TSA. This damage was a continuation of the stands defoliated along the highway in the ICH of the Okanagan TSA.

Damage in the South Coast Region increased slightly to 2,197 ha in the Fraser TSA. Disturbances were mainly located around Tulameen Mtn., Urguhart Creek and Nahatlatch Lake.

### **2011 Treatment Program**

High value stands with moderate to severe populations predicted were treated with the biological control agent *Bacillus thuringiensis* var. *kurstaki* (Btk) in the formulation Foray 48B®. The product was applied aerially in a single application per stand at a rate of 2.4 litres/ha.

A total of 28,766 ha were treated in the Thompson/Okanagan Region. Treatments were applied with UH12ET Hiller and AS315B Lama helicopters from Western Aerial Applications Ltd. Block sizes ranged from 96 ha to 11,787 ha and treatments occurred from June 21<sup>st</sup> to July 5<sup>th</sup>. A total of

17,653 ha were sprayed in the Sabiston Lake area of the Kamloops TSA. Blocks south of Princeton and around Spahomin Lake amounted to 7,094 ha, and the remaining 5,127 ha were treated in the Peachland/Summerland areas of the Okanagan TSA.

In the Cariboo Region, application was carried out with two fixed wing AT 802 Air Tractors over 20,880 ha. Blocks ranged in size from 568 ha to 5,393 ha and treatments were conducted from June 26<sup>th</sup> to July 4<sup>th</sup>. Two blocks totalling 7,293 ha were located in the Quesnel TSA on the border of the Williams Lake TSA along the Fraser River. The remaining 13,587 ha were treated in the Williams Lake TSA from the northern TSA boundary south to Gaspard Creek.

Bud flush and larval growth was carefully monitored to determine optimal spray application. Development was late due to the cool spring; hence treatments were later than normal in most areas. The treatment goal was to protect foliage and reduce the native western spruce budworm population. Pre and post treatment sampling in some of the treatment areas indicated that this goal was achieved.

### **Population Monitoring and Proposed Treatments**

Western spruce budworm egg mass surveys were conducted at 706 sites across eleven TSAs in the fall of 2011 (Table 4). Based on the density of egg masses found for a given area of foliage (10m<sup>2</sup>), expected defoliation in the spring of 2012 was calculated for each surveyed area. This prediction is one of the criteria used for prioritizing treatment areas. Other criteria such as values at risk, stand recovery capability and previous damage are also considered.

With infestations on the rise in many areas, the number of sites surveyed increased by 63 from last year. Predicted severities increased substantially as well. The percentage of moderate sites increased to 246 (35%) from 98 (15%) and sites with severe defoliation predicted rose to 73 (10%) from only 4 (<1%) last year. Sites with light defoliation consequently decreased and nil predictions remained the same.



*AS315B Lama helicopter spraying near Princeton at dawn*



*AT 802 Air Tractor treating a Cariboo block*

Table 4. Summary of western spruce budworm defoliation predictions for 2012 based on 2011 egg mass survey results.

Region	TSA	Number of Sites by Defoliation Category				Total Sites
		Nil	Light	Moderate	Severe	
Cariboo	100 Mile House	23	41	24	6	94
	Williams Lake	8	64	46	14	132
	Quesnel	0	6	1	4	11
Thompson/ Okanagan	Kamloops	11	38	18	5	72
	Lillooet	0	12	2	0	14
	Merritt	0	29	39	20	88
	Okanagan	5	34	57	17	113
Kootenay/ Boundary	Boundary	16	45	49	7	117
	Cranbrook	1	27	10	0	38
	Revelstoke	1	0	0	0	1
South Coast	Fraser	3	23	0	0	26
	<b>Total</b>	68	319	246	73	706

In the Cariboo Region, a large area stretching from Williams Lake south to Meadow Lake and west to Gaspard Creek is expected to sustain considerable defoliation without treatment. A few smaller infestations are also predicted to be active west of Alexis Creek. In response to these predictions, a total of 50,000 ha are proposed for treatment in this region.

Infestations in the Thompson/Okanagan Region are also active but more scattered in nature. Areas of concern were noted in the Okanagan TSA, particularly in the south, between Merritt and Spences Bridge and a few smaller areas outside of Kamloops. Up to 50,000 ha are also proposed for the treatment program in this region in 2012.

The western spruce budworm outbreak is new in the Kootenay/Boundary Region, and areas of concern are more concentrated. Substantial defoliation is predicted for the Midway to Rock Creek area, and in response treatments are planned in 2012 for protecting approximately 10,000 ha.

Sites sampled in the South Coast Region predicted only nil to light defoliation. Hence, a treatment program is not required next year in this region. If all western spruce budworm treatment projects in BC proceed as planned next spring, it will be the largest aerial defoliator treatment ever conducted in the province.



*Parasitized western spruce budworm egg mass*

## Douglas-fir tussock moth, *Orgyia pseudotsugata*

The current Douglas-fir tussock moth outbreak in the Thompson/ Okanagan Region affected 16,801 ha this year. Area damaged was similar to last year after a slightly higher peak of 17,512 ha in 2000. However, intensity levels showed that severe stand damage peaked last year with 10,159 ha (63%) affected, compared to only 2,241 ha (13%) in 2011 (Figure 12). This follows the typical short outbreak pattern of Douglas-fir tussock moth, where populations build and collapse rapidly. In areas where the outbreak was finished, mortality was mapped for the first time in 2011 with 8,793 ha of damage delineated (Figure 13). Observed stand mortality ranged from 10 to 100%, but the majority of the disturbances were rated as severe. This outbreak is the largest ever documented in BC.

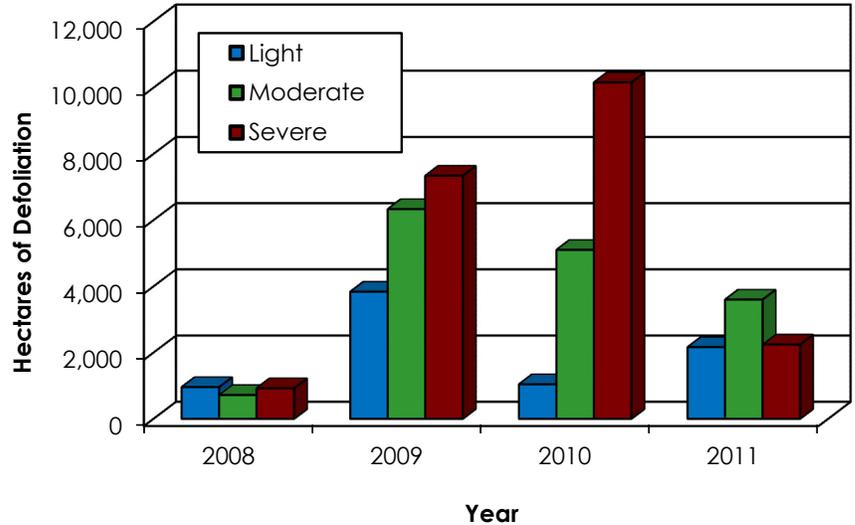


Figure 12. Hectares defoliated by Douglas-fir tussock moth by damage intensity, 2008 - 2011.

Actual current 2011 defoliation was 8,008 ha in total, when considered separately from the mapped mortality. Defoliation first occurred during the present outbreak in the Kamloops TSA, with 88 ha affected in 2007. The majority of the current defoliation continues to be in this TSA, with 5,431 ha mapped this year (Figure 13). Damage has moved however from initial infestations around Kamloops and the South and North Thompson Rivers westward. Most of the 2011 defoliation

was mapped from the western tip of Kamloops Lake to the Bonaparte River area. Areas affected by the Douglas-fir tussock moth in the Okanagan TSA continued to be around Okanagan and Skaha Lakes with 1,550 ha recorded. The highest levels of damage occurred around Carrs Landing, Summerland and Mt. Nkwala west of Penticton. Lillooet TSA sustained 1,027 ha of damage along the eastern edge, in particular around Spences Bridge and creeks along the Fraser River from Pavillion northward.



Figure 13. Douglas-fir tussock moth damage mapped in 2011 (current defoliation red, mortality purple).

Douglas-fir tussock moth populations are monitored annually with pheromone traps placed at specific sites in the 100 Mile House, Boundary, Kamloops, Lillooet, Merritt and Okanagan TSAs. This system is designed to provide warning of rising populations so treatments can be initiated early in an outbreak situation.

Based on 2010 trap catches and subsequent egg mass surveys, aerial control treatments with Foray 48B® were conducted with Hiller UH12ET and AS315B Lama helicopters from Western Aerial Applications Ltd. The product was applied aurally in a single application per stand at a rate of 4.0 litres/ha. A total of 7,150 ha were treated from June 21<sup>st</sup> to 24<sup>th</sup>. All Kamloops TSA sites totalling 5,942 ha were in the western portion of the TSA, with an additional 643 ha around Pavilion in the Lillooet TSA and 564 ha near Peachland in the Okanagan TSA.

The general rise in average trap catches from 2006 to 2008 mirrored the development of the current outbreak quite well (Table 5). Prior to outbreaks the number of moths caught corresponds well with populations, as the egg masses produced are relatively healthy.

Table 5. Average number of Douglas-fir tussock male moths caught per trap, 2006 – 2011 at six trap cluster sites; number of sites in brackets.

Year	TSA					
	100 Mile House	Boundary	Kamloops	Lillooet	Merritt	Okanagan
2006	0.5 (24)	-	19.0 (9)	1.5 (1)	2 (2)	4.2 (8)
2007	0.9 (24)	-	34.9 (9)	15.7 (1)	14.0 (2)	5.7 (8)
2008	2.2 (24)	-	67.3 (9)	40.0 (1)	23.0 (2)	41.6 (8)
2009	3.9 (30)	4.2 (9)	16.5 (9)	15.7 (1)	30.1 (2)	19.0 (8)
2010	1.7 (30)	1.7 (9)	18.5 (19)	7.8 (1)	29.6 (2)	9.6 (12)
2011	1.6 (30)	72.7 (9)	33.2 (19)	82.5 (1)	7.8 (11)	8.5 (12)

In 2009 average trap catches decreased as populations peaked and/or were controlled in many areas. This trend continued in 2010 and 2011 with a few exceptions. Moth catches have risen substantially in the Rock Creek, Midway and Bridseville areas of the Boundary TSA. Since these sites have only been monitored for three years and the number of sites is relatively low, it is uncertain if the Boundary catches actually indicate an impending outbreak. Some of the Kamloops TSA sites, primarily in the western portion, and the one Lillooet TSA site at Pavilion also saw an increase in moths this year. Since outbreaks are fairly localized, trap averages per district do not show the entire picture. Also once an outbreak is underway, high trap moth numbers are less meaningful as a high percentage of the egg masses can be infected with virus, which would not be predictive of the next year’s population.

In the fall of 2011, 468 sites in the Thompson/Okanagan Region were surveyed for the presence of viable Douglas-fir tussock moth egg masses. Of these sites, 24 (6%) showed populations that may warrant treatment, 184 (39%) predicted only light defoliation and at the remaining 184 sites (55%) no egg masses were found. Areas of concern are in the Kamloops TSA around Veasy Lake and in the upper Deadman River area, where an estimated 2,000 ha may be treated in 2012. Egg mass surveys will also be conducted around the trap monitoring areas in the Boundary TSA this winter to determine if the population is actually increasing and whether treatment is warranted.



*Douglas-fir tussock moth female on egg mass*

## Douglas-fir beetle, *Dendroctonus pseudotsugae*

Area damaged by Douglas-fir beetle in BC peaked in 2009 at 100,726 ha affected with a dramatic decline to only 15,789 ha last year. This reduction in size and number of infestations continued in 2011 with 8,866 ha attacked (Figure 14). However, intensity of damage increased for the 2<sup>nd</sup> consecutive year with 1,103 ha (12%) trace, 3,847 ha (44%) light, 2,975 ha (34%) moderate, 920 ha (10%) severe and 22 ha (<1%) very severe delineated.

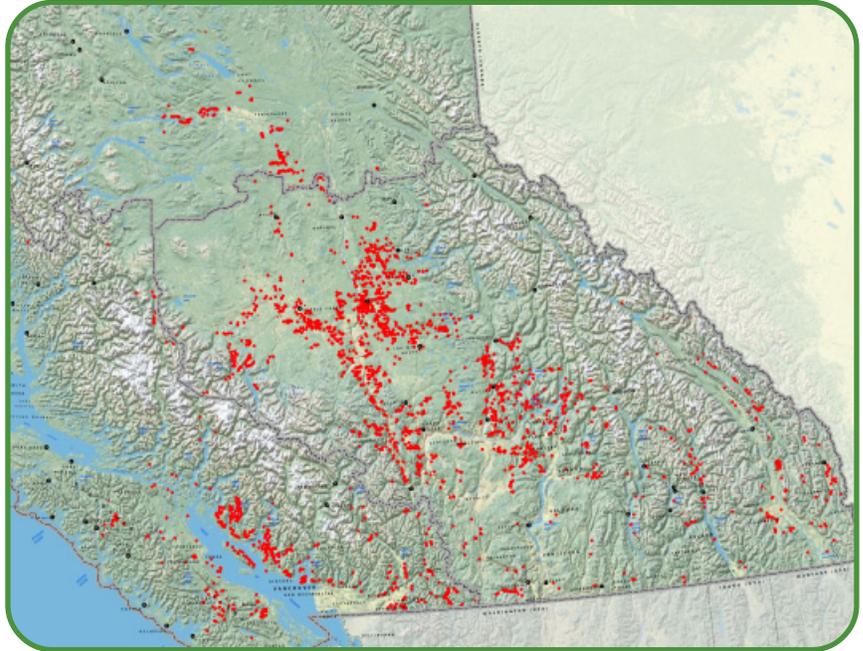


Figure 14. Douglas-fir beetle mortality recorded in BC in 2011.

Infestations in the Cariboo Region declined by more than half to 2,829 ha of damage since last year, with the majority (2,829 ha) recorded in the Williams Lake TSA. This is

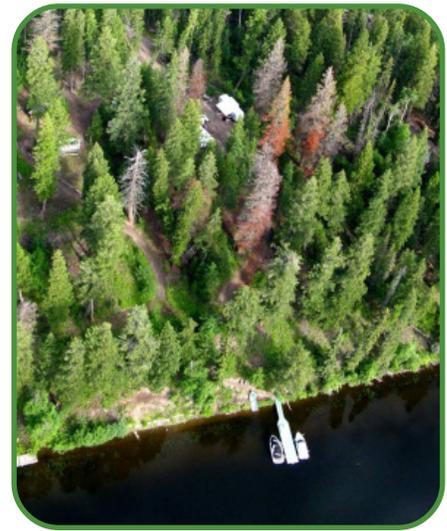
well below a peak of 93,284 ha affected in 2009. Small spot infestations were scattered throughout Douglas-fir stands, but most of the attack occurred around Alexis Creek and south of Hanceville. Tree damage due to ice and snow in 2008 and extensive wildfires in 2010 have resulted in a building Douglas-fir beetle population in this TSA. Ground surveys done to date indicate an average of three currently attacked trees for every one red attack. Although only 288 ha were mapped in the Quesnel TSA (primarily at the northern boundary along the Fraser River), 2010 wildfires, particularly the Meldrum complex fires and the eastern edge of the Pelican Fire on the border with the Prince George TSA, are of concern for building populations. The remaining 237 ha of attack in this region were observed in the 100 Mile House TSA, chiefly south of Lac la Hache.

Attack in the South Coast Region remained relatively stable at 2,209 ha affected. Most of this (1,692 ha) continued to occur in the Fraser TSA, particularly south of Silvertip Mountain along the Skagit River. Infestations in the Sunshine TSA dropped to 494 ha and were scattered along inlets from Desolation Sound down to Sechelt. Ground observations determined that the beetle population is decreasing due to both the control efforts and possibly the cool wet spring which may have hampered emergence and dispersal. The remaining 23 ha in the South Coast Region occurred in the Soo TSA. Minor small scattered infestations also occurred in all TSAs within the West Coast Region, with the exception of Queen Charlotte TSA. No TSA sustained over 100 ha of attack, with a total of 264 ha delineated in the region.

Small infestations were scattered throughout Douglas-fir stands in the Thompson/Okanagan Region, totalling 1,731 ha of attack. A total of 680 ha of damage were observed in the Kamloops TSA, where an aggressive trap tree program appears to be successfully controlling the beetle population. In the Lillooet TSA, 607 ha were affected in the eastern half. Although only 350 ha of damage were observed aerially in the Okanagan TSA, ground surveys have located more current attack than anticipated. Hot spots are east of Cherryville and Mable Lake, the Adelphi/Will Lake area and west of Falkland. Merritt TSA contained the remaining 94 ha of attack.

Douglas-fir beetle infestations decreased slightly to 1,500 ha of damage in the Kootenay/Boundary Region. Invermere TSA sustained 440 ha of attack, primarily at the northern boundary along the Kootenay River. A total of 373 ha of damage were observed in the Kootenay Lake TSA, mainly from Lardeau to the northern reaches of Duncan Lake. The majority of the 305 ha recorded in the Cranbrook TSA occurred in the Grave Lake area. The Kootenay River infestations in the Invermere TSA extended into the Golden TSA up to Kicking Horse River, with 261 ha affected. Minor infestations in the remaining Kootenay/Boundary Region TSAs totalled 141 ha.

Infestations in the Omineca Region continued to decline from a peak of 1,968 ha in 2009 to only 195 ha this year. All the attack occurred in the Prince George TSA. The majority of the attack was observed in the Prince George District, particularly along the Blackwater River. Lindgren funnel traps used to monitor Douglas-fir beetles in this district also indicated a population decline. Scattered spots were observed in the Vanderhoof District, with some attack concentrated along Francois Lake. Control efforts are focused on the Bobtail, Cluculz, Fraser and Francois Lake areas, including use of anti-aggregation pheromones on private land along the lakeshore. Trap trees felled in seven areas will be harvested or burned before the next beetle flight. Ground surveys on 80% of the sites indicated an average green to red ratio of 2:1. The district plans to treat 85% of the sites that have more than two infested trees. An ungulate winter range improvement burn was conducted north of Francois Lake this spring which resulted in substantial Douglas-fir beetle attack of smaller diameter scorched trees. Luckily, survival of the beetle in these smaller trees was poor. From this exercise, district staff concluded spring burning should be held off until the Douglas-fir beetle infestation level subsides. The only other Douglas-fir beetle mortality in northern BC occurred further west along Francois Lake in the Lakes TSA of the Skeena Region. A total of 138 ha were identified as attacked, but most of this damage occurred in one lightly infested polygon.



