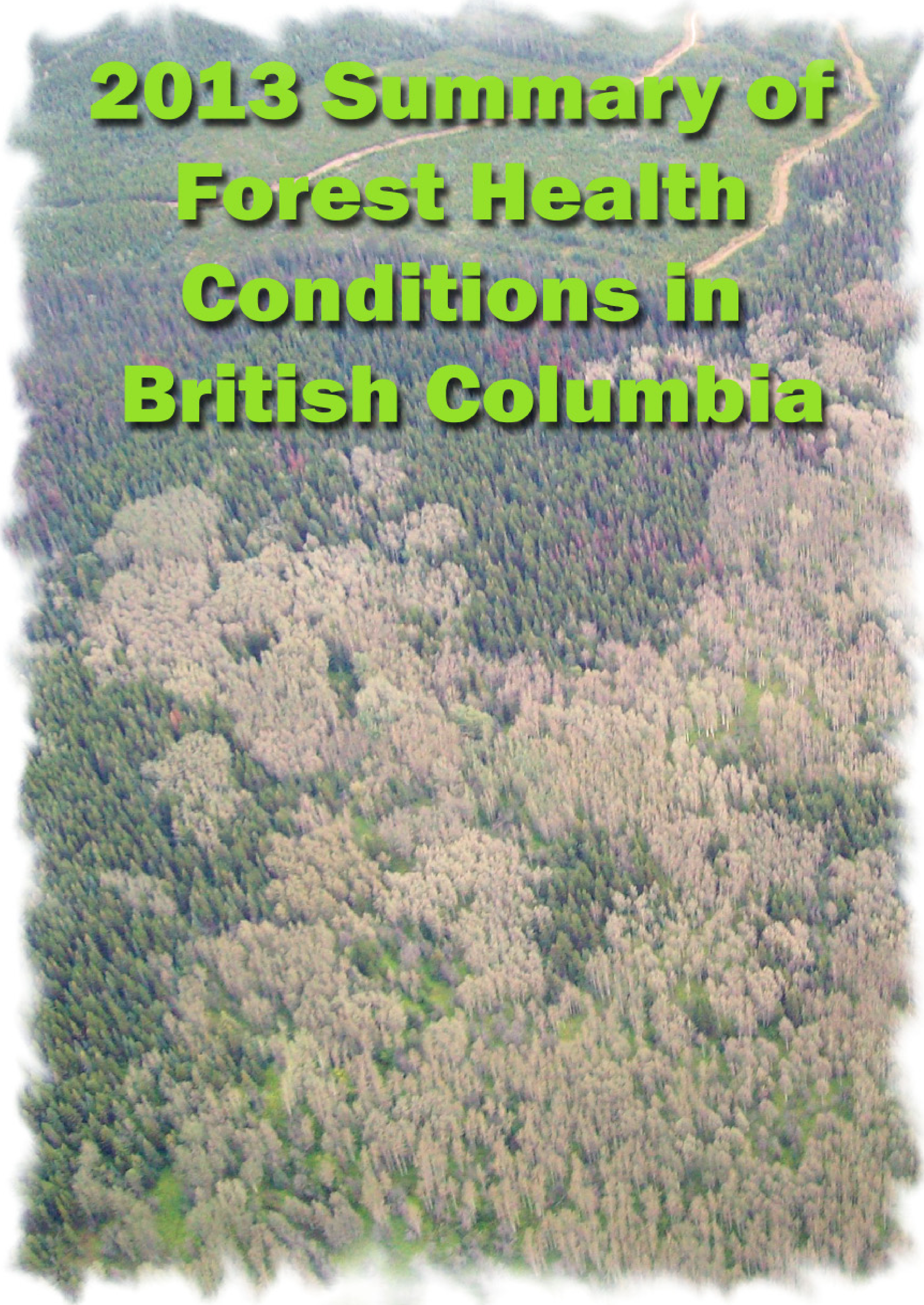
2013 Summary of Forest Health Conditions in British Columbia



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Front cover photo by Sean McLean: Serpentine leaf miner, venturia blight and mountain pine beetle damage near Smithers

2013 Summary of Forest Health Conditions In British Columbia

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Summary

The *2013 Summary of Forest Health Conditions in British Columbia* (BC) is a compilation of forest health information gathered during 2013 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. Additional information is collected from insect population assessments, detailed surveys and ground observations of trained personnel. Summaries of special projects, meetings, presentations and publications conducted by MFLNRO entomologists, pathologists and their associates in 2013 are also included.