*Douglas-fir beetle mortality on private land on Cluculz Lake*

### **Laminated root disease, *Phellinus weirii***

Observed laminated root disease damage was back to 2009 levels with only 203 ha affected provincially, after a peak of 2,251 ha last year. As root disease effects do not change this radically from year to year, the difference was most likely a factor of differing visibility of the damage from the air and perhaps, variable surveyor skill levels. Actual root disease incidence is considerably higher than what is visible from the height of the aerial overview surveys. Recorded infection centers were all small and scattered.

Damage intensity was assessed as 22 ha (11%) trace, 108 ha (53%) light, 44 ha (22%) moderate and 29 ha (14%) severe. All the damage continued to be noted in coastal areas of BC with 103 ha located in the West Coast Region. Arrowsmith TSA contained 68 ha mid TSA east of Alberni Inlet. The remaining 33 ha in Kingcome TSA occurred north of Klaklakama Lakes. A similar amount of damage (100 ha) was observed in the South Coast Region. Of this, 68 ha were recorded in the Sunshine TSA near Halfmoon Bay and Lund. Fraser TSA, which sustained most of the damage in this region last year, only had 20 ha delineated in 2011, primarily near Cultus Lake. Soo TSA contained the remaining 12 ha of damage near Brackendale and Port Douglas.

# DAMAGING AGENTS OF SPRUCE

## Spruce beetle, *Dendroctonus rufipennis*

After a peak in 2003 when 315,953 ha were damaged by spruce beetle provincially, levels of attack declined rapidly. With the exception of some relatively small infestations, spruce beetle mortality has been low in BC for the past five years. In 2011, disturbances declined by a third since last year for a total of 19,346 ha impacted. Intensity of attack was also down with 2,550 ha (13%) trace, 13,570 ha (70%) light, 2,384 ha (12%) moderate, 728 ha (4%) severe and 114 ha (1%) very severe. Most of the infestations decreased in size but remained in the same general areas as last year. It was observed however that attacked trees faded later than normal due to cool weather, hence

damage may be underestimated. With considerable flooding damage of spruce stands this year, particularly in the northern interior, spruce beetle populations may start to re-build.



*Spruce and western balsam bark beetle attack in Fort Nelson TSA*

The only substantial new infestations were delineated on 8,802 ha in the Fort Nelson TSA of the Northeast Region. The largest disturbance was located at the confluence of the Toad and Liard Rivers, with three other polygons mapped nearby. Low level flight passes with photo documentation were used to identify the causal agent, though ground confirmation was not conducted because of the remote location of these infestations.

was down almost four-fold since 2010 to 6,755 ha. With the exception of a few scattered spots, all the damage continued to be observed in the eastern portions of Williams Lake and 100 Mile House TSAs, from Quesnel Lake down to Hendrix Creek. Disturbances totalled 4,868 ha and 1,706 ha, respectively, with an additional 181 ha in Quesnel TSA.

The majority of the decline in spruce beetle attack occurred in the Cariboo Region, which

Infestation levels in the Thompson/Okanagan Region remained relatively stable with 2,804 ha affected. The majority of the disturbances (2,319 ha) continued to occur in the Kamloops Forest District around Mt. Tod and Silwhoiakun Mtn. Most of the remaining attack (385 ha) was delineated in the southern tip of the Merritt TSA near Flat Top Mtn. This infestation appears to be geographically contained, and sanitation harvesting efforts appear to be making an impact on the infestation's growth. Minor infestations were also recorded over 83 ha in the Lillooet TSA and 18 ha in the Okanagan TSA.

Damage in the Kootenay/ Boundary Region was similar to last year with 480 ha of attack. Virtually all (478 ha) continued to be recorded in the Invermere TSA around Franklin Peaks. The majority of this tree mortality has been laid out for salvage harvesting. Only a few spot infestations were observed in the other TSAs.

Omineca Region sustained 216 ha of damage in 2011. Attack in Robson Valley TSA continued to occur in the Dawson Creek area, with 129 ha affected. The remaining 87 ha were delineated in the Prince George TSA, primarily in the south around Ahbau Lake in the Prince George District and in small scattered spots within the Vanderhoof District. The small infestation found in windfall at Georges Creek last year is presently being salvage harvested. The southwest corner of the vast Binta fire is of concern for the Vanderhoof District: substantial spruce blowdown has occurred due to roots damaged by the fire. Licensees are attempting to salvage the blowdown, but it is very difficult to work in the area due to the high hazard of unstable trees. Susceptible spruce in this fire as well as the Ootsane fire are also of concern in the Nadina Forest District, although only a few spot infestations were noted during the overview survey, totalling only 5 ha for the entire Skeena Region.

A total of 216 ha were affected in the West Coast Region. Almost all (214 ha) were located in the Mid Coast TSA in small scattered infestations. The remaining 2 ha were observed in the Kingcome TSA. A further 68 ha were mapped the South Coast Region, primarily along the northern edge of the Soo TSA where a total of 55 ha of damage occurred. Fraser and Sunshine TSAs contained 9 ha and 4 ha of attack, respectively.

### **Large-spored spruce-labrador tea rust, *Chrysomyxa ledicola***

Damage caused by large-spored spruce-labrador tea rust was observed for the first time during the aerial overview surveys this year. Ground checks were undertaken to confirm the damaging agent. This rust affected spruce of all ages, turning infected needles chlorotic, in contrast with remaining healthy green needles. All the damage was recorded in the Fort Nelson TSA of the Northeast Region. A total of 12,153 ha were mapped between the Liard and Toad Rivers around Ewe Mountain. Intensity of the damage was rated as 542 ha (5%) light, 7,084 ha (58%) moderate and 4,527 ha (37%) severe.



*Spruce affected by large-spored spruce-labrador tea rust*



*Close-up of infected needles*

# DAMAGING AGENTS OF TRUE FIR

## Western balsam bark beetle, *Dryocoetes confusus*

Provincially, western balsam bark beetle attack dropped to one-fifth that recorded last year, to a total of 325,711 ha affected. This is the lowest level of recorded damage since 1999. Disturbances peaked in 2004 with over 2 million hectares of attack.

Intensity levels rose slightly since 2010 with 295,848 ha (91%) trace, 27,413 ha (8%) light, 1,675 ha (1%) moderate and 775 ha (<1%) severe delineated. The same stands tend to be attacked year after year with chronic, low levels of mortality. This is reflected in the high proportion of trace intensity damage that is recorded. Unfortunately, this low level of attack can result in large changes in hectares affected depending on whether the disturbances are mapped as small scattered spots or large trace intensity polygons. Mapping style most likely contributed to the precipitous drop in hectares affected this year, but surveyors also generally noted that attack did appear to be lower than what has historically been mapped. Mortality occurred in the same general areas as before, but tended to be recorded as spots or small polygons rather than large polygons. Late colour change of infested trees may have also been a contributing factor.

Unlike previous years when most of the attack was noted in the northern interior of BC, this year the Thompson/Okanagan Region sustained the highest level of damage (Figure 15). Disturbances were scattered throughout susceptible timber types in the Kamloops and Okanagan TSAs, where 53,209 ha and 53,037 ha were delineated, respectively. Levels in the Okanagan TSA were similar to last year, but infestations in the Kamloops TSA increased 17 fold, which was the largest increase noted in the province. The remaining attack in this region occurred in small, scattered areas of the Merritt and Lillooet TSA with 3,206 ha and 1,274 ha affected, respectively. The regional entomologist noted that balsam bark weevil (*Pissodes striatulus*) is quite active in southern sub-alpine fir stands in the region: this weevil has been causing tree mortality in concert with western balsam bark beetle. Details on how much the balsam bark weevil is contributing to overall levels of mortality can be found in the 2011 *Overview of Forest Health for Southern British Columbia* publication.

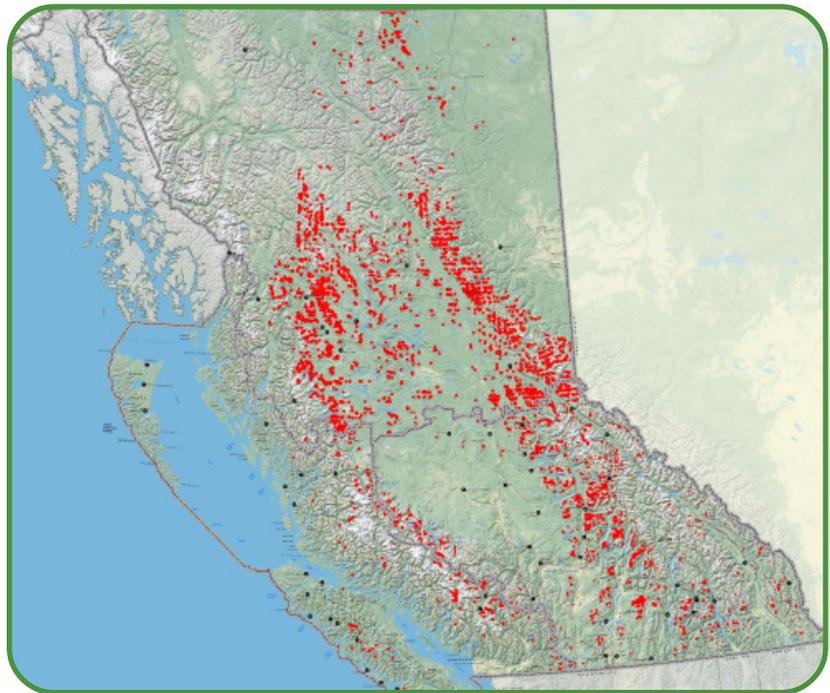


Figure 15. Western balsam bark beetle damage mapped in 2011.



*Pissodes striatulus*

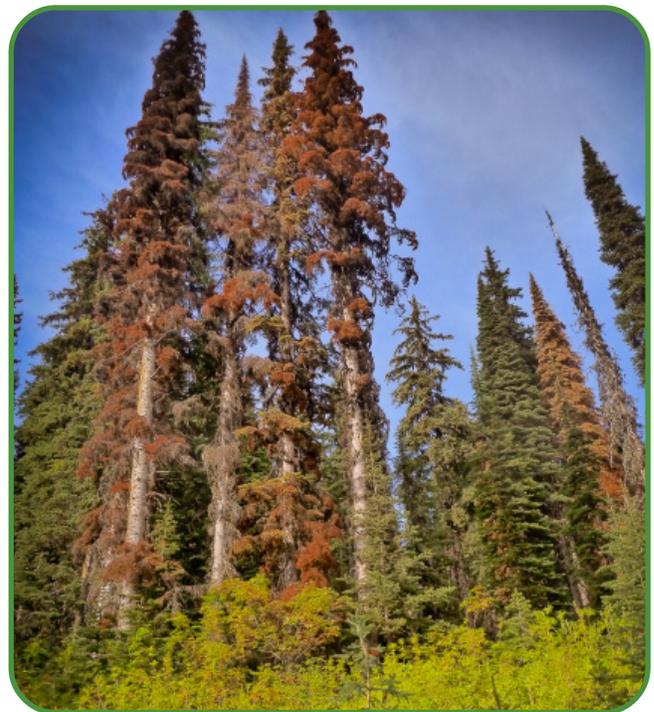
Omineca Region had the largest decrease in western balsam bark beetle attack since 2010, from 843,295 ha to 78,192 ha. A substantial portion of the 2011 damage (44,782 ha) occurred in the Prince George TSA. Concentrations were noted along the southern boundary of the Prince George Forest District, and the mid portion of the Fort St. James Forest District. Most of the 23,939 ha mapped in the Mackenzie TSA were in the southern half, with the majority between Ospika Arm and Peace Reach of Williston Lake. Robson Valley TSA contained 9,571 ha of scattered damage.

Western balsam bark beetle mortality was observed over 65,354 ha in the Skeena Region, down considerably from last year. About half the attack (32,354 ha) was mapped in the Morice TSA, particularly around Nadina Lake and west of Houston. Disturbances totalled 12,417 ha of dispersed attack in the Kispiox TSA. Infestations near Whitesail, Tesla and Taltapin Lakes accounted for the majority of the 10,782 ha of damage observed in the Lakes TSA. In the Bulkley TSA, 8,468 ha of mortality were recorded with concentrations around Mt. Seaton and Astlais Mtn. Other minor areas of attack were delineated in the remaining Skeena Region TSAs.

Infestations in the Cariboo Region accounted for 44,825 ha of damage at similar levels as 2010. Most (26,911 ha) occurred in the Williams Lake TSA in susceptible types along the western edge of the TSA and east of Horsefly. In the Quesnel TSA 12,630 ha were mapped, primarily east of Swift River. Damage was confined to 5,284 ha in the far eastern portion of the 100 Mile House TSA.

Northeast Region contained 16,384 ha of attack. Infestations in Fort Nelson TSA accounted for 11,585 ha, chiefly mid TSA in the northern portion. Small areas of damage occurred along the western boundaries of the Dawson Creek and Fort St. John TSAs with 3,193 ha and 1,606 ha recorded, respectively.

Small infestations were observed throughout the Kootenay Boundary Region TSAs, with a total of 5,253 ha recorded regionally. Damage was also minor in the West Coast Region where 4,440 ha were delineated. The only exception was in the Mid Coast TSA where 4,175 ha were mapped, primarily around Mt. Marvin. The South Coast Region had the lowest level of damage, with 538 ha mapped.



*Western balsam bark beetle mortality*

## Two-year-cycle budworm, *Choristoneura biennis*

Two-year-cycle budworm defoliation in BC rose to 178,205 ha in 2011, up from 97,094 ha last year but not as high as the peak of 396,855 ha in 2009. Most of the damage usually occurs in the northern interior, where this budworm has peak defoliation during odd years. Severity was also somewhat higher than last year, with 150,966 ha (85%) light, 25,279 ha (14%) moderate and 1,960 ha (1%) severe delineated.

Omineca Region sustained 89,185 ha of defoliation, most of which (73,478 ha) was located in the Prince George TSA (Figure 16). Almost all of this damage occurred in the Fort St. James Forest District, where ground observations noted considerably more than was visible from the air: defoliation was virtually district-wide, particularly in valley bottoms extending upwards to a mid elevation band visible on mountain slopes. From the air, the heaviest damage was mapped near Salmon Lake, Chuius Mtn. and West Landing. Most of the 2009 damage (262,020 ha) occurred in expanded infestations in the same general areas of this district. An additional 15,707 ha were marked in the Mackenzie TSA, mainly on Little Gaffney Creek and south of Philip Lakes and Skog Mtn. Traces of two-year-cycle budworm defoliation were observed from the ground along the main valleys in Robson TSA, but nothing was visible from the air. This budworm has peak defoliation in even years in this TSA so this is not unusual.

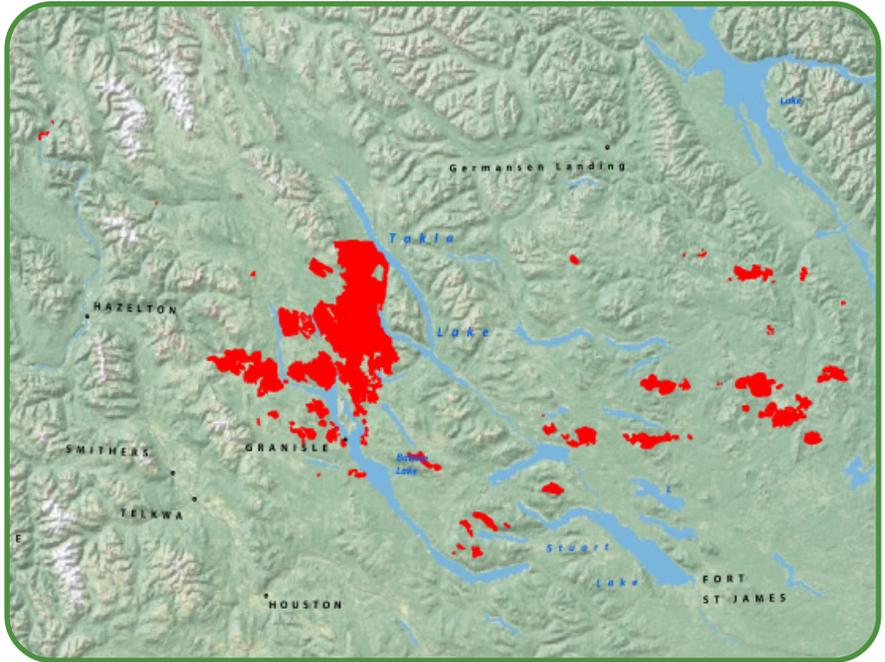


Figure 16. Two-year-cycle budworm defoliation mapped in 2011.

Skeena Region contained 80,020 ha of damage in 2011. Morice TSA sustained most of this defoliation with 69,736 ha affected, primarily in the northern tip around Morrison Lake. Nadina District staff are concerned that this damage to young spruce plantations will be significant, particularly around Tochcha Lake. Although budworm damage usually has its greatest impact to understory trees in older stands, 20 to 30 year old stands are sustaining significant defoliation, particularly along mature stand edges. This edge effect can virtually affect the entire young stand when it is surrounded by mature trees. Infestations from the Morice TSA expanded into the Bulkley TSA, affecting 16,957 ha primarily around the Torkelsen Lake area. Damage in the Lakes TSA was only 2,087 ha, but most of the defoliation was noted at the moderate level, particularly around Gullwing Creek and Klaytahnkut Lake. The remaining 240 ha of severe damage were observed in the Kispiox TSA near Kuldo and Le Clair Creek. Defoliation was noticeable but not mapped around Gunanoot Lake in this TSA as well.

No defoliation was visible in the Cariboo Region this year, as two-year-cycle budworm damage peaks in even years in this area. However, ongoing damage is of concern in the Quesnel TSA near Mt. Tom where a research trial examining the suitability of partial cut harvesting minimizing the impacts to Cariboo habitat is underway. Partial cut harvesting leaves vulnerable understory trees at greater risk of budworm damage than if the overstory was completely removed as is done through conventional clearcut harvesting. Budmining surveys conducted in the spring within the research trial area predict severe defoliation for the stands in 2012.



*Young spruce plantation defoliated by two-year-cycle budworm in Morice TSA*



*Two-year-cycle budworm larvae in Prince George TSA*

Therefore, approximately 1,000 ha are proposed to be treated with Foray 48B® next spring to protect this research project. Although Foray 48R® is registered for use against two-year-cycle budworm, the treatment will be the first time this product has been used operationally to control this budworm species.

Defoliation mapped last year in the Flathead Valley of the Cranbrook TSA was not recorded this year. Damage continued in 2011 in this general area, but it was suspected to be primarily western spruce budworm and was coded as such. Comments were added in the database however for the appropriate polygons that two-year-cycle budworm is possibly a contributing damaging agent as well.

### **Delphinella needle cast, *Delphinella* spp.**

Delphinella needle cast damage is rarely visible from the air, and was recorded for the first time on 3,334 ha in the Kalum TSA during the 2009 aerial overview surveys. Last year was quite dry in the area and no damage was observed. In 2011 Delphinella needle cast damage returned in the same general area, but at a higher intensity over smaller disturbances. A total of 1,331 ha were affected, with 414 ha (31%) light and 916 ha (69%) rated as severe. Polygons were mapped south of Terrace along the Skeena and Wedeene Rivers. Some other nearby damage mapped as unknown may be caused by Delphinella needle cast as well.

# DAMAGING AGENTS OF HEMLOCK

## Western hemlock looper, *Lambdina fiscellaria lugubrosa*

### Recorded Defoliation

Damage by western hemlock looper more than doubled since last year to 7,051 ha. Intensity of attack also increased marginally, with 6,300 ha (89%) light and 751 ha (11%) moderate defoliation noted.

New infestations occurred in the Cariboo Region, affecting 5,774 ha in the Williams Lake TSA. Defoliation was recorded along Quesnel Lake from the north arm through to Summit Lake in the east, and south to the east tip of Horsefly Lake.

The Thompson/Okanagan Region sustained 680 ha of attack. Damage in the northern portion of the Kamloops TSA occurred in similar areas as last year, but at a reduced scale with 602 ha affected. Concentrations were observed around Mt. Huntley, Thunder River and the North Thompson River. Minor infestations along the northeastern edge of the Okanagan TSA accounted for the remaining 77 ha in this region.

All of the 597 ha noted in the Kootenay/Boundary Region occurred in the Revelstoke TSA. Defoliation was up slightly since last year and occurred in the same general areas along Revelstoke Lake.

### Population Monitoring and Proposed Treatments

Pheromone traps have been used consistently since 2003 in chronic areas of the southern interior to monitor western hemlock looper populations. Trap catches were very high in 2003, which corresponded to the final year that substantial (39,398 ha) defoliation occurred during the last outbreak in the southern interior. Moth numbers then remained very low until 2008, when averages within the monitored TSAs began to climb (Table 6). Calibration of trap counts is still incomplete: the number of moths caught that will indicate an outbreak is imminent will be known once the first year of significant defoliation occurs in the impending outbreak. This year trap catches and other observations indicated that populations are most likely becoming high enough to cause considerable defoliation in 2012. A treatment program with Foray 48B® is therefore planned for next year in specific high value stands.

Average moth counts (6-trap clusters per site) in the Kamloops Region varied widely, but several areas of concern were apparent. Unlike the other TSAs, moth catches in the Kamloops TSA dropped last year after a peak in 2009 (Table 6). However, numbers are again on the rise, particularly around Myrtle Lake where an

Table 6. Average number of western hemlock looper male moths caught per trap at various MFLNRO monitoring sites (6-trap clusters per site), 2006 - 2011.

Year	TSA (# sites)		
	Kamloops <sup>(6)</sup>	Okanagan <sup>(10)</sup>	Revelstoke <sup>(11)</sup>
2006	4.7	3.7	4.4
2007	18.8	7.9	1.9
2008	545.9	171.9	25.0
2009	829.8	541.3	69.5
2010	548.0	541.5	346.8
2011	697.7	852.5	724.7



*Hemlock looper larva*

average of 1,376 moths/trap were trapped. Average moth counts in the Okanagan TSA have climbed steadily. Of particular concern are sites at the north end of Mabel Lake to Sugar Lake, where catches ranged from 842 to 2,682 moths/trap. A treatment program of approximately 5,000 ha is planned for the Thompson Okanagan Region. Western hemlock looper egg sampling is planned to confirm treatment areas.

All 6-trap monitoring sites in the Kootenay/Boundary Region are located in the Revelstoke TSA. Average trap counts more than doubled this year, with the largest numbers of moths trapped at Downie Creek (1,135 moths/trap), Pitt Creek (1,274 moths/trap) and Kinbasket Lake (1,533 moths/trap). Larvae found during tree beatings at 25 permanent monitoring

locations in the Arrow, Revelstoke and Kootenay Lake TSAs also pointed to rising populations. Historical data from beatings in these areas indicate that defoliation is probable in the year after the average number of larvae reach 8-10, with larvae found in at least 64% of the sites. In 2011, western hemlock looper larvae were found at 84% of the sites and counts reached an average of 22/site (up from 2.4/site in 2010). Egg sampling will be conducted in this region as well, with an estimated 1,500 ha planned for treatment.

In addition to the permanent 6-trap cluster monitoring sites, 38 single traps were deployed in the Cariboo Region in 2011. Trap catches varied widely from 12 to 1053 moths/trap. In the 100 Mile House TSA, 5 traps were placed in the Canim Lake area where the average per trap catch was 279. The site with the highest trap catch with 1053 moths was located at 6km on the 6000 Road. The remaining traps were located in the Williams Lake TSA, with 15 at the east tip of Horsefly Lake (average 150 moths/trap), 7 around Crooked to Bosk Lakes (average 50 moths/trap), 6 around Abbot Creek to Spanish Lake (average 185 moths/trap) and 5 from Cariboo River to Cariboo Lake (average 99 moths/trap). Trap catches were used to define 46 egg collection sites. Egg counts predicted serious 2012 defoliation at several sites in the general area of Quesnel and Horsefly Lakes in the Williams Lake TSA, where light defoliation was most frequently observed this year. Areas of highest concern were Tasse Lake where 7 sites predicted moderate to severe defoliation, Hen Ingram Lake where 7 sites predicted moderate defoliation and Abbott Creek where 4 sites predicted severe defoliation. Approximately 10,000 ha are proposed for treatment next year in this region.

No defoliation was observed in coastal regions this year. In the Sunshine Coast TSA of the South Coast Region, nine individual western hemlock looper pheromone traps have been deployed to monitor populations for the last four years. Most counts have remained low (around 25 moths average) but one trap located in the Rainy River area caught 250 moths in 2010.

## Western blackheaded budworm, *Acleris gloverana*

Defoliation by western blackheaded budworm was confined to coastal areas of BC this year, with 41,142 ha affected. Intensity of the damage was rated as 23,381 ha (57%) light, 15,952 ha (39%) moderate and 1,809 ha (4%) severe.

The majority of the disturbances continued to be observed in the Queen Charlotte TSA, where 37,378 ha were mapped. Hemlock was the primary host species. Historically, outbreaks in this TSA occur approximately every eight years and last two to four years. This trend appears to be holding true for the present outbreak, which started in 2009 and peaked last year in both hectares affected (87,497 ha) and intensity of attack (Figure 17). Movement of the infestations followed historical trends as well, starting in 2009 on the southern islands, moving substantially northward in 2010, and shrinking overall in 2011. Anecdotal observations have noted that younger thinned stands are more heavily damaged than unthinned stands and that south to southwest aspects are more defoliated than northern aspects. Twenty repeatedly infested polygons are presently targeted for ground surveys to study the impact of repetitive budworm damage to stands.

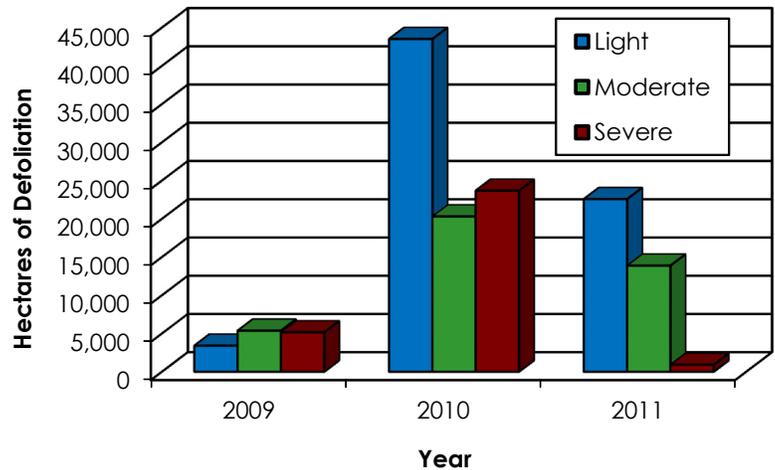


Figure 17. Hectares defoliated by western blackheaded budworm in Queen Charlotte TSA by damage intensity, 2009 - 2011.

Historically in coastal outbreaks, infestations usually first appear on Vancouver Island and the Lower Mainland and then progress northward. The last outbreak was an exception, as defoliation only occurred in the Queen Charlotte TSA. The present outbreak is unusual as well, as it began in the north and this year moved southward into the Kingcome TSA, affecting 3,602 ha located mainly on Vancouver Island around Holberg Inlet. Most of the host trees affected in this area were true firs, and it was observed that northern aspects were most heavily damaged. Helicopter reconnaissance of the general area noted substantial defoliation that was missed by the aerial overview survey. Minor damage was also mapped in the Strathcona and Mid Coast TSAs, at 118 ha and 32 ha, respectively. The remaining 12 ha of damage was located in the Sunshine TSA in the South Coast Region.



Western blackheaded budworm defoliation on Vancouver Island

Over 10,000 ha of western blackheaded budworm damage was observed in the Skeena Region last year, but no defoliation was found in 2011. Short outbreaks are historically common in the interior, and they are not cyclical like coastal outbreaks.

# DAMAGING AGENTS OF LARCH

## Larch needle blight, *Hypodermella laricis*

Larch needle blight can infect trees of all sizes and the magnitude of blight on individual trees tends to be variable. The fungus, *Hypodermella laricis*, forms airborne spores which infect needles during April to May rain events. About a month after infection, the needles noticeably turn reddish-brown and curl inwards. By mid-summer, black fruiting bodies can be seen on the undersides of the needles. Unlike larch needle cast infections (*Meria laricis*), the foliage afflicted with blight tends to remain attached to the tree after autumn leaf fall. Infected trees may suffer terminal shoot death and reduced growth but trees typically survive. However, two or three years of successive, severe infections on the same tree may cause death.



Needles infected with larch needle blight

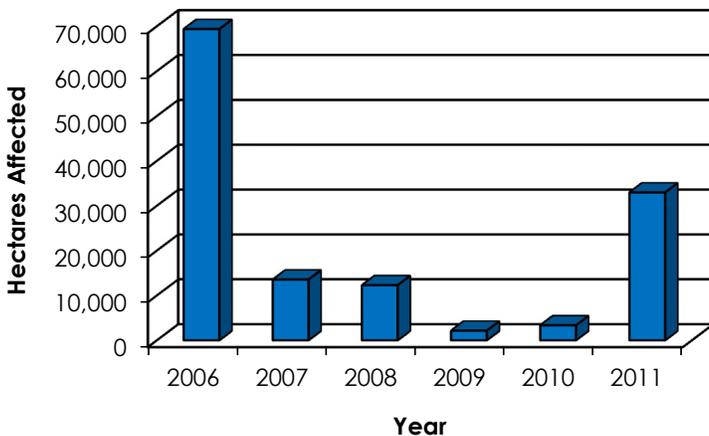
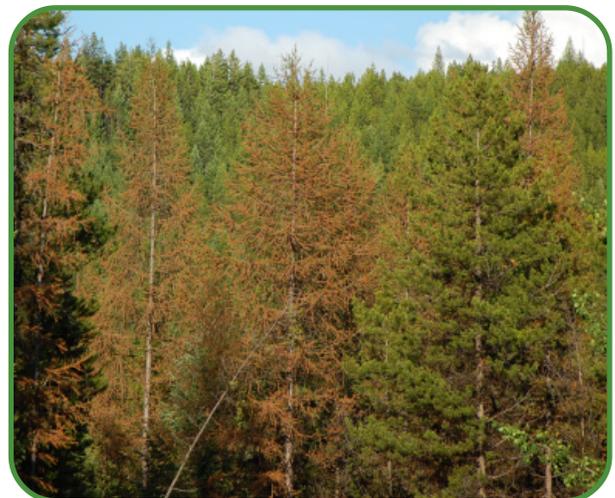


Figure 18. Hectares damaged by larch needle blight in BC, 2006 - 2011.

After a peak of 68,228 ha of damage in 2006, area affected by larch needle blight returned to relatively low levels for four years (Figure 18). In 2011, damage rebounded to 32,719 ha after ideal conditions for needle infection occurred in the spring. Most of the disturbances were located in relatively small scattered pockets throughout the southern portion of the Kootenay/ Boundary Region. Intensity of damage was rated as 21,555 ha (65%) light, 7,788 ha (24%) moderate and 3,612 ha (11%) severe. Boundary TSA sustained the most damage

with 14,041 ha affected. The largest concentration of polygons occurred on the western edge of the TSA around Beaverdell. A total of 9,774 ha were mapped in the Cranbrook TSA, particularly in the Wigwam and Flathead areas. In the Arrow TSA a further 5,574 ha were affected, especially between Castlegar and Salmo. Kootenay Lake TSA sustained 2,420 ha of damage, primarily in the southern third. Minor areas of lightly infected stands totalled 899 ha in the Invermere TSA and one light polygon was observed in the south tip of the Revelstoke TSA. The Thompson/Okanagan Region contained the remaining attack in the Okanagan TSA, where mostly light damage totalling 235 ha were mapped east of Greyback Mtn.



Trees infected with larch needle blight

Based on ground reconnaissance, the blight impacted all age classes. In addition to larch needle blight, minor larch needle cast infections were also observed. During the early aerial overview flights, it was noted that the younger age classes were particularly affected, and that damage occurred from the ground upwards. This may have been due to higher moisture conditions closer to the ground.

The question arises as to whether trees will be severely impacted due to successive years of infection. Since damage over the past two years has been very modest, significant impact is unlikely. Continued monitoring will be useful in understanding patterns of larch needle blight incidence. Associated GIS analysis would be beneficial in identifying recurring blight infection centres which may indicate where acute growth and mortality impacts would be expected.

### **Larch casebearer, *Coleophora laricella***

Larch casebearer is an introduced defoliator of western larch, first recorded in BC at Rossland in 1966. Since then this defoliator has spread throughout south-eastern BC, but a biological control program initiated in 1969 has been effective at reducing populations.

Damage by larch casebearer has not been recorded aurally since 1995, until 6 ha of defoliation were observed in the Cranbrook TSA last year. In 2011, 78 ha were mapped in the Okanagan TSA south of Coldstream. Intensity was defined as 22 ha of light and 57 ha of moderate damage. The area was ground checked, with confirmation that larch casebearer was the damaging agent.

## **DAMAGING AGENTS OF CEDAR**

### **Yellow-cedar decline**

Although previously recognized as a damaging agent of yellow-cedar, this decline was not recorded during the aerial overview surveys until 2006 when 5,232 ha were mapped along the coast of BC. Delineation of disturbances has varied widely since then with a peak in 2008 of 47,130 ha. This is partly because not all of the coastal forests are surveyed each year. As well, yellow-cedar decline is an ongoing process where new mortality is sometimes difficult to differentiate from old mortality.

In 2011, a total of 5,852 ha of damage were observed, down almost half from last year. Intensities were lower as well at 2,871 ha (49%) trace, 1,848 ha (32%) light, 203 ha (4%) moderate and 903 ha (15%) severe. Unlike last year, most of the disturbances were noted in the West Coast Region, where 4,737 ha were affected. The majority of the damage (3,639 ha) occurred in Mid Coast TSA, particularly between Good Hope and South Bentinck Arm. The remaining 1,098 ha were located in the Kingcome TSA, especially north of Knight and Kingcome Inlets.

Yellow-cedar decline damage was highest in the Skeena Region last year, but only 1,115 ha were observed there in 2011. Most of the decrease occurred in the North Coast TSA, which was surveyed at a lower intensity this year. A total of 1,010 ha of damage were clustered along the north half of Observatory Inlet. A few small disturbances totalling 105 ha were also observed primarily at the southern tip of the Kalum TSA.

# DAMAGING AGENTS OF DECIDUOUS TREES

## Aspen (serpentine) leaf miner, *Phyllocnistis populiella*

The present aspen (serpentine) leaf miner outbreak was first observed in the 100 Mile House TSA in 2002 and by 2005 infestations had expanded northward to encompass the Williams Lake TSA as well. Minor defoliation was also observed in the Skeena Region. However, damage was light and scattered throughout mixed species stands and attempts to map disturbances did not occur during the aerial overview surveys until 2006, when scattered damage was recorded throughout the Kootenay/ Boundary Region. Widespread mapping of aspen leaf miner defoliation started in 2009, when 109,609 ha were affected throughout all Regions except the South Coast. Infestations almost doubled to 209,605 ha last year, and hit a record peak of 669,050 ha detected in 2011 (Figure 19). Aside from the mountain pine beetle, this leaf miner affected more hectares this year than any other damaging agent. Intensity levels were assessed at the same proportion as last year, with 268,590 ha (40%) light, 210,290 ha (32%) moderate and 190,270 ha (28%) severe.