An estimated 92% of the province was flown in 2013, resulting in 8.7 million hectares (ha) of damage caused by a wide variety of forest health agents recorded on forested lands in BC. Bark beetles continued to be the lead damaging agent. The current mountain pine beetle outbreak continued to decline to just under 3 million ha of mortality, with minor expansions occurring in northeast and southeast portions of the province. Although mortality continued to be rated as trace, western balsam bark beetle damage doubled for the 2nd consecutive year to 1.3 million ha. Spruce beetle infestations however decreased by more than half since 2012 to 18,694 ha. Douglas-fir beetle attack was down by half as well, accounting for 10,360 ha of dispersed damage throughout the host species.

Deciduous defoliators continued to be abundant. Aspen leaf miner defoliation grew to a record 2.6 million hectares affected throughout the province, with northern BC sustaining the largest and most intense infestations. The current forest tent caterpillar outbreak expanded this year to a peak of 581,932 ha, primarily in the Prince George TSA with some expansions into neighbouring TSAs. Minor infestations of large aspen tortrix in the northern interior and birch leaf miner in the southern interior affected 2,184 ha and 1,415 ha, respectively.

Three conifer budworms continued to cause notable defoliation in 2013. Although western spruce budworm damage was still substantial, area affected was down for the second consecutive year to 128,038 ha in southern BC. High value stands at risk of moderate to severe defoliation in 2013 were successfully treated with the biological insecticide *Bacillus thuringiensis* var. *kurskaki* (Btk). A total of 76,884 ha were treated in the Thompson/Okanagan and Cariboo Regions combined. Two-year cycle budworm infestations rose slightly over last year to 88,760 ha with all the damage occurring in the southern interior where the cycle is in its low year. In the northern interior, no discernable damage was recorded indicating the outbreak collapsed. The western blackheaded budworm outbreak in the West Coast Region subsided slightly to 30,700 ha, with the majority of the damage continuing to be observed in the Kingcome TSA.

The current western hemlock looper outbreak peaked last year with a typically sharp decline to only 841 ha of damage in the Kootenay/Boundary Region in 2013 and a further 1,094 ha of cumulative old defoliation resulting in mortality mapped in the Williams Lake TSA. Results from population assessments concurred that this outbreak is now over.

Damage from diseases that were discernable from the height of the aerial overview surveys continued to be dominated by Venturia blight, with a new record of 837,586 ha recorded in 2013. Damage was particularly extensive and intense in the northern part of the province. Larch needle blight damage decreased substantially to 6,304 ha, located primarily in the Kootenay/Boundary Region. Other needle blights and casts caused relatively low levels of damage.

A variety of abiotic agents caused damage in 2013, but only a few affected substantial areas. Wildfires damaged 27,291 ha with most of the fires being small and scattered. Mortality in old wildfires caused by a complex of factors was virtually the same as last year with 14,696 ha affected. Yellow cedar decline disturbances were recorded on 18,667 ha in the coastal TSAs. Aspen decline in the Thompson/Okanagan and Northeast Regions totalled 3,279 ha and Douglas-fir decline was noted for the first time in the Okanagan TSA with 130 ha mapped. Flooding damage was down to 9,143 ha observed in small scattered areas across BC. Windthrow damage decreased as well to 4,230 ha with more than half occurring in the Haida Gwaii TSA.

Other damaging agents such as pine needle sheathminer, lodgepole pine sawfly, slides, white pine blister rust and mechanical/chemical treatments affected localized stands throughout the province.

2013 Summary of Forest Health Conditions in British Columbia

Introduction

A wide variety of tree species grow in British Columbia (BC) and are host to many damaging agents including insects, diseases, animals and abiotic factors. These agents can cause forest disturbances that vary greatly in size, intensity and location from year to year. Hence, an annual aerial overview survey is conducted across all of the forests of BC (regardless of ownership) to assess these disturbances in a cost effective and timely manner. For all commercial tree species, all visible damage is recorded by agent, severity, area and tree species.

For the past seventeen years these surveys have been the responsibility of the BC government. The ministry presently responsible is the BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO). Prior to 2011 results were tabulated in this annual report by forest district, but in recent history district boundaries have experienced several changes. Therefore, to maintain our ability to report on trends the data has since been summarized by Timber Supply Areas (TSAs) as they have relatively fixed boundaries (Figure 1). One anomaly is the accounting of damage occurring within the Pacific and Cascadia TSAs that form small fragmented units within several larger TSAs. These new TSA's data summaries are not represented separately in this report but are incorporated within the larger TSA units they were part of previously.