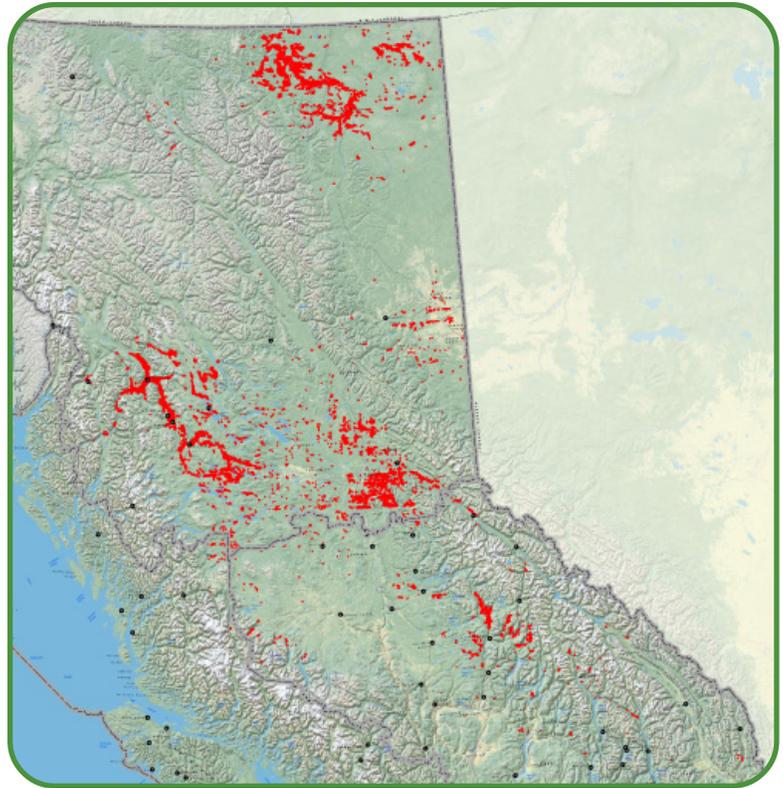


Figure 19. Aspen leaf miner defoliation mapped in 2011.

A total of 233,358 ha of defoliation were recorded in the Northeast Region. The Fort Nelson TSA, particularly in the eastern half, was most affected with 220,634 ha of attack. The entire TSA was surveyed this year compared to approximately a third in 2010, hence this could partially account for the large increase from only 4,874 ha. Scattered stands in the northern half of the Dawson Creek TSA were damaged, with 10,774 ha delineated. Attack extended into the Fort St. John TSA at the north and south boundaries where 1,951 ha were mapped.

Skeena Region sustained 229,060 ha of defoliation. Infestations noted last year continued to grow and intensify in the Kispiox TSA, where 82,619 ha were defoliated, 88% of which were rated at the severe level. The bulk of the damage occurred along the Bulkley, Kispiox and Skeena Rivers. The severe intensity Bulkley River infestation continued south into the Bulkley TSA, where a total of 36,604 ha were affected. Intensity dropped to primarily light and moderate in the Lakes and Morice TSAs where 58,517 ha and 46,934 ha were mapped, respectively. Most of the damage in these TSAs occurred in the northern half. Infestations along the Skeena and Nass Rivers in the Kalum TSA damaged 2,938 ha. Minor defoliation was also noted in the Nass and Cranberry TSAs with 883 ha and 565 ha affected, respectively.

Aspen leaf miner defoliated 155,525 ha in the Omineca Region, chiefly at light to moderate intensity. Most of this damage (149,921 ha) was contained in the Prince George District portion of the Prince George TSA. Defoliation in the Robson TSA mainly occurred along the Fraser River with 3,509 ha recorded. Mackenzie TSA had small infestations at the north and south boundaries with 2,096 ha affected.

Defoliation was light to moderate in the Thompson/Okanagan Region, where 34,865 ha were attacked. The Kamloops TSA sustained 33,162 ha of the damage, mainly mid TSA along water bodies. The remaining 1,703 ha were observed in the northern half of the Okanagan TSA.

Attack in the Cariboo Region was assessed at 11,348 ha. Almost all of the 7,045 ha of defoliation recorded in the Williams Lake TSA was rated as severe, and ranged from Big Lake east to McKinley Lake. In contrast, 3,315 ha of damage in the Quesnel TSA were light to moderate, with concentrations of attack around Kluskoil and Bowron Lakes. Only 987 ha of predominantly severe damage were mapped in the 100 Mile House TSA from Forest Grove to Lac des Roche.



*Aspen leaf miner defoliation in Quesnel TSA*



*Aspen leaf miner attacking cottonwood*

Infestations were mostly light to moderate and found in small scattered patches throughout the Kootenay/ Boundary Region, with the exception of Invermere TSA. Damage totalled 3,341 ha. The West Coast Region sustained 1,553 ha of attack, all located in the northeastern corner of the Mid Coast TSA.

Aspen leaf miner most commonly attacks trembling aspen in BC. However this year a substantial amount of cottonwood was also damaged. A total of 17,383 ha of leading cottonwood stands were affected, with a further 84,759 ha of aspen stands containing a component of cottonwood delineated.

## Venturia blight, *Venturia* spp.

Venturia blight, also known as aspen and poplar leaf and twig blight, was mapped across a record 125,319 ha of primarily aspen stands in 2011. This is up from only 6,621 ha in 2010, most likely because the wet spring and early summer of 2011 provided optimum conditions for high infection rates. Venturia blight damage has been relatively low since 2002, when 80,156 ha were infected. Actual damage this year was even higher than recorded, since damage intensified in the Skeena Region as summer progressed and scattered damage became very noticeable throughout the Cariboo Region, after the aerial overview surveys were conducted. Intensity of damage was rated as 82,159 ha (66%) light, 32,768 ha (26%) moderate and 10,391 ha (8%) severe.



Severe Venturia blight damage near Clinton in the 100 Mile House TSA

The Northeast Region had the most area affected at 70,254 ha, though most (94%) was rated as light. Damage was quite spotty over large areas in this region; hence large light polygons were frequently mapped. Dawson Creek TSA contained 46,552 ha of damage in the northern half of the TSA. Disturbances in the Fort Nelson TSA were smaller and more dispersed, but still totalled 16,202 ha. Fort St. John TSA had 7,500 ha recorded, primarily along the north and south boundaries of the TSA.



Venturia blight damage to aspen clones near Smithers

Skeena Region sustained 53,772 ha of damage due to Venturia blight infections and the intensity was substantially higher than in the Northeast Region, with 51% moderate and 19% severe. The majority of the 18,534 ha mapped in the Bulkley TSA occurred along the Bulkley River. Of the 17,118 ha observed in the Morice TSA, most was situated around Houston. Infection centers totalling 16,046 ha were more scattered in the Lakes TSA, with concentrations around Buckley and Francois Lakes. Damage in the Kispiox TSA was located along the Skeena and Suskwa Rivers, with 1,626 ha affected. This was the only TSA where infections went down considerably from last year when 4,635 ha were damaged. A further 448 were mapped along the Kitimat River in the Kalum TSA.

The remaining Venturia blight damage recorded in the province this year was 1,293 ha in the Omineca Region. Prince George TSA contained 1,146 ha of the damage, primarily along the western edge of the Vanderhoof Forest District. A few small infection centers totalled 147 ha in the Mackenzie TSA.

## Forest tent caterpillar, *Malacosoma disstria*

The current forest tent caterpillar outbreak began around 2008, with a peak this year of 453,137 ha affected across BC, more than triple the total area recorded last year (Figure 20). Intensity of damage also continued to increase, with 121,550 ha (27%) light, 275,530 ha (61%) moderate and 56,057 ha (12%) severe mapped.

The majority of attack continued to be observed in the Omineca Region, where 402,979 ha were affected. Prince George TSA sustained 379,253 ha of the defoliation, primarily in the western half of the Prince George Forest District. A further 22,677 ha were damaged in the southern tip of the Mackenzie TSA and 1,049 ha were recorded in the northern portion of the Robson TSA.

Infestations continued southward into the Cariboo Region, where 40,099 ha were damaged in the Quesnel TSA from Blackwater Mtn. in the west to Coldspring House in the east. Ground observations indicated forest tent caterpillar populations are in decline within this TSA, but many aspen stands have sustained a combination of forest health agents including forest tent caterpillar, aspen leaf miner and *Venturia* blight. It will be easier to confirm once the current damage subsides, but it appears that consecutive years of damage is leading to aspen decline in some stands. Minor infestations also damaged 28 ha in the Williams Lake TSA.

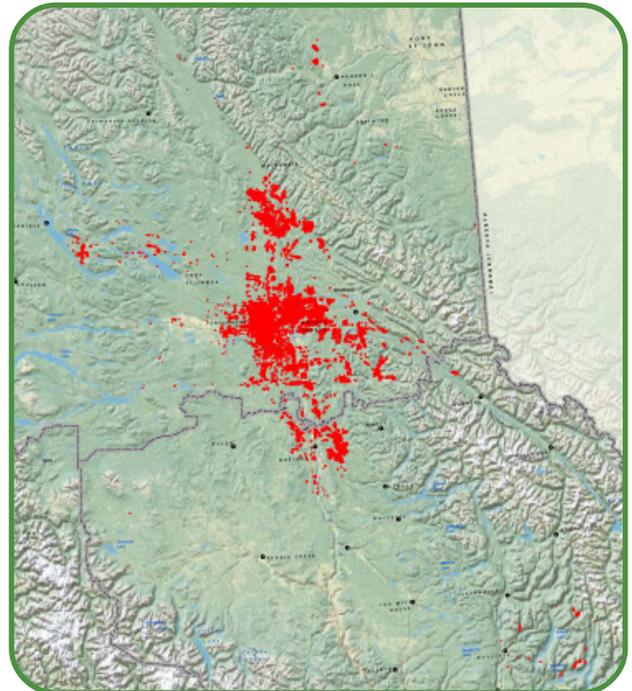


Figure 20. Forest tent caterpillar defoliation mapped in 2011.



Forest tent caterpillar larvae in Prince George TSA

Defoliation totalling 4,009 ha occurred in the Northeast Region near Bullhead Mountain. Dawson Creek TSA sustained 3,697 ha and the attack spilled into Fort St. John TSA where 312 ha were affected.

Most of the defoliation in the Skeena Region was observed in the northern tip of the Lakes TSA, where 3,150 ha were mapped. Minor infestations were also noted in the Morice and Kalum TSA with 171 ha and 39 ha affected, respectively.

The remaining 2,661 ha of attack was observed in the Thompson/Okanagan Region. Okanagan TSA sustained 1,426 ha of damage in the northern portion of the TSA, and 1,235 ha were observed in the middle of the Kamloops TSA.

## Large aspen tortrix, *Choristoneura conflictana*

The last large aspen tortrix outbreak began abruptly in 2003 when 794,303 ha were affected, of which 460,464 ha occurred in Fort Nelson TSA. Damage declined rapidly from that point, with almost no defoliation attributable to large aspen tortrix over the last two years.

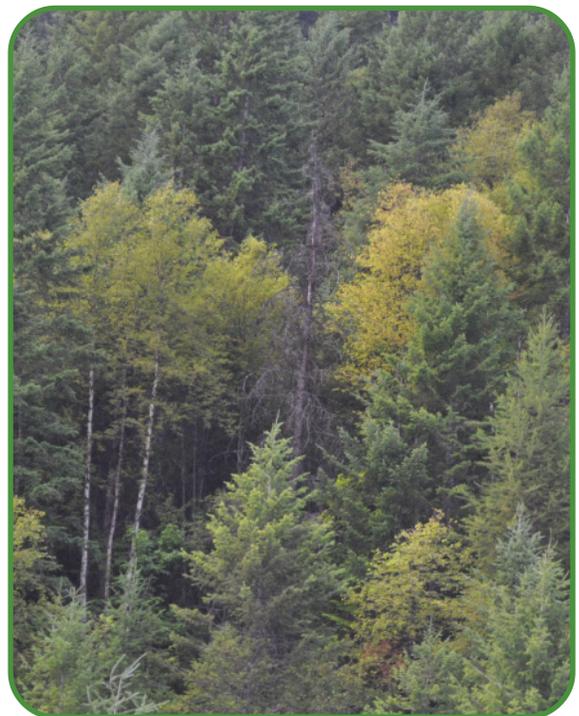
In 2011 large aspen tortrix defoliation returned to the eastern half of the Fort Nelson TSA, where 51,810 ha were affected. Minor infestation activity of 127 ha was also recorded in the Fort St. John TSA. Most of the defoliation was assessed as light at 45,510 ha (88%) with 5,170 ha (10%) moderate and 1,257 ha (2%) severe. Ground confirmation of the damaging agent was not conducted, but district staff concurred that large aspen tortrix is the main aspen defoliator for the area and timing for a new outbreak fits the historical profile. A minor portion of the southern damage may also have been due to Bruce spanworm, which was noted where appropriate in the database comments. It is suspected that at least some of the aspen defoliation last year in the Fort Nelson TSA that was attributed to Bruce spanworm was actually large aspen tortrix. If defoliation continues next year, effort will be made to positively identify the damaging agent.

## Birch leaf miner, *Fenusa pusilla*

Birch leaf miner damage in the southern interior dropped to a third of that recorded last year. A total of 2,915 ha were affected with 2,124 ha (73%) light, 777 ha (27%) moderate and 14 ha (<1%) severe, which is also down in intensity from 2010. Disturbances remained small and scattered.

The Kootenay/ Boundary Region continued to sustain the most attack, with 2,915 ha mapped. Arrow TSA contained 880 ha of defoliation, with concentrations around old Glory Mtn. and Whatshan Lake. Most of the 577 ha observed in the Kootenay Lake TSA occurred along the Duncan and Lardeau Rivers. Minor infestations (under 110 ha in each TSA) were mapped in each of the other TSAs. Ground observations noted additional scattered attack, particularly in the south, that was not visible from the air.

Damage due to birch leaf miner also occurred in the Thompson/Okanagan Region with 1,144 ha affected. A total of 930 ha were noted in the Kamloops TSA, particularly around Mt Morrissey, Adams Lake and Barriere. The remaining 214 ha were scattered throughout the northern half of the Okanagan TSA.



Birch leaf miner damage in Arrow TSA

## Aspen and birch declines

Deciduous declines are difficult to detect from the height of the aerial overview surveys and thus are not often mapped. Aspen decline has become more prominent in BC over the past few years and in 2011 374 ha of damage was delineated. Intensity was rated as 16 ha (4%) light, 287 ha (77%) moderate and 71 ha (19%) severe. All disturbances were small and scattered, and were primarily located in grassland/forest interface areas.

The majority (330 ha) occurred in the Thompson Okanagan Region. Merritt TSA sustained 270 ha of mainly moderate damage around the Merritt area. Okanagan TSA had 34 ha of severe aspen decline in a polygon near Keremeos and 25 ha of moderate damage were located in the southern portion of the Kamloops TSA. The remaining 44 ha, mostly rated as severe damage, were scattered throughout the 100 Mile House TSA in the Cariboo Region.

Minor birch decline noted in the Kootenay/ Boundary Region in 2009 and the Fort Nelson TSA in the Northeast Region in 2010 were not observed in 2011.



*Aspen decline in the Merritt TSA*

## Gypsy moth, *Lymantria dispar*

Although the North American strain of the European gypsy moth has been periodically discovered in BC, aggressive detection and prompt eradication programs have succeeded in preventing its establishment. To date, no defoliation has been detected during the aerial overview surveys.

Monitoring pheromone traps caught 30 male moths in 2009 and two control programs were consequently conducted in the spring of 2010; one in Richmond (766 ha) and one near Harrison Hot Springs (25 ha). Treatment consisted of three applications of the Foray 48B® at a rate of 4 liters per ha.

Pheromone trap results from the fall of 2010 showed the treatment was very successful, and that further treatments were not required. In 2011 trap catches continued to fall to the lowest level recorded since the monitoring program began. Only 6 moths were caught, with 1 in Richmond, 2 in Victoria, 2 in Langley and 1 in Revelstoke. A treatment program will not be required in the spring of 2012, though monitoring will continue in the summer. Further information regarding the gypsy moth program and historical records can be accessed at the MFLNRO's gypsy moth website at <http://www.for.gov.bc.ca/hfp/gypsymoth/index.htm>.

## Bruce spanworm, *Operophtera bruceata*

The current Bruce spanworm outbreak began in 2008 in the Northeast Region with 97,804 ha impacted. Infestations grew quickly, and the outbreak peaked at 1.7 million hectares last year. In 2011, defoliation dropped dramatically to only 9,043 ha with intensities rated as 7,153 ha (79%) light, 1,722 ha (19%) moderate and 170 ha (2%) severe.

Confirmation of whether the damaging agent is primarily Bruce spanworm, forest tent caterpillar or large aspen tortrix was particularly difficult this year. The Bruce spanworm outbreak was definitely on the decline, while forest tent caterpillar damage was increasing in the south and large aspen tortrix damage was increasing in the north.

Fort St. John TSA was the most affected by Bruce spanworm, with 5,412 ha delineated. However, defoliation mapped along the southern edge of the TSA was noted in the database comments to possibly have forest tent caterpillar damage in the stands as well, while the northern disturbances noted that large aspen tortrix populations were most likely in the stands too. Forest tent caterpillar was also a suspected component of the Bruce spanworm damage found in the remaining TSAs. Dawson Creek TSA contained small scattered areas of attack totalling 3,157 ha. The remaining defoliation was identified in the Omineca Region, with 330 ha in the southern portion of the Mackenzie TSA and 144 ha in the eastern tip of the Prince George TSA.



*Bruce spanworm defoliation in Fort St. John TSA*

## Satin moth, *Leucoma salicis*

After a peak of 1,608 ha of satin moth defoliation provincially in 2009, only 9 ha of damage were observed last year. Total area affected rose to 604 ha this year, with most of the defoliation delineated in one 569 ha lightly damaged polygon east of New Denver in the Arrow TSA. Lillooet TSA contained two small light intensity polygons north of Spences Bridge that totalled 24 ha. The remaining 11 ha were moderately damaged in one infestation west of Kingsvale in the Merritt TSA. Ground observations noted minor satin moth populations around the City of Prince George as well.

# DAMAGING AGENTS OF MULTIPLE HOST SPECIES

## Armillaria root disease, *Armillaria ostoyae*

Damage due to *Armillaria* root disease is rarely seen during the aerial overview surveys. Over the last decade, less than 100 ha of *Armillaria* root disease infections centers have been observed annually in BC. In 2011, a total of 154 ha of damage were delineated as 28 ha (18%) light, 74 ha (48%) moderate and 34 ha (34%) severe.

The Thompson/Okanagan Region contained 102 ha of stands damaged by *Armillaria* root disease. Of this, 76 ha were located in the Okanagan TSA south of White Lake and east of Mabel Lake. The remaining 26 ha occurred in the Kamloops TSA west of Niskonlith Lake and west of Raft Mtn. In the 100 Mile House TSA of the Cariboo Region, one severely affected polygon of 52 ha was mapped near Mount Timothy.

## Black army cutworm, *Actebia fennica*

Defoliation from black army cutworm has not been previously recorded during the aerial overview surveys. This is due to damage being relatively localized and uncommon, and defoliation being difficult to see due to the small size of typical host plants and trees. Outbreaks usually occur in recently burned areas.



*Black army cutworm larvae*



*Seedling defoliated by black army cutworm*

In June 2010 the Greer Fire in Vanderhoof District burnt 1600 ha. The burn was planted in the spring of 2011 and when the black army cutworm larvae emerged shortly thereafter, substantial defoliation occurred on natural spruce regeneration and planted lodgepole pine seedlings. Ground observations noted that feeding was also heavy on fireweed, prickly rose and green alder (herbaceous plants and shrubs are co-defoliated). Interestingly, dandelions and Bicknell's geranium were not damaged.

The general area of damage was brought to the attention of the aerial overview surveyors, and the distinct lack of vegetation in an area west of Nulki Lake made it possible to delineate the damage from the air. One lightly defoliated polygon of 67 ha was mapped. Anecdotally, black army cutworm defoliation was also observed this spring within 2010 wildfire areas in the Quesnel TSA.

## Pitted sap rot, *Trichaptum abietinum*

Pitted sap rot fungus can infect a wide range of coniferous hosts. The decay is very finely pitted, almost laminated, and is limited to the sapwood in the butt, root collar and roots of infected trees.

Pitted sap rot was identified this year from observations made from the ground in lodgepole pine trees killed by mountain pine beetle in the Fort St. James District of the Prince George TSA. The regional pathologist noted that the decay appeared to be both aggressive and advanced. District staff have observed that pitted sap rot is prevalent throughout the district in trees that have been dead four years or longer. An estimated 50% of the older mountain pine beetle mortality appears to be infected, which could adversely affect the merchantability of these stands.



*Pitted sap rot decay*

## Abiotic injury and associated forest health factors

**Wildfire** damage severely affected only 15,149 ha this year and hit a record low for number of fires. This was in stark contrast to 2010 when a dry, hot summer resulted in a peak of 302,154 ha of damage.

The Skeena Region contained most of the damage with 11,061 ha affected. Almost all the damage occurred in the spring in one 11,000 ha fire at Wheeler Lake in the northeast portion of the Cassiar TSA. A total of 2,706 ha of forest burned in the Northeast Region, with the highest concentration between Moodie Lakes to Kechika River in the Fort Nelson TSA. Cariboo Region sustained the most damage last year with 154,617 ha affected, but small scattered fires in 2011 totalled only 596 ha. Wildfires burnt 408 ha in the Omineca Region this year. One fire south of Nulki Lake in the Prince George TSA accounted for 404 ha of this damage. The Thompson/Okanagan TSA, which historically has sustained substantial wildfire damage, recorded a total of 257 ha affected. The remaining regions had less than 100 ha of wildfire damage per region.

**Flooding** damage more than doubled over last year to 10,701 ha. Most (94%) of the damage was rated as severe. The disturbances were small and scattered with the exception of the eastern half of the Fort Nelson TSA, where the majority of the damage continued to occur. Flooding in Fort Nelson TSA totalled 8,548 ha, with the largest disturbance covering 3,000 ha near Kimea Creek. Another 403 ha in the Fort St. John TSA and 145 ha in the Dawson Creek TSA were mapped in the Northeast Region. Flooding damage was actually higher than aerially observed in these two TSAs, where sizable portions of the northern road system were washed out. This was also the case in the adjacent Mackenzie TSA of the Omineca Region, where only 26 ha of flooding were mapped from the air. Prince George TSA contained the remaining 161 ha of damage in this region. In the West Coast Region, Mid Coast and Kingcome TSAs sustained 365 ha and 239 ha of damage, respectively. Flooding was minor in the rest of the province, with no more than 100 ha of damage per TSA.

**Windthrow** damage increased three fold since last year to 10,541 ha affected provincially, which is the highest level since 2005. Most of the damage (86%) continued to be rated as severe. Unlike last year when the majority of the damage occurred in the Kootenay/Boundary Region, in 2011 Omineca Region was most affected with 3,775 ha mapped. A considerable portion of this damage (2,969 ha) occurred in primarily spruce stands along the Parsnip Reach of Williston Lake in the Mackenzie TSA. Some of the disturbances were quite large, including one mapped at 778 ha. This damage continued down into the Prince George TSA, where a further 806 ha were delineated. The Northeast Region contained 2,871 ha of windthrow damage with 1,535 ha of chiefly aspen affected west of Halfway River in Fort St. John TSA. Fort Nelson TSA sustained 1,271 ha of mostly spruce windthrow west of Elieh Lake. The remaining 64 ha in this region were located in the Dawson Creek TSA.



*Flooding damage to forest and CN Railway tracks near Chetwynd*

Skeena Region had 1,887 ha of windthrow damage recorded primarily in hemlock stands. Disturbances observed in the Kalum TSA were small and scattered, affecting 795 ha. District staff noted that an intense wind event that occurred in November 2010 caused substantial windthrow in the areas of Skeena River, Big Cedar, Sterling and Rosswood. Access to the community of Rosswood was cut-off for a couple of weeks by extensive windthrow on the road system. These

particular windthrow events were not detected during the aerial overview surveys. Recorded damage was heaviest in the Kispiox TSA west of Kitwancool Lake, with a total of 773 ha affected. Small scattered areas of windthrow also affected 235 ha in the North Coast TSA, with minor events in other TSAs within the region.



*Blowdown damage at Mt. Timothy in 100 Mile House TSA*

Wind damage was low in the West Coast Region, with the exception of the Queen Charlotte TSA where the survey recorded small scattered areas of damage with a concentration around Logan Inlet that amounted to 1,348 ha of blowdown. Disturbances in other TSAs throughout the province were minor, with less than 120 ha affected per TSA.

**Redbelt** damage reached a peak of 5,287 ha in 2011, which is the highest level recorded since 2005. Although many tree species can be affected, lodgepole pine continued to be the main species. A large amount of the damage (79%) was recorded at the moderate level, with 20% assessed as severe. Frequently the majority of the damage occurs in the Northeast Region, as was the case this year when 4,279 ha were affected. All the disturbances were in the Fort Nelson TSA, with a concentration of redbelt around the confluence of the Liard and Beaver Rivers. In the Cariboo Region 905 ha were affected, with 545 ha in Williams Lake TSA and 359 ha in 100 Mile House TSA. The disturbances were adjacent near the southern boundaries of the TSAs in drainages along the Fraser River. The remaining 103 ha were observed in one polygon along the Parsnip River in the Prince George TSA of the Omineca Region.

**Slides** accounted for 1,630 ha of damage in BC, down by a third from last year. Of this, 237 ha were identified as caused by avalanches. Most (89%) of the damage was rated as severe, with the remaining hectares recorded as very severe. All disturbances were small and scattered. The West Coast Region sustained 746 ha of damage, of which 507 ha were mapped in the Mid Coast TSA. A total of 277 ha were mapped in the Kootenay/ Boundary Region across all TSAs. The total area of slide damage in the South Coast Region was recorded at 187 ha, with 135 ha occurring in the Soo TSA. All remaining damage across the province was under 70 ha per TSA.

**Snow press** damage commonly occurred in aspen stands on 906 ha across the province, of which 902 ha were mapped in the Northeast Region. Half the damage was rated as moderate, with the remaining areas split between light and severe intensity. Dawson Creek TSA sustained 887 ha of the damage from Bear Mountain northward, with one 15 ha polygon extending into the Fort St. John TSA near Cecil Lake. The remaining 4 ha of snow press occurred in the Fraser TSA of the South Coast Region.

**Drought damage** continued to drop sharply, down to only 9 ha from a peak of 65,817 ha in 2008. The damage was delineated as severe and one polygon of 8 ha was located near Kemano River in the Kalum TSA of the Skeena Region. The other hectare was observed as spot damage in the Arrowsmith TSA of the West Coast Region.

**Road salt** damage is rarely visible at the height of the aerial overview survey, but 9 ha were observed in 2011. The disturbance was mapped in one polygon at severe intensity near 108 Mile House in the 100 Mile House TSA of the Cariboo Region.

**Desiccation damage** was noted during ground checks in the Bambrick Creek area of the Williams Lake TSA. The damaged stand was a naturally regenerated young pine stand approximately 20 years old. Serious damage occurred only to old foliage on the edge of the stand, extending inwards approximately 10



*Desiccation damage near Bambrick Ck in Williams Lake TSA*

to 20 meters. Current foliage was unaffected. A few spruce trees on the stand edge were also damaged. The foliage appeared to have been desiccated by a strong wind coming from the west. The event may have occurred on November 16<sup>th</sup> 2010 when a cold front was noted to cause similar damage in Mackenzie TSA. Since the event occurred prior to the growing season, new foliage was not affected. This damage was not observed during the aerial surveys.

## Animal damage

Most animal damage is scattered, does not affect the entire tree, or the damage occurs on very small trees. Therefore, animal damage is difficult to detect at the height the survey is flown and is usually underestimated.

**Black bear** (*Ursus americanus*) damage was observed across 404 ha in BC this year, up five-fold from 2010. Most (86%) of the damage was recorded as light, with the remaining split between trace and severe intensity. Damage was localized in scattered patches. The Kootenay/Boundary Region sustained 332 ha of the damage, with the majority (291 ha) located in the Invermere TSA, particularly near Flett Peak and Spillimacheen Mtn. In the Thompson/



Porcupine damage in the Kalum TSA

Okanagan Region, 47 ha of attack were noted within the Kamloops and Okanagan TSAs. West Coast Region contained 25 ha of bear damage, of which all but one spot occurred in the Arrowsmith TSA. The remaining 1 ha was located in the Sunshine Coast TSA of the South Coast Region.



Porcupine feeding on tree bole

**Porcupine** (*Erethizon dorsatum*) damage was detected on 88 ha provincially, mainly at moderate intensity. The Kalum TSA of the Skeena Region contained 86 ha of the attack in three young stands of amabilis fir and spruce. The affected stands were located on the Shames River west of Terrace. Damage was quite extensive for porcupine. Ground confirmation of the damaging agent was made.

**Long-tailed voles** (*Microtus longicaudus*) were noted during ground observations to be causing ongoing damage to seedlings on recently harvested areas east of Golden. This damage has been observed to occur for up to five years post harvesting.

## MISCELLANEOUS DAMAGING AGENTS

**Unknown defoliation** declined substantially since 2010 from 38,957 ha to 5,083 ha across BC this year. Intensity was recorded as 3,640 (72%) light, 291 ha (6%) moderate and 1,147 ha (22%) severe. Damaging agents could not be identified for most of these disturbances due to inaccessibility. The Omineca Region sustained 2,966 ha of defoliation, with 2,604 ha in the Mackenzie TSA and 362 ha in the Prince George TSA. Most of the damage in this region occurred on aspen. In the Skeena Region a total of 1,799 ha were affected. Morice and Lakes TSAs sustained 468 ha and 233 ha of damage, respectively, to spruce stands. Aspen and spruce were defoliated over 551 ha in the Kispiox TSA. Western hemlock was defoliated in the Kalum and North Coast TSAs, with 450 ha and 97 ha affected, respectively. The remaining 318 ha of damage was mapped in the West Coast Region, with 275 ha in the Mid Coast TSA and 42 ha in the Arrowsmith TSA.

**Unknown damage** affected 1,731 ha provincially this year, in two specific locations. Several disturbances were mapped across 901 ha in the Fort Nelson TSA of the Northeast Region. Young lodgepole pine between the Grand Canyon of the Liard River and the Grayling River were killed. The areas were not ground checked, but it was suspected that the mortality was due to either Warren root collar weevil or secondary bark beetles. Intensity of damage was light to moderate. In the Kamloops TSA of the Thompson/Okanagan Region, 830 ha of western red cedar were lightly affected. The disturbances were located mid TSA from Clearwater Peak east to Adams River. From the air, foliage was observed to be discoloured but ground checks were not conducted due to access constraints.

**Alder decline** was noted to be occurring in scattered patches throughout the Skeena Region, with a total of 1,578 ha affected. As green alder is not considered a commercial tree species in this region, the damage was mapped but not included in the aerial overview database. Most (94%) of the damage was severe with the remaining denoted as moderate. Alder decline damage occurred primarily in the valley bottoms.

**Alder defoliation** in the Robson TSA was first observed last year, and continued primarily on Hugh Allan Creek east of Kinbasket Lake this year. A total of 114 ha of mainly severe damage were delineated. Since interior alder is classified as a brush species, the defoliation was not included in the database. The damage was inaccessible for ground confirmation, but it was likely defoliated by an alder sawfly.



*Alder decline in the Skeena Region*

**Willow leaf blotch miner** (*Micurapteryx salicifoliella*) defoliation intensified throughout the range of willow in Fort St. John, Fort Nelson and Dawson Creek TSAs. This damage has been observed over the past two years, but not to the level seen in 2011. In many willow stands, every leaf was mined. This damage was not mapped since willow is not a commercial tree species.

**Foliage disease** on arbutus was observed moderately affecting 5 ha near Horseshoe Bay in the Fraser TSA and lightly affecting 4 ha west of Departure Bay in the Arrowsmith TSA. Identification of the casual disease was not made, but it was suspected to be *Didymosporium arbuticola*.

**Poplar and willow borer** (*Cryptorhynchus lapathi*) has been noted as active in the Skeena Stikine District over the past two years. Primarily young willow has been affected in valley bottoms within the ICH biogeoclimatic zone.



Willow leaf blotch miner in Fort St. John TSA

## FOREST HEALTH PROJECTS

### 1. Birch decline investigation continues

*Michael Murray, Forest Pathologist, Kootenay/Boundary Region*

Paper Birch (*Betula papyrifera*) offers a variety of attributes in BC including syrup, veneer, beverage flavour, medicinal tonic, and teeth cleaner. The decline of paper birch has been widespread throughout the southern interior of the province. Characterized by crown die-back, most mature birch appear susceptible. The spatial distribution patterns and actual causation remain poorly understood. Beginning in 2009, 25 birch sampling sites were inventoried in the Kootenay/ Boundary Region. A total of 247 trees were increment cored. Additionally, several dozen trees had cross-

sections collected. These samples provided the material to identify possible perturbations in growth, tree stress, and to better understand predisposing factors. Using a tree ring lab in Nelson, possible links between climate and tree stress are being examined.



Sampling birch crown

In October, a separate sampling was conducted to target fungal pathogens. Birch trees were selected from seven locations (between Slocan Lake and Salmo). Paul Andersen (Wildfire Management Branch, Kootenay Lake Zone) provided sawyer skills in felling 26 trees. Once felled, we cut off upper stem segments where the dieback was occurring. The logs were then delivered to the UBC Forest Pathology Lab,

supervised by Dr. Richard Hamelin. The lab is currently culturing fungi from the logs in order to identify possible pathogens. This is a meticulous process, but should reliably reveal the various fungal species present. Additionally, samples of *Armillaria* mycelial fans are also being identified to species using DNA at the Pathology Lab.



UBC Hamelin lab

## 2. Blister rust screening for whitebark pine launched

*Michael Murray, Forest Pathologist, Kootenay/Boundary Region*

During 2011, the Kootenay/Boundary Region formally initiated efforts to develop disease resistance within whitebark pine (*Pinus albicaulis*). These subalpine trees are very valuable to wildlife for providing large seeds and canopies in a harsh timberline environment. Whitebark pines regulate snowmelt and protect soils on steep mountain slopes. The introduced disease white pine blister rust has reduced whitebark pine over the past century. Dead and dying trees are the majority in many locations and the mountain pine beetle has further denuded stands to unprecedented low levels.

In BC, a small proportion of whitebark pine is likely to promote defensive mechanisms that ensure the tree's survival. Successful identification of these rare trees relies on careful selection from naturally occurring populations. By identifying candidates in the field, we can test their resistance through established rust screening procedures similar to the successful western white pine screening program.

Forty trees were selected in BC this year to undergo rust screening. Candidate trees were selected based on their vigour and lack of disease. Stands were chosen based on accessibility and disease incidence. Locations that had high disease incidence serve as better samples because a greater proportion of non-resistant trees are already dead. Therefore, the remaining trees are more likely to be resistant.

It was necessary to install protective cages over the cones early in the summer to shield seeds from wildlife until ripe and ready for collection. Cages were placed on cones by climbing or using a tree-tong fabricated for this purpose. We returned in September and October to retrieve about 360 cages with approximately 900 cones. Seeds were extracted and sent to two facilities. The MFLNRO Kalamalka Research Centre near Vernon



Squirrel (top rt.) and chipmunk (top left) harvest uncaged cones from a whitebark pine near Moyie, BC

received seeds from all 40 trees. The Research Centre will propagate seedlings in 2012 and rear them for at least two years before implementing an inoculation process using the blister rust fungus (*Cronartium ribicola*). In parallel with this, a subset of seedlings will be reared and inoculated at the Dorena Genetic Resources Center (US Forest Service) in Oregon. After inoculations, seedlings will be observed for several years for signs of blister rust. Results between the centers will be compared. Concurrent field trials using a subset of outplanted seedlings are also anticipated to provide additional comparison.

In addition to the Kalamalka and Dorena Centres, valuable partners in this project include the Whitebark Pine Ecosystem Foundation, The Nature Conservancy of Canada, Panorama Ski Area, and the Columbia Basin Trust and its grantees (Keefer and Associates, White Bark Consulting).