Information from this annual aerial overview surveys is used by many groups including government agencies, industry, academia and the public for a variety of purposes. These include setting government strategic objectives, directing management and control efforts against damaging agents, providing data for research projects, supporting timber supply analyses, contributing to the database for the National Forest Pest Strategy and providing national indicators for sustainable forest management.

Once the surveys are flown in the summer, the data is digitized, reviewed and collated. Results are presented in this report by individual damaging agents (by host tree species) for the present year, with comparisons where appropriate to previous years. Hectares (ha) of damage as discussed in this report are obtained directly from the aerial overview survey data. Current damage information collected by other methods (such as helicopter and ground assessments) for agents that are not visible during the aerial survey is also discussed but since the methods differ it is not added to the overview database. This supplemental information primarily includes damage caused by diseases. Information from assessments to estimate population levels for specific insects (such as pheromone trapping, egg surveys and tree beatings) is also included when appropriate.

Relevant forest health projects, presentations, meetings and publications conducted by MFLNRO pathologists, entomologists and their collaborators over the last year are documented after the individual damaging agents. This report encapsulates forest health information from a MFLNRO perspective and does not necessarily include activities conducted by other agencies. More detailed forest health information for the Southern Interior Area is available in their annual report at: http://www.for.gov.bc.ca/rsi/ForestHealth/Overview.htm.

TSA Code	TSA Name
Cariboo Region	
TQU	Quesnel Timber Supply Area
TMH	100 Mile House Timber Supply Area
TWL	Williams Lake Timber Supply Area
Kootenay/Boundary Region	
TAR	Arrow Timber Supply Area
TBO	Boundary Timber Supply Area
TCB	Cranbrook Timber Supply Area
TGO	Golden Timber Supply Area
TIN	Invermere Timber Supply Area
TKL	Kootenay Lake Timber Supply Area
TRE	Revelstoke Timber Supply Area
Northeast Region	
TDC	Dawson Creek Timber Supply Area
TFN	Fort Nelson Timber Supply Area
TJO	Fort St. John Timber Supply Area
Omineca Region	
TMK	Mackenzie Timber Supply Area
TPG	Prince George Timber Supply Area
TRV	Robson Valley Timber Supply Area
Skeena Region	
TBU	Bulkley Timber Supply Area
TCA	Cassiar Timber Supply Area
TKI	Kispiox Timber Supply Area
TKM	Kalum Timber Supply Area
TLA	Lakes Timber Supply Area
TMO	Morice Timber Supply Area
TNA	Nass Timber Supply Area
TNC	North Coast Timber Supply Area
South Coast Region	
TFR	Fraser Timber Supply Area
TSC	Sunshine Coast Timber Supply Area
TSO	Soo Timber Supply Area
Thompson/Okanagan Region	
TKA	Kamloops Timber Supply Area
TLI	Lillooet Timber Supply Area
TME	Merritt Timber Supply Area
TOK	Okanagan Timber Supply Area
West Coast Region	
TAS	Arrowsmith Timber Supply Area
THG	Haida Gwaii Timber Supply Area
TKC	Kingcome Timber Supply Area
TMC	Mid Coast Timber Supply Area
TST	Strathcona Timber Supply Area

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

Methods

Aerial observers recording forest health damage

Aerial overview surveys are conducted using small fixed wing aircraft with a team of two experienced observers sitting on opposite sides of the airplane. An additional observer-in-training sometimes sits behind the most experienced surveyor and "shadows" their work. Each MFLNRO region has a minimum of two observers and a plane with a pilot who is familiar with the local terrain. Noted damage is sketched on customized 1:100,000 scale maps (colour Landsat 5 satellite images with additional digital features). After each flight, the individual working maps are collated onto one mylar which is then digitized to obtain the final spatial data. Survey methodology and digitizing standards can be viewed at http://www.for.gov.bc.ca/hfp/ health/overview/methods.htm.

The surveys are conducted when the main forest health factor(s) damage for a given area is most visible, weather conditions permitting. Flights began this year on July 3rd and were completed on September 12th (Table 1). Overall, flying conditions were ideal. The spring weather prior to the survey period was quite wet throughout the province, which helped to keep the fire hazard (and hence summer visibility issues) down. This was followed by a primarily warm and dry summer which extended into September. There were localized wildfires and marine fog in coastal drainages that sometimes impeded visibility but generally conditions were very good for surveying. Total flying time to complete the surveys provincially in 2013 was 695.9 hours, with 25 surveyors and ten aircraft companies involved.

Table 1. Flying hours and survey dates by region for the 2013 provincial aerial overview survey.

Regions	**Flight hours**	**Survey Dates**
Cariboo	106.2	July 22nd – Aug 2nd
Thompson/Okanagan	55.1	July 15th – July 30th
Kootenay/Boundary	98.0	July 22nd – Aug 16th
Omineca & Northeast	226.9	July 15th – Sept 18th
Skeena	113.0	July 3rd – Sept 12th
West & South Coast	96.7	July 24th – Sept 10th
Total	**695.9**	**July 3rd – Sept 18th**

Coverage intensity and survey progress was monitored by recording flight lines with recreational quality Global Positioning Satellite (GPS) receiver units (Figure 2). Survey lines were flown between 700m to 1400m above ground, depending on visibility and terrain. Over fairly flat ground lines were flown 7km to 14km apart, depending on the intensity of mapping activity. In mountainous terrain valley corridors were flown. Intensity of mountain coverage depended on visibility up side drainage from main drainages and local knowledge of the tree line within high drainages. Aircraft speed ranged from 130 to 180 kph depending on wind speed and the extent and variety of damage. All commercial tree species within viewing range of the observers were surveyed for visible damage, regardless of land ownership or tenure.

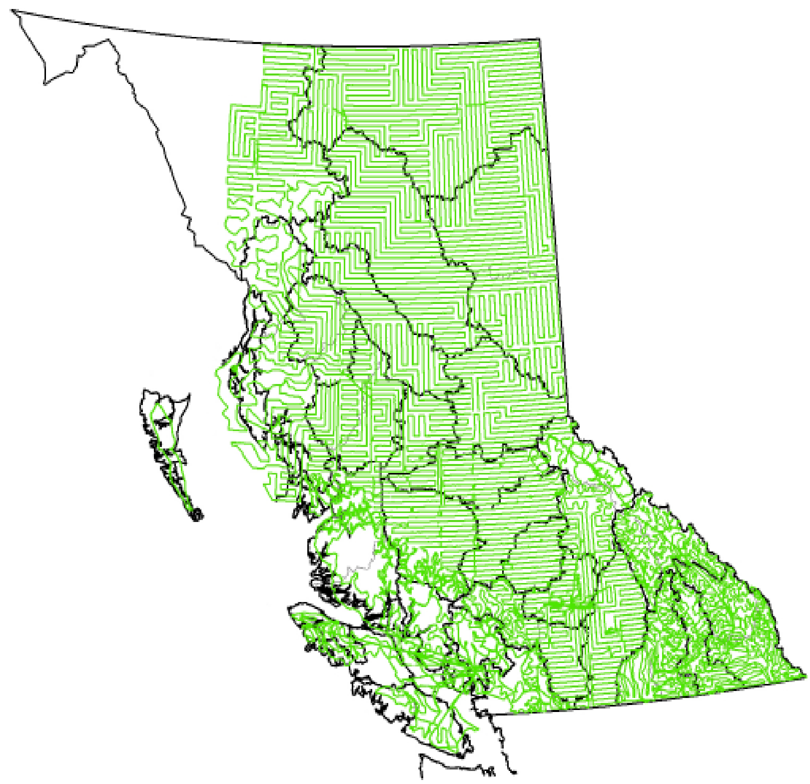


Figure 2. Flight paths flown while conducting the 2013 aerial overview surveys.

The annual goal is to survey all forested land in BC, weather and funding permitting. This goal is difficult to reach within the optimal survey timing window, therefore high priority areas and major drainages in low priority areas (where damage has historically been low) are targeted first. In 2012 all regions were adequately covered, with the exception of the Skeena Region. This year coverage in the Skeena Region improved, with all the priority areas flown. In total an estimated 92% of the province was flown, which is a new aerial overview survey project record. The percentage flown was calculated using area estimates measured with a digital planimeter. The estimate did not factor in whether areas contained non-forested types such as lakes, shrubs, grasslands or alpine.