### **3. Elytroderma stem infection assessments on Progeny Trials at the Willow Canyon Long Term Research Site**

*Richard Reich, Forest Pathologist, Omineca Region*

#### **5 Year Reassessment for Elytroderma Stem Infection Spread and Impact in a First Generation Progeny Trial:**

Elytroderma needle and shoot disease is caused by *Elytroderma deformans* (Weir) Darker. Although Elytroderma needle disease in lodgepole pine is documented, stem infections on lodgepole pine do not appear to have been described in the literature. The purpose of this project is to both describe the symptoms of Elytroderma stem infections on lodgepole pine, to report its vertical and horizontal rate of spread on stems over a five year period, and to describe the relative period of susceptibility to stem infection in young lodgepole pine. The overall purpose of the monitoring project is to determine the long term impact of stem infections on growth, yield, and survival. Stem infections were monitored over a five year period in a lodgepole pine progeny trial from age 19 to 24 years old.

The progeny trial was established in 1986 and contains 290 open pollinated lodgepole pine families. It was first assessed for Elytroderma stem infections, on all living trees, in the fall of 2005 by the author. Stem infections are typically somewhat sunken, and elongate oval to somewhat diamond shaped portions of the stem. The outer bark is somewhat roughened and cracked, and sometimes slightly resinous. Since the inner bark and cambium of these infections was typically live, these infections only loosely fit the textbook definition of a canker (wounding and repeated callusing is usually necessary before a lesion is termed a canker). However, their general sunken appearance is somewhat similar to a wide stalactiform blister rust canker, or a tall comandra blister rust canker, aside from the obviously dead central zone, which results from sporulation. Stem infections are difficult to see in a regular photograph: hence, an image that can be viewed three dimensionally with a stereoscope is available at <http://www.for.gov.bc.ca/ftp/HFP/external/!publish/AerialOverview/2011/>.

A total of 1017 trees out of 4476 live trees (22.7%) were identified as highly certain of being stem infected. An additional 209 trees (4.4% of total live trees) were identified as suspect or probable, bringing the total (including probable) to 27.4% of the living trees. In 2006, a more detailed assessment was conducted on a randomly selected sample of approximately 300 Elytroderma

stem infected trees. The final sample size was somewhat lower (262) as certain trees failed the final field selection criteria. Detailed assessments of canker location, dimensions, and symptoms were collected for each stem infection. The year of infection was estimated by determining the age of the stem internode at the estimated point of origin. The point of origin was typically determined to be the most sunken and cracked portion, which was typically the midpoint horizontally, but often somewhat lower than the vertical midpoint.

In the fall of 2011, each stem infection was reassessed by Theresa McMurchy and Kennedy Boateng for top and bottom height and for circumference girdled. The final number of trees that were maintained for future monitoring was 219. Trees were excluded if they were killed by other forest health agents, or if multiple *Elytroderma* infections merged, etc.



*Elytroderma* stem infection

The preliminary results indicate that individual stem infections appear to be spreading at a fairly steady rate horizontally and vertically, regardless of both crown class, and tree DBH. An increased proportion of the infected tree cohort is currently 100% girdled, and the degree of stem deformity is also slowly increasing over time. Very little new stem infection was observed in the stand as a whole, and had appeared to have peaked prior to age 10. Stem infections appear to be having a relatively low impact on tree survival at this point in time. This is likely due to the ability of the infected cambium to survive over long periods of time.

Destructive sampling of non-study trees revealed that traumatic resin canals can be found in the phloem of stem infections, but it's unclear whether this is an effective resistance mechanism. Although a stand level incidence of 27.4% may seem relatively high, it is probably insufficient to reliably screen for family level resistance, though infection by family ranged from 0 to 78%.

### **Initial Assessment of *Elytroderma* Stem Infection and Impact in a Second Generation Progeny Trial:**

The Willow Canyon second generation progeny trial contains 139 families and was established in 2002 adjacent to the first generation progeny trial described above. All trees were assessed for forest health conditions in 2007, and then reassessed in 2011 after 10 growing seasons. The 2011 general forest health assessment was conducted by Theresa McMurchy and Kennedy Boateng.

A total of 418 out of 5434 live trees (6.7%) had *Elytroderma* stem infections confirmed. The infection dimensions (top and bottom height, and circumference girdled) and the age of internode at the point of origin, of 100 randomly selected infected trees, were subsequently assessed. Of these, 4 trees were subsequently removed from the sample leaving 96 trees for detailed periodic monitoring.

Family level resistance screening is clearly not a realistic objective in the future of this installation due to the very low level of infection achieved by age 10.

This trial will also be monitored to determine the long term impact of stem infections on growth, yield, and survival. Infection condition monitoring will be conducted on a 5 year periodic basis.

### Comparison of the results for the two sites

The period of susceptibility was compared for the two progeny trials and found to be very similar. Most stem infections appear to occur at a very early age, peaking well before age 10.

Infection levels of several forest health factors are considerably lower at the 2nd generation trial than the adjacent 1st generation trial. This could be due to a number of factors such as lower risk due to climate change, or perhaps an increased level of resistance in the 2nd generation trees. The very short period of risk for several forest health factors may also result in highly variable stand level infection conditions during the period of peak susceptibility. Short term variability in weather conditions may result in considerable variability in site level risk.

## 4. Forest health trials in the Omineca Region

*Richard Reich, Forest Pathologist, Omineca Region*

Long term forest research installations within the Tree Improvement Program are ideal sites for collecting forest health data due to the direct connection with numerous program level objectives. The forest health conditions on many of these installations have been evaluated for a broad range of uses. Although resistance is typically the primary interest, timber supply impacts, spatial patterns of disease occurrence and spread, epidemiology, ecological relationships, etc. can also be gleaned from these installations. Sometimes these secondary products become the prime interest for evaluation and monitoring, especially if it is determined that critical thresholds for evaluating resistance screening have not been met.

What makes these trials of particular value, besides the program linkage, is the integrated trial design. Each installation is directly connected with a particular phase in the tree breeding cycle, and consists of a documented genetic population that is often replicated on several different sites. These populations range from a very large number of open pollinated families selected from a large range of provenances for a typical progeny trial, to a relatively small number of clones from relatively few provenances for an orchard. This range in population parameters provides a unique opportunity to investigate the different levels of variability in data sources.

In the fall of 2011 several major operational trials were reassessed by Kennedy Boateng and Theresa McMurchy. Forest health factors that were assessed included the hard pine stem rusts (*Cronartium comandra*, *Cronartium coleosporioides*, and *Endocronartium harknessii*, Elytroderma (*Elytroderma deformans*) stem infections, Boron micronutrient deficiency, and pine terminal weevil (*Pissodes terminalis*). The results of these assessments will continue to inform the pine stem rust management strategies in the districts, support the hazard rating surveys, and will be reported on in a project specific basis.



*Pine terminal weevil attack*

## 5. Lakes TSA hard pine rust surveys 2011

*Alex Woods, Forest Pathologist, Skeena Region*

A contract was let in 2011 to survey 70 stands for hard pine rust in the Lakes TSA. Results of the contract were:

- 99% of stands have rust
- 43% of stands have >20% incidence
- 5 stands have >50% rust
- Highest rust incidence was 1 stand with 59% comandra blister rust
- 5 stands have <800 sph, remainder have adequate stocking

The extent of rusts in the Lakes TSA and the apparently chaotic expression of those rusts on the landscape brings into question the ability to hazard rate with any accuracy to a scale finer than the biogeoclimatic zone. The unpredictable weather patterns associated with global warming and the strong tie between precipitation and hard pine rusts brings even more uncertainty to an already difficult to predict relationship between hard pine rusts and landscape level hazard and risk. The fact that hard pine rusts are very prevalent in young lodgepole pine stands throughout much of the BC Central Interior does not seem to be reflected in Forest Stewardship Plan stocking standards.

## 6. Lodgepole pine dwarf mistletoe trial assessment

*Leo Rankin, Forest Entomologist, Cariboo Region*

*Joan Westfall, Forest Health Consultant, EntoPath Management Ltd.*

*Julie Brooks, Forest Health Consultant, Forest Health Management*

A trial was established south of Raven Lake in the Cariboo-Chilcotin District in 1982 to study the potential for eradication of lodgepole pine dwarf mistletoe (*Arceuthobium americanum*) through juvenile spacing. Two adjacent blocks were spaced; one without regard to mistletoe infections and one where an attempt was made to remove mistletoe-infected stems. The trial was re-assessed in 1991, 1995, 2002 and 2008, with some additional information collected in 2011. The incidence of lodgepole pine dwarf mistletoe (DMP) infections has increased throughout the assessments, both in percentage of trees attacked and in number of infections per tree. Spacing to eradicate mistletoe has not had any positive effect, although there is uncertainty as to whether DMP levels were similar in both blocks at the time of plot establishment.

Individual infections on plot trees have been tracked since 1991 and detailed data have been collected. The number of trees infected and number of infections per tree has steadily increased with each assessment. After the last assessment 78% of the plot trees were infected with lodgepole pine dwarf mistletoe. On average, new branch and stem infections were located higher up the tree than earlier infections. However, from the 2002 to the 2008 assessment, 28% of the older infections were observed as dead or dying from suspected shading.

Average movement of individual branch infections per year were tracked over time and as the trees have grown, the rate of infection movement has decreased substantially (Table 7). As with the dying infections, shading is suspected to be a factor in growth decline.

Table 7. Average movement of lodgepole pine dwarf mistletoe infections per year along a branch between assessment periods (N=number of infections).

	Interval	N	Avg. movement – SE (cm/year)	Range of movement (cm/year)
Movement along branch	1995-2002	36	1.8 – 0.27	0.2 – 8.0
	2002-2008	279	0.6 – 0.05	0 – 7.1



Lodgepole pine dwarf mistletoe stem infection

To study the impact of DMP infection severity on tree growth, all plot trees were assessed using the whole-tree Hawksworth scale. Levels of infection were grouped into light (0-2), moderate (3-4) and severe (5-6).

Table 8. Hawksworth scale used to compare the impact of DMP on lodgepole pine plot trees.

Hawksworth scale	No. PI	DBH ± SE (cm)	Height ± SE (cm)
0-2	40	9.2 ± 0.34a*	765 ± 24.8a
3-4	55	8.4 ± 0.41a	652 ± 26.1b
5-6	28	6.3 ± 0.37b	525 ± 28.6c

\*Means (SE followed by the same letter are not significantly different, (t-test, P > 0.05)

Lodgepole pine dwarf mistletoe was shown to adversely affect both height and diameter of plot trees (Table 8). There was no significant difference in DBH between lightly and moderately infected

trees but both groups were

significantly larger in diameter than severely infected stems. For height, all three infection classes were significantly different, with heavily infected stems on average almost a third shorter than lightly infected trees.

Other forest health agents noted in the trial included *Lophodermella* and *Elytroderma* needle casts, squirrel feeding (primarily on DMP) and western gall rust, none of which heavily impacted affected trees. In 2007, mountain pine beetle killed 14% of the plot trees, removing the largest stems in the blocks.



Measuring DMP infection growth

## 7. Lodgepole pine dwarf mistletoe update

David Rusch, Forest Health Technologist, Cariboo-Chilcotin District  
Leo Rankin, Forest Entomologist, Cariboo Region

Lodgepole pine dwarf mistletoe (*Arceutobium americanum*) is extremely common in the lodgepole pine dominated forests of the Chilcotin SBPSxc. After the mountain pine beetle epidemic many small diameter overstory dwarf mistletoe infected residual trees survived. The effect of these residual trees on the dwarf mistletoe rating of the lodgepole pine understory is being investigated.



Lodgepole pine dwarf mistletoe  
branch infection

Thirty polygons were randomly selected from all lodgepole pine leading polygons greater than 10 ha and older than 30 years within 2 km of a road. Fifteen of these were sampled in 2011 using a 300 m x 5 m transect. All layer 1 trees in the transect were rated for dwarf mistletoe using the Hawksworth scale. At 0-10 m, 100-110 m, and 200-210 m trees in layers 2 to 4 were also sampled.

Fourteen of the 15 polygons had dwarf mistletoe in the transect. The average incidence (based on area) was 66%. The dwarf mistletoe rating for layer 1 and layer 3 trees was 1.6 and 1.4 respectively. The average basal area was 6.5 m<sup>2</sup>/ha compared to 17.9 m<sup>2</sup>/ha predicted by VRI. If you assume that the rating will go up by one class every 15 years the expected dwarf mistletoe rating of the stands at rotation will be significantly higher than the current mistletoe rating in the residual layer 1 trees.

## 8. Pests of young pine stands: comandra blister rust

Leo Rankin, Forest Entomologist, Cariboo Region  
Joan Westfall, Forest Health Consultant, EntoPath Management Ltd.  
Julie Brooks, Forest Health Consultant, Forest Health Management

Nineteen permanent sample plots (PSP) were established to gather information on incidence, impact and movement of forest health factors within young lodgepole pine stands in the Cariboo Region, after extensive earlier surveys revealed high pest incidence in many young stands. The plots were established between 1996 and 1999 in several biogeoclimatic subzones. Each PSP had a specific forest health focus including weevils, rusts, needle and root diseases, and animal damage. The PSPs have been re-assessed several times. As the trees have aged, damaging agents of older pine such as *Atropellis* canker and mountain pine beetle have become important in several plots. When the data from these plots were compiled by specific damaging agent, several interesting observations were noted; particularly for comandra blister rust (*Cronartium comandrae*).

In this project, two PSPs were specifically established to study the effects of comandra blister rust (DSC). Within these plots, there has been considerable ongoing mortality due to DSC. In other permanent sample plots with lower initial DSC levels, ingress has mostly replaced the trees which have died due to DSC and stand density has been maintained, with a possible regeneration delay.

However, in the DSC PSPs, even the infill has been susceptible to comandra. Younger, smaller trees are most susceptible and less time is needed for cankers to completely encircle the stem. Based on DBH measurements of all plot trees at the last assessment, there was a significant difference between the trees which succumbed to DSC and those that survived (Table 9).

In most DSC-affected plots, the pattern of infection has changed since plot establishment (Figure 21). In the eight years between establishment and most recent assessment, branch infections have decreased substantially, due primarily to the movement of many branch infections into the stem, with less active branch infections dying. Stem infections encircling <50% of the stem varied to a minor extent, as branch infections moved into the stem or minor stem infections moved to encircle the tree (>50% encircling). Infections encircling <50% of the tree are expected to decline in the future as new branch infections decrease. The vast majority of infections are >50% encircling, and most (95%) have resulted in tree mortality. A total of 66% of PSP 2 and 60% of PSP 7 trees have succumbed to DSC, with 1,320 sph and 3,320 sph live trees remaining, respectively.

Table 9. Comparison of age and DBH of trees (PI) dead due to comandra blister rust at last assessment vs. live trees (PI) in two permanent sample plots in the Cariboo Region.

Plot No.	Status	N	Average	
			DBH	Age (based on sample trees)
2	Live	165	5.9 - 0.253a	19
	Dead due to DSC	68	3.3 - 0.329b	15
7	Live	193	2.9 - 0.174a	14
	Dead due to DSC	78	0.7 - 0.128b	10



*Comandra blister rust stem infection*

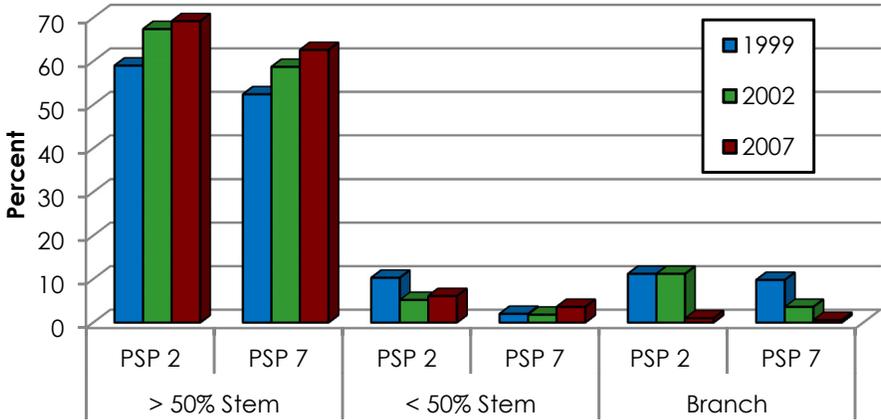


Figure 21. Incidence of comandra blister rust infections in PSP 2 and PSP 7 between 1999 and 2007.

## 9. Pine needle cast trial assessment

Leo Rankin, Forest Entomologist, Cariboo Region

Joan Westfall, Forest Health Consultant, EntoPath Management Ltd.

Julie Brooks, Forest Health Consultant, Forest Health Management

Eight permanent sample plots were established in 1995 to study the incidence and impact of pine needle cast (*Lophodermella concolor*) on young lodgepole pine stands. The plots were located in the Cariboo-Chilcotin District adjacent to Palmer Lake Road. Plots were rectangular and consisted of 100 trees each. The trials were reassessed in 2002 and again in 2008-09. Tree heights, diameter at breast height (DBH) and needle cast intensity was assessed each time, with other forest health factors also recorded in 2002 and 2008-09.

New pine needle cast (DFL) infections have declined at the permanent sample sites since 2003, which marked the end of ten years of high DFL infection rates in the Cariboo-Chilcotin District. Since the 2002 assessment, needle volume loss attributed to DFL has decreased in both incidence and intensity. Despite this, there was significant growth reduction for DFL-infected trees in seven of the eight plots, when the change in height and DBH from 1995 to 2008/09 was analyzed. When change in tree growth was examined for all eight plots together, reductions in the height growth of DFL-infected trees was particularly noticeable. Compared to nil and lightly affected trees, height growth was 20% less for moderately infected trees and 72% less for severely damaged trees. The average change in DBH was less dramatic, with only severely infected trees showing the significant growth reduction of less than half that for trees with lower infection levels (Table 10). There were no significant differences due to stand density and/or biogeoclimatic zones.

Table 10. Average change in height and DBH of live lodgepole pine in 8 *Lophodermella* impacted plots between 1995-2008/09.

DFL Level	N	Avg. change in height (cm) – SE	Avg. change in DBH (cm) – SE
Nil	139	242 – 7.89a	3.8 – 0.179a
Low	308	242 – 6.10a	4.7 – 0.147b
Moderate	241	194 – 6.97b	3.9 – 0.165a
Severe	26	67 – 7.71c	1.8 – 0.243c

All means – SE followed by the same letter are not significantly different ANOVA, Tukey's ( $p>0.05$ )

The incidence of other forest health factors such as Elytroderma needle cast (not observed initially), western gall rust, and lodgepole pine terminal weevil has increased since the last assessment. Therefore, changes in growth attributed to DFL may have been confounded by other pest activity. However, trees attacked by lodgepole pine terminal weevil were significantly larger than non-attacked trees in all plots, indicating a lack of correlation with DFL impact. Although overall incidence of lodgepole pine terminal weevil has increased by 27%, the seriousness of associated defects has decreased substantially since 2002. The impact of western gall rust stem infections on tree growth was not significant.

## 10. Pine stem rust management committees in the Omineca Region

*Richard Reich, Forest Pathologist, Omineca Region*

Pine stem rusts, as a group of forest pathogens, are potentially the most damaging young stand diseases of lodgepole pine in the province. As a result, they are the top priority for management. The new challenges brought by both a changing climate and reduced natural regeneration, which is a result of seed viability loss in older mountain pine beetle killed stands, add to the complexity of managing lodgepole pine. Stem rust management committees are being developed in each district within the Omineca Region to provide a source of guidance and support within the professional reliance framework. The goal is to have an active committee in each district in 2012.

Pioneering work in the Mackenzie District, starting in 2005, demonstrated how valuable the interaction between government and forest licensee professionals can be. The main thrust of the committee involved developing an operational framework for resolving issues, providing training and creating a practical rust management strategy based on local conditions. The initial success of the committee was seen immediately through increased dialogue and exchange of ideas. While the rust management strategy was being forged, field training sessions for silviculture surveyors, and field sessions to discuss operational issues were conducted. The results of these sessions were communicated to management and their support was maintained.

Starting in 2011, a rust management committee was formed in the Vanderhoof District, and subsequently in the Prince George District. Training sessions were held in both districts for silviculture surveyors and for silviculture supervisors to present the district rust management vision and strategy for rust management in order to ensure that surveyors are equipped to collect reliable data. The success of the training sessions will be seen years from now when surveys demonstrate the reliability of the data, as was done in the Mackenzie District. Reliability of the silviculture survey data increased dramatically as a result of annual surveyor training.

Plans for 2012 are to form a committee in the Ft. St. James and Peace Districts, and to conduct annual training sessions for surveyors in each district. The training sessions have three distinct goals: presenting the district rust management strategy, presenting rust hazard maps and resultant district severity ranking data, and operational surveyor training. Presenting this integrated approach demonstrates the value of collecting highly reliable data, and highlights the numerous uses.



*Western gall rust branch infection*

## 11. Pine stem rust maps generated from the RESULTS database

*Richard Reich, Forest Pathologist, Omineca Region*

The distribution and severity of pine stem rusts was mapped using data from the provincial silviculture (RESULTS) database for all plantations in the province. A severity map was created for the central interior rust zone and one for the south east rust zone. This map has a topographic relief background, and displays the rust incidence class. Each of the hard pine stem rusts is presented on a separate map, with a fourth map showing all three rusts combined. In addition to the “regional view” maps, a district scale map is created for use at the district scale.

The “regional view” map shows regional trends such as the elevation trend and local hotspots. District scale maps show more of the local trends and hotspots in enough detail to know exactly where the plantations are located. The amazing feature of these maps, when viewed at these scales, is that they show expected trends even in areas where independently collected data is unavailable.

Independent data was collected for hazard rating purposes in the Mackenzie and Vanderhoof districts, but it also serves as a validation tool. This data shows that the RESULTS database data may be of value, depending on the district. This finding has reinforced the current high priority placed on training rust surveyors.

The data used for the maps was also summarized to create a rust severity ranking at the district level. This severity ranking can be used to prioritize districts for hazard rating surveys, timber supply review emphasis, and silviculture planning.

## 12. Research project: western spruce budworm outbreak history and impacts

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

The western spruce budworm, *Choristoneura occidentalis* Freeman (Lepidoptera: Tortricidae), occurs widely throughout western North America, feeding primarily on Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, and often, on true firs, *Abies* (Fellin 1985). Budworm defoliation causes tree mortality, reduction of growth rates and can increase fire hazard on some sites. Due to the budworm’s preferential feeding on current year’s buds and foliage, height growth is severely reduced or eliminated during years of defoliation. In addition, severe defoliation over several years often causes upper crown mortality, known as top-kill, and may lead to the formation of stem defects (Van Sickle et al. 1983; Alfaro and Maclauchlan 1992). The budworm can have extremely devastating effects on Douglas-fir stands, by reducing overall growth and yield, increasing susceptibility to other insect pests and diseases, and limiting management options.

Historically, the western spruce budworm has occurred in the southern interior around the Thompson/Okanagan (Kamloops) Region with minor outbreaks into the Kootenay Boundary (Nelson) Region (Figure 22). Since the late 1990’s it has increased dramatically in the Cariboo Region (Figure 22) and in 2011 has expanded into historic and new areas of the Kootenay Boundary Region.

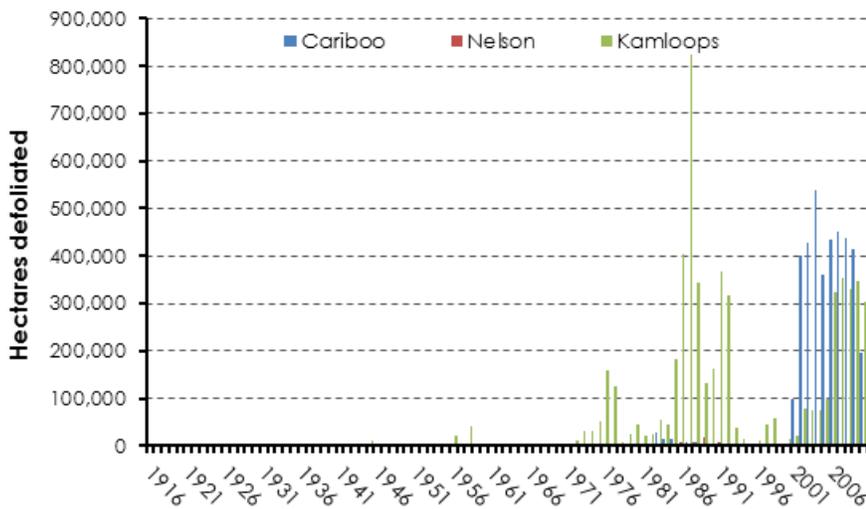


Figure 22. Historic western spruce budworm defoliation as mapped during the aerial overview surveys (CFS and MFLNRO).

This project investigates the history, longevity and intensity of past budworm outbreaks in the expanded range and the resultant impacts are quantified. The *Btk* treatments used in managing the budworm since 1987 are being evaluated to determine return on investment and to examine if these management strategies are transferrable to new outbreak areas in central and northern BC.

A return on investment calculation for western spruce budworm (WSB) was conducted by MFLNRO in 2009 that showed a rate of return of 12-15% on stands that are harvested within 15 years of treatment. This analysis was based on a long history of research and treatments of budworm in the southern interior. It now appears that WSB is expanding its “outbreak range” in both elevation and extent. The current outbreak now extends north into the Quesnel Forest District, well outside the known historic outbreak range. Early indications are that the impact in these new areas is more severe than expected. Additionally, stand composition and structure has changed dramatically over the past decade. First, many stands formed by fire suppression and logging have developed very dense, overstocked understory layers (layer 3 and 4 trees) that are conducive to budworm success. Second, fir-pine mixed species stands where mountain pine beetle has removed most of the lodgepole pine component results in largely Douglas-fir or spruce dominated stands. This scenario offers a new or extended range for budworm. Changing stand structure, composition and density combined with climate change offers a different and often more suitable habitat for western spruce budworm.

The objectives of this project are twofold:

Quantify the expansion and impact of the budworm complex in the south and north-central interior; and determine the tree and stand response to direct control (spraying with *Btk*). By achieving these objectives we will be able to refine the criteria required for investment decisions for treatment programs. To date, we have re-defined the geographic outbreak areas for budworm in BC and updated the spatial overlay analysis. A total of 24 existing growth and yield plots have been re-measured and 11 new plots established. Increment cores have been collected and analyzed for all plots. In addition, 461 3.99 m circular plots have been assessed in seven geographic locations.



Western spruce budworm larva

### 13. Root disease control trial 1991- 2011: some preliminary findings

*Michael Murray, Forest Pathologist, Kootenay/Boundary Region*

Root rot, especially *Armillaria ostoyae*, causes significant mortality of plantation trees, affecting most biogeoclimatic zones in the southern interior of BC. Removal of stumps from the ground has been considered an effective treatment for reducing disease spread associated with planted trees. However, evaluation of the longer-term effectiveness of post-harvest stump treatments is lacking. The Knappen Creek Root Disease Trial, near Grand Forks, is one of the earliest established *Armillaria* trials in BC. After harvesting in 1989, the 30-hectare study site was divided into five treatment sub-units: 1) stump removal & root raking; 2) stump removal only; 3) planting one meter away from stumps/major roots, and; 4) planting (no other treatments). An additional fifth unit is provided by a patch of unharvested forest. These distinct treatments provide an excellent opportunity to compare the effects of stumping on *Armillaria* root disease as expressed in the regenerating cohort of trees which were planted in 1991 (mostly lodgepole pine, Douglas-fir, and western larch).

During the autumn of 2011, all 20 original plots were re-located and about 3,000 permanently tagged trees were re-assessed for growth and forest health. A previous re-survey was conducted in 1997.

Preliminary findings indicate a noticeable difference in incidence of *Armillaria* between the treatments. In the stump removal treatment, 6.7% of trees had signs of *Armillaria*, whereas 17.0% of trees in the stump & root retention area had the disease (Table 11). The percent of dead trees within each treatment reflected similar occurrences with 7.6% and 16.8% respectively. We examined all dead trees for signs of *Armillaria* and found signs of mycelial fans on 62.5% of these trees. The actual incidence was likely higher, but mycelial fan imprints disappear with natural degradation of woody tissue over time. An unexpected finding relates to the two stump removal treatments where results indicate more root disease associated with stumping followed by root raking. This is counter to the expectation of lower disease incidence wherever more inoculum sources (roots and stumps) are removed. This may be a reflection of higher incidence of root rot in the vicinity of the root-raked plots found during trial establishment. Differences in tree growth (height and diameter) as a reflection of treatment are not as evident, with a slightly better overall growth where stumps were removed.

Further analyses are being conducted to compare responses between different tree species. Comparisons between 1997 and 2011 are also being performed.

Table 11. Measured observations within each root disease treatment block.

Treatment (location in harvest unit)	Live and Dead Trees with <i>Armillaria</i> (%)	Average Growth (height / dbh)	Dead Trees (%)
Stumps removed (NE)	6.7	9.7 m / 9.1 cm	7.6
Stumps removed + roots raked (SE)	9.7	9.2 m / 9.4 cm	9.6
Stumps retained + seedlings planted 1.5m from all stumps and large roots (SW)	12.2	8.0 m / 7.8 cm	12.7
Stump & roots retained (NW)	17.0	9.3 m / 9.0 cm	16.8

## 14. Top dieback of lodgepole pine in central BC

*Alex Woods, Forest Pathologist, Skeena Region*

In mid-summer of 2011 staff in Nadina District were preparing to initiate an aerial fertilization program. The field staff noticed that the stands they were intending to fertilize were suffering leader dieback. The damage seemed to progress quickly over several weeks. The tops of 25-35 year old lodgepole pine were suffering as much as 2-3m top dieback. The Canadian Forest Service was sent samples and they identified the weak pathogen *Cenangium ferruginosum*. According to Sinclair and Lyon 2nd ed., *Cenangium ferruginosum* is common after drought or after an unusually cold winter, especially if a severe winter is preceded by an unusually mild autumn. The summer of 2010 was particularly dry throughout BC and in November of 2010 temperature in Burns Lake BC went from a high of +11C to a low of -29C over a period of 4 days. This could be another unpredictable forest disease condition linked to an erratic weather pattern.



Top dieback on young lodgepole pine tree

## 15. Vanderhoof District hard pine stem rust hazard rating surveys

*Richard Reich, Forest Pathologist, Omineca Region*

Hazard rating surveys were initially conducted for pine stem rusts of young lodgepole pine stands in the years 1999 to 2001 in the Vanderhoof District. The purpose was to determine if key predictive variables exist that can be used to predict high risk sites. The initial results indicated that the Vanderhoof District was generally a low risk district, and that the RESULTS database contained reasonably accurate data for this district. In 2011, 43 additional stands were surveyed to increase the number of sample stands belonging to specific site series of certain biogeoclimatic subzone/variants. The surveys were conducted during the rust sporulation period and included the collection of major site factors, ecological classification, and alternate host abundance. Factors collected at the plot level included elevation, aspect, slope, mesoslope position, biogeoclimatic site series, soil moisture regime, soil nutrient regime, and soil characteristics relating to the alternate host. Also collected at the plot level was the abundance of *Geocaulon lividum*, (the alternate host for comandra blister rust), and abundance of *Rhianthus minor*, *Castilleja miniata*, and *Melanpyrum lineare*, (alternate hosts for stalactiform blister rust). The data will be analyzed this winter to create a hazard rating to guide silviculture prescriptions in the Vanderhoof District. The data will also be used to independently verify the reliability of the rust survey data submitted by licensees at the free growing declaration stage.

# FOREST HEALTH PRESENTATIONS

## A century of outbreaks: tracking the western spruce budworm in BC

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

### **Venue:**

Entomological Society of BC AGM, Abbotsford, BC, October 14, 2011.

### **Abstract:**

The story of western spruce budworm in British Columbia reflects the changing climatic and human patterns observed this past century in Douglas-fir dominated forest environments. WSB has less predictable population fluctuations than other defoliating insects, with outbreaks lasting several years or collapsing after only one to two years. Based upon analysis of stand structure, geographic and topographic features, ecosystems and defoliation history, twelve distinct outbreak regions have been defined. Within these geographic outbreak regions the periodicity of budworm outbreaks is described. BC has records of budworm outbreaks going back to 1909 that help illustrate population fluctuations. The first recorded outbreaks occurred on Vancouver Island in the early 1990's yet no outbreaks have since occurred on the island. Thomson and Benton (2007) attribute the cessation of WSB outbreaks on Vancouver Island as possibly due to warming sea temperatures that promote early larval emergence and thus poor synchrony between insect and host tree. Since the 1930's all WSB outbreaks have occurred in the interior of BC. The Coast region has experienced very regular, periodic budworm outbreaks since 1940 but the scale of outbreaks has decreased over the past two outbreak cycles. The dry canyon forests near Lillooet have the longest and most regular, chronic, outbreak cycles with five distinct outbreaks in the past century. Each outbreak ranged from a few thousand, to over a hundred thousand hectares of annual defoliation. Although budworm can occur in most Douglas-fir dominated ecosystems, there are still some areas where there appears to be no history of WSB outbreaks.

Budworm is present at low levels in most susceptible forest types. However these insect populations may or may not be able to reach what we define as outbreak proportions unless certain stand conditions are met or some biological or physiological triggers occur. In 2006 Maclauchlan *et al.* reported that there were large areas of susceptible forest type in south and central BC, such as the Cariboo-Chilcotin, where WSB had never reached outbreak levels. The Thompson Okanagan has seen large, often sustained outbreak periods, but these have all occurred within the past three decades. Prior to the 1970's the budworm seldom reached outbreak levels in this region.

Budworm was first mapped in the Cariboo Region in 1974 but only over a small area and no outbreaks were recorded until the late 1990's. Once the budworm population expanded it spread rapidly, mingling with existing endemic populations throughout the Cariboo-Chilcotin. The Cariboo budworm outbreak is one of the largest and most sustained outbreaks ever recorded in BC. The most recent chapter in the budworm saga now has populations expanding north between Williams Lake and Quesnel and into the Kootenay/ Boundary Region in southern BC. The Quesnel outbreak marks the most northern outbreak yet recorded. Similarly, outbreak populations built in the Princeton and Merritt areas in the past decade where historically there also had been little or no records of outbreak level populations.

The WSB is reacting to our changing climate and increasingly favourable and available host resource. Current budworm outbreaks are distinguished by their expansion into higher elevations and new territory. This change in outbreak dynamics is a response by the insect to milder, more suitable climatic conditions, altered stand conditions and forests that have little inherent resistance to this insect. As the climate warms, budworm may continue to expand in range toward the limit of its primary host, Douglas-fir.



*Western spruce budworm expansion into the ICH Biogeoclimatic Zone west of Revelstoke, where not historically mapped before*

Maclauchlan, L.E., J.E. Brooks and J.C.

Hodge. 2006. Analysis of historic western spruce budworm defoliation in south central British Columbia. *For. Ecol. Manage.* 226: 351-356.

Thomson, A.J. and R.A. Benton. 2007. A 90-year sea warming trend explains outbreak patterns of western spruce budworm on Vancouver Island. *The Forestry Chronicle* 83(6): 867-869.

### **Blister rust: updates and actions**

*Michael Murray, Forest Pathologist, Kootenay/Boundary Region*

#### **Venue:**

Whitebark Pine Symposium, Lillooet, BC, July 14-15, 2011.

#### **Abstract:**

Blister rust is widespread. Recent findings from 20-40 year old plantations with mixed species indicate it is the leading forest health agent (behind animal damage) among all trees, even though it was only found on white pine. In the Kootenays at higher elevations, whitebark pine replaces white pine in abundance. Infection of whitebark pine is commonly over 70% and in some places is greater than 90%. Blister rust screening for whitebark pine, similar to successful efforts for western white pine, is warranted. The USA has screened more than a thousand whitebark pine parent trees resulting in more than 60 trees being designated as resistant. Such efforts are beginning in BC with 40 candidate trees selected in the West Kootenays.

## **Climate change and forest diseases; the role of forests in climate regulation and our role as Forest Pathologists**

*Alex Woods, Forest Pathologist, Skeena Region*

### **Venue:**

Western International Forest Disease Work Conference (WIFDWC) Leavenworth, Washington, October 10-14, 2011.

### **Abstract:**

Forests cover about 1/3 of the planet but have been reduced by 40% in the last 300 years. Forests have a wealth of ecological and socio-economic functions such as water and soil conservation, food, wood, fuel, fibre and of course carbon storage. The importance of the resources increases with a growing population. The interaction between atmosphere, climate and forest is a key issue. Pathogens, insects and wildfire can have huge effects on forest landscapes and are all strongly affected by climate.

The slow temporal adaptation characteristics of forests make them vulnerable to fast climatic changes and risk factors such as diseases. Thousands of hectares have already been killed by new disease problems in Canada where climatic factors such as precipitation and temperature play a major role. Trends are well documented. Large scale degradation of forests due to diseases occurs frequently.

In the tropics primary production is directly affected by temperature and a positive feedback loop may provoke further negative effects.

For about ten major forest diseases negative impacts of climate change can be predicted with low to medium levels of uncertainty. For some other diseases, problems may become less severe. However, much is still unknown. Maladaptation of forests to climate change makes them even more vulnerable to climate change than agricultural systems.

## **Climate change, forest health and the future of whitebark pine**

*Michael Murray, Forest Pathologist, Kootenay/Boundary Region*

### **Venue:**

Webinar, Online Silviculture Dialogue Series, FORREX, December 14, 2011

### **Abstract:**

The ecologically valuable and increasingly threatened whitebark pine can be retained and promoted with appropriate silvicultural techniques. Whitebark pine is especially vulnerable in the mixed conifer zone (often closed-canopy, acute competition, and high fire hazard). Silvicultural options include harvesting competing species and promoting whitebark pine with group retention and wildlife tree reserves. Blister rust canker-free trees are especially valuable for promoting disease resistance and should be retained. Burning must be very carefully applied. Designating whitebark pine as an acceptable species for the regeneration of harvest units is also recommended.

## Forest health fitness: moving beyond the beetle

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

### **Venue:**

ABC FP Annual General meeting, Vancouver, BC, February 24, 2011

### **Abstract:**

Two lines in the *Forest Act* confer a heavy responsibility to foresters and should have far reaching implications on how we approach the health of our forests and their management. The first responsibility is to encourage the maximum productivity of the forest and range resources; the second is to manage, protect and conserve the forest and range resources of the government, having regard to the immediate and long term economic and social benefits they may confer on British Columbia. However, given that BC has experienced the largest mountain pine beetle outbreak on record, have we learned from this and embraced managing from a landscape level and working together toward a common goal? Insects are complex animals and are influenced by many biological and physical parameters. The “usual culprits” are going in or out of outbreak mode – but the outbreaks are growing in size and changing or expanding their range.

This presentation focused on how scientifically based hazard and risk rating systems can provide a more stable planning framework with reduced risk to silviculture investment by: increasing the success of regeneration practices; increasing the productivity of immature stands; and, decreasing losses of mature timber. Existing hazard and risk rating systems for mountain pine beetle, western spruce budworm and spruce weevil are used for planning harvest, stocking standards and control programs such as aerial spraying for defoliators. Developing these systems for other insects or diseases requires risk analysis of new habitats, addressing some of the following points:

- Possible new or expanding geographic ranges for tree and insect species
- Changing or different climatic envelopes at different times in the future (means and extremes)

The best recommendation - manage for complexity and use the knowledge gained from the analysis of historic outbreaks, forest types, geo-physical and biological parameters to better guide future management and treatment decisions.

## Forest health update – the advance and decline of outbreaks

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

### **Venue:**

SISCO, Penticton, BC, April 4<sup>th</sup>, 2011

### **Abstract:**

Twenty-six damaging agents causing 1.7 million hectares of visible damage, ranging from tree mortality to light defoliation, was mapped in the southern interior’s 2010 aerial overview survey. This does not take into consideration pest impacts that are not visible from the air such as western gall rust, dwarf mistletoe, weevils and various root diseases to name a few. Many of these pest impacts are overlapping in distribution and even occur within the same stand or on the same tree, resulting in “cumulative impacts”.

The area affected by mountain pine beetle in the southern interior declined by 76% in 2010, to 558,118 hectares. This represents the most drastic decline in BC due to the severe host depletion in the Quesnel and Cariboo areas. Douglas-fir beetle also declined substantially in 2010 to only 10,860 hectares mapped, due largely to the population collapse across most of the Cariboo-Chilcotin. Spruce beetle increased in the Cariboo, yet declined in the south, to 29,922 ha mapped in 2010. Western balsam bark beetle continued to cause widespread mortality across most high elevation areas with 183,167 ha affected in 2010. Reduced damage levels from western spruce budworm were noticed across much of the Cariboo-Chilcotin, 100 Mile House and Okanagan Shuswap Districts with just under 500,000 ha of defoliation. Budworm populations expanded in the Thompson Rivers and Quesnel Districts. Quesnel represents a new and expanded range for budworm. After three years of outbreak, the Douglas-fir tussock moth appears to have peaked in 2010. The area defoliated in 2010 changed little from 2009 at 16,303 ha affected. This outbreak is now the largest on record in BC, with 36,500 ha of defoliation mapped since 2007, compared the 1981-1984 outbreak that resulted in 31,844 ha of defoliation. Aerial spraying was conducted in 2008-2010 without which the outbreak would have been more extensive. The other most prevalent and damaging pests were two-year cycle budworm (70,694 ha), aspen (serpentine) leaf miner (67,282 ha) and forest tent caterpillar (37,844 ha).

One option to assist in the early prediction and detection of outbreaks or pest damage is the use of hazard and risk rating. Hazard and risk ratings are currently being updated for two of the major insect defoliators, western spruce budworm and Douglas-fir tussock moth, using almost 100 years of spatial overview data, climate and biological parameters.



AT 802 Air Tractors spraying for western spruce budworm control

## **FREP stand development monitoring (SDM): Is this what we planned for?**

*Alex Woods, Forest Pathologist, Skeena Region*

### **Venue:**

Coastal Silviculture Committee, Nanaimo, BC, February 22, 2011

### **Abstract:**

The Stand Development Monitoring (SDM) protocol is designed to provide the Ministry of Forests, Lands and Natural Resource Operations 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. The FREP SDM protocol 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. SDM (as with other FREP assessments) will also help inform resource management professionals of the results of current and past management practices and policies. This enhances the knowledge base on which professional advice and accountability are based and can help guide policy makers and on-the-ground natural resource professionals with providing professional advice and balancing social, environmental and economic values in the interest of British Columbians.

A central aspect of SDM involves a comparison of the species composition from the free-growing declaration inventory label to the current species composition. This presentation will include a discussion of findings to date from five intensive studies, including the Strathcona TSA, as well as recently completed SDM pilots from the BC Interior. An emphasis will be placed on species composition and changes in leading species where they have occurred. The implications of such changes in leading species and the role that they may have in timber supply forecasting will also be discussed. The FREP SDM protocol is currently fully implemented throughout the province.

## **Hard pine stem rust hazard rating and its uses in British Columbia**

*Richard Reich, Forest Pathologist, Omineca Region*

### **Venue:**

Western International Forest Disease Work Conference, Leavenworth, Washington, October 10-14, 2011

### **Abstract:**

Hazard ratings for forest pathogens are relatively uncommon, and even more uncommon for pine stem rusts. Predicting future stand risk to hard pine stem rusts is critical to maintaining lodgepole pine productivity in British Columbia. The purpose of this project is to develop a hazard rating for hard pine stem rusts in BC. The project itself is designed to determine the value of key predictive variables in modelling risk to rust infection. The study design utilized an empirical approach to test a wide range of variables since the key factors influencing rust risk are currently unknown. A second major purpose is to evaluate the potential for using this hazard rating data to independently verify the reliability of the rust incidence contained in the provincial silviculture database (RESULTS). Preliminary spatial examination of the RESULTS rust incidence data, using severity rating colour-theming on a relief backdrop map, indicates a good correspondence with the spatial patterns expected from the independent hazard rating data. Hazard rating surveys provide valuable insight into future stand risk and reveal relationships with high risk sites. Expanding the rust identification training for silviculture surveyors to all high risk districts will help to increase the reliability of the corporate database. Additionally, expanding the hazard rating process to other districts will provide independent verification for the use of the RESULTS data for an expanded area. These tools are being incorporated into district rust management strategies.

## Hazard and risk rating of defoliators in BC

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

**Venue:**

SERG International, Victoria, BC, February 6, 2011

**Abstract:**

A hazard and risk rating project is underway for two defoliating insects in BC: the western spruce budworm and Douglas-fir tussock moth. A hazard/risk rating system will allow managers to better understand range dynamics of these two insects and identify substantial changes in range or impacts cause by these two defoliators. The project has elucidated the outbreak periodicity and duration of all mapped defoliation cycles in BC and re-defined 12 geographic outbreak areas within the province. This spatial analysis will help outline and highlight changes over time and will allow for better insight into the current and potential climatic and ecological ranges of these insects.

## Park operations for protecting whitebark pine

*Michael Murray, Forest Pathologist, Kootenay/Boundary Region*

**Venue:**

BC Protected Areas Research Forum, UBC, Vancouver, BC, December 6-8<sup>th</sup>, 2011

**Abstract:**

Science-derived knowledge of whitebark pine dynamics has prospered yet the species declines in abundance primarily due to forest health factors. Parks have a key role in protecting and restoring whitebark pine. Based on recent and emerging studies plus operational experience, we can implement numerous measures. Briefly illustrated topics include enhancing tree resistance to disease and insects, careful fire management, restorative plantings, and prioritization. A list of useful resources for informed planning and implementation was offered.

## Pine stem rust strategy development

*Richard Reich, Forest Pathologist, Omineca Region*

**Venue:**

Northern Silviculture Committee Summer Workshop, Mackenzie, BC, June 15-16, 2011

**Abstract:**

The purpose of this field session was to enable participants to develop practical pathogen recognition and detection skills, as well as to gain a broader perspective of the utility of a hard pine stem rust hazard rating to predict high risk sites. A three step process was presented that outlined the various sources of information that can be evaluated to determine future stand risk. This process was based on the draft Vanderhoof Rust Management Strategy. Recently created regional and district scale rust maps were presented and discussed. These maps provide a spatial perspective of the pine stem rust management issue in BC. Ranking of the severity of rust incidence by rust

category was presented at a district level based on data contained in the provincial silviculture (RESULTS) database. The Mackenzie District was ranked as having the highest collective hard pine stem rust severity in the province.

The field exercise portion of this stop provided hands on experience for identification of each rust pathogen using the standard silviculture survey methodology for collecting this information. The exercise involved dividing the approximately 70 participants into 10 groups in order to assess 10 pre-established plots, and then compare their results with that of the trainers. The combined rust incidence for the stand was 94%, which worked well for the training exercise and for the discussion regarding the value of having a hazard rating system for the Mackenzie District.

### **Post free growing – still free growing?**

*Alex Woods, Forest Pathologist, Skeena Region*

**Venue:**

Northern Silviculture Committee Summer Field Tour, Mackenzie, BC, June 15<sup>th</sup>, 2011

**Abstract:**

The objectives of Stand Development Monitoring (SDM) are:

- To look back at previous stand condition as determined at prior silviculture survey and see if stands are on assumed growth trajectories.
- To determine current yield in a manner that can be compared to G&Y model projections.
- To quantify species specific impacts due to damaging agents.

Sam Davis, Ken White, Erin Havard and I surveyed a spruce/balsam stand from the SDM random list for the Mackenzie TSA to determine whether or not it was following the assumed trajectory based on the stand's earlier silviculture survey. We found that the selected stand was performing considerably better than *Table Interpolation Program for Stand Yields* (TIPSY) forecasts that were based on the prior silviculture survey input data. We tallied the number of trees by layer (Layer 1 >12.5 cm dbh, Layer 2 7.5 – 12.5 cm dbh and Layer 3 < 7.5 cm dbh but > 1.5 m tall). TIPSY forecast that the 28 year old Sx leading stand should contain 517 layer 2 trees/ha and 55 Layer 1 /ha while we found 1520 Layer 2 and 380 Layer 1 trees per ha in our SDM survey. Spruce leading stands may be more productive than modelled in TIPSY. The results of this demonstration helped initiate a Forests For Tomorrow funded project to survey 30 randomly selected even-aged stands aged 15-40 from the Mackenzie TSA. The results of this project may inform the current Mackenzie TSA Timber Supply Review.

### **Pine stem rust management strategies**

*Richard Reich, Forest Pathologist, Omineca Region*

**Venue:**

Northern Silviculture Committee Winter Workshop, Prince George, BC, Feb 15-16, 2011

**Abstract:**

The purpose of the Pine Stem Rust Management Strategy in the Omineca Region is to guide the development of a multifaceted approach to minimizing and avoiding losses to pine stem rusts in

high risk zones. The 6 major pillars of the strategy integrate the major elements of forest resource stewardship. The pillars are:

- 1) District rust management committee
- 2) District rust management strategy development
- 3) Hazard and risk rating
- 4) Operational control
- 5) Timber Supply Review (TSR) impacts
- 6) Filling key knowledge gaps

We are learning that one of the keys to effective rust management is a coordinated and comprehensive approach which involves the major stakeholders through a management committee. This ensures accountability and also enables stakeholder interaction and the development of a coordinated approach. One of the most important elements of the strategy is to develop the hazard and risk rating system in order to quantify pine stem rust risk locally. This then informs the prescription stage. Examples were provided of research filling key knowledge gaps and informing the rust management strategy.

## **Update on forest health in BC**

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

### **Venue:**

National Forest Pest Management Forum, Ottawa, Ontario, December 6, 2011

### **Abstract:**

There was excellent aerial overview survey coverage in BC this year except in the North-west where the weather was awful for nearly the entire summer. The highest priority areas were flown but the remaining half of the Skeena Region could not be surveyed. There are a number of tree-killing bark beetle species in BC with the top three being mountain pine beetle, spruce beetle and Douglas-fir beetle. Mountain pine beetle continues to decline with 4.6 million hectares affected (compared to 6.2 million in 2010). The bulk of the activity is in the north where the most severe damage is occurring. Treatment efforts are now only focussed on protecting currently undamaged valleys in the southeast of BC where we are not seeing huge increases in attack due to the topography and uneven distribution of susceptible pine. As of 2010, mountain pine beetle has impacted 17.5 million ha of mature forests (>60 years of age) in BC. This represents 18% of BC's total 95 million ha land area, about a third of the 55 million ha area of forested land in BC, and about half of the 37 million ha of forest land in the interior of the province. The mountain pine beetle has impacted about 9.9 million hectares of the timber harvesting land base (THLB) representing about 45% of the total 22 million hectare THLB area in BC. We estimate that 51% of the pine volume has been killed and by the end of the outbreak, about 61% will be dead. Other predominant pests include the western spruce budworm and many other defoliating insects and pathogens.

## Yellow-Cedar Decline

*Stefan Zeglen, Forest Pathologist, Coast Area*

**Venue:**

National Forest Pest Management Forum, Ottawa, Ontario, December 7<sup>th</sup>, 2011

**Abstract:**

For almost 30 years researchers in Alaska, and more recently British Columbia, have tried to decipher why vast areas of yellow-cedar have declined and died and continue to do so. Yellow-cedar is cultural, ecologically and economically vital to the Pacific Northwest of North America. Various research projects have defined the extent of decline throughout the northern range of yellow-cedar distribution, the longevity of the decline, and hypothesized a model to describe why it occurs. A synopsis of the historical research that got us to this point, and a description of current work including testing the decline hypothesis, creating a hazard model for yellow-cedar stands, and assessing the ecological impacts of dead yellow-cedar in ecosystems, was presented.

## FOREST HEALTH MEETINGS

### 2012 Western Forest Insect Work Conference

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

**Venue:**

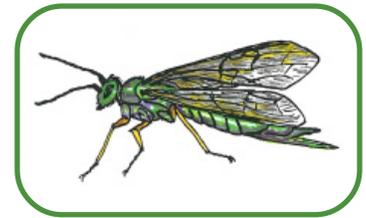
WFIWC, Penticton, BC, March 26-29, 2012

**Summary:**

The 2012 Western Forest Insect Work Conference (WFIWC) is being hosted by BC entomologists this year in Penticton, BC. The work conference will be held at the Penticton Lakeside Resort, March 26-29, 2012. The 2012 WFIWC theme is "Cumulative Effects of Insect Outbreaks". This is an international event where forest entomologists from the western United States (including Alaska), Canada and Mexico get together to share and discuss the most recent research findings, trends across the Pacific Northwest and operational experiences.

There will be two Plenary Sessions on topical subjects such as climate change, outbreak dynamics and cumulative effects. There are four workshop sessions planned with three to four concurrent workshops in each session. Workshop topics are diverse, ranging from "Unusual/up and coming issues: Declines and other insect observations" and "Spatial dynamics of outbreaking bark beetles"; to, "Forest Health Condition Reports". A special graduate student session has been organized plus there are two Founders Award presentations this year. A choice of two field trips plus numerous social and "fun" events are planned.

For more information and registration details please visit the WFIWC web site:  
<http://www.fsl.orst.edu/wfiwc/>.



Adult Sirex wood wasp

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Data and project information:

Resource Practices Branch -

Harry Kope, Provincial Forest Pathologist

Kootenay-Boundary Region -

Jennifer Burleigh, Provincial Forest Entomologist

Art Stock, Forest Entomologist

Thompson-Okanagan Region -

Michael Murray, Forest Pathologist

Lorraine Maclauchlan, Forest Entomologist

Cariboo Region -

Kevin Buxton, Forest Health Specialist

Ominica Region -

Leo Rankin, Forest Entomologist

Robert Hodgkinson, Forest Entomologist

Skeena Region -

Richard Reich, Forest Pathologist

Ken White, Forest Entomologist

Coast Regions -

Alex Woods, Forest Pathologist

Stefan Zeglen, Forest Pathologist

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In Memory of Marc Crozier, Trek Aerial Surveys

Photographs:

Alex Woods (top dieback lodgepole pine)  
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Alex Woods (alder decline)  
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