For the past five years final sketch maps have been promptly scanned, geo-referenced and posted at http://www.for.gov.bc.ca/ftp/HFP/external /!publish/Aerial_Overview/ for use by anyone requiring immediate access to the information, particularly for operational planning. The final provincial summaries of the spatial and tabular data were available by January 24th, 2014.

Tree mortality was identified by the colour of tree foliage. Only trees killed within the past year were mapped. Clumps of up to 50 dead or dying trees were mapped as spots. When digitized, 1 to 30 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 containing mortality were delineated 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, only polygons were mapped for these agents and these were assessed for intensity based on the amount of foliage damaged in the past year over the entire polygon (three damage intensity classes, Table 2), with two exceptions. In the northern interior, Venturia blight damage sometimes severely affects only a small clump of trees (most likely a single clone) within a stand of otherwise suitable hosts, and was therefore recorded as spots. For serpentine leaf miner, damage visible from the air tended to have an “all or nothing” signature with very little difference in damage from tree to tree. However, in many areas of the province aspen occurs in mixed rather than pure stands. Therefore, in 2012 mapping procedures were modified to record damage in a manner similar to mortality, in that severity ratings are based on the percentage of the stand affected, rather than the intensity of the defoliation to the trees. To be consistent with other defoliators though, only the three severity categories (light, moderate and severe) were employed.

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.
Foliage Damage (defoliating insect and foliar disease)	Light	Some branch tip and upper crown damage, barely visible from the air.
	Moderate	Noticeably damaged foliage, top third of many trees severely damaged.
	Severe	Completely damaged tops, most trees sustaining more than 50% total foliage damage.
	Grey	Cumulative foliage damage resulting in mortality, recorded at end of damage agent cycle.

Foliar damage can sometimes result in tree mortality. Once a damaging agent has run its course in a given area, cumulative damage that has resulted in mortality is recorded once as grey (Table 2). This occurred in some areas affected by western hemlock looper and western blackheaded budworm this year.

Data collected during the aerial overview survey has known limitations. Not all damage is visible, either due to the height flown or the timing of the surveys. Spruce beetle mortality for example can be under-reported because stressed foliage from current tree death can change very quickly and/or happen outside the survey period. Also many diseases cause significant growth loss and tree defects that aren’t visible by aerial assessments, such as mistletoe infections.

Care must also be taken in interpretation of the data. Area recorded as affected by a certain forest health 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. Additionally, the relatively broad intensity classes and known errors of omission must 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 used the overview survey data to estimate cumulative and projected volumes of pine killed by the mountain pine beetle as the data is the only complete record of the outbreak's progress across the province. Furthermore, the annual survey data is being used by districts to estimate non-recoverable losses that are important for incorporating pest-caused losses in timber supply reviews.

General Conditions

Damage observed across BC during the 2013 aerial overview surveys totalled 8,682,579 ha (Table 3). This is the fourth consecutive year that aggregated disturbances have declined provincially, mainly due to the waning mountain pine beetle outbreak. Bark beetles continued to be the leading forest health damage agents. Mortality due to mountain pine beetle fell slightly to 2,973,936 ha from last year, with minor expansions in the northeastern and southeastern parts of the province. Area affected by western balsam bark beetle doubled for the second consecutive year to 1,320,574 ha, though 98% of the mortality remained trace. Spruce beetle damage decreased to less than half that recorded last year to 18,694 ha, of which almost half occurred in the Prince George TSA, though the level of mortality was mainly trace. Douglas-fir beetle damage also dropped by half to 10,360 ha, scattered throughout southern BC.

The gap between damage by bark beetles compared to defoliators decreased to the lowest level since 2001, with aspen leaf miner accounting for three quarters of the defoliator damage at 2,577,703 ha. Substantial damage of trembling aspen and to a lesser extent cottonwood by this agent has been observed since 2009, and area affected has risen every year since then, particularly in the north. The forest tent caterpillar outbreak reached a peak of 591,910 ha this year, with most of the damage continuing to occur in the Omineca Region. Western spruce budworm continued to cause the most damage to conifer stands in the province, though defoliation was down substantially since last year to 128,038 ha, recorded chiefly in the Cariboo and Thompson/Okanagan Regions. The two-year-cycle budworm outbreak in northern BC which has accounted for the majority of the damage in odd years for over a decade appears to be over. All 88,760 ha of defoliation recorded in 2013 occurred south of Prince George down to the northern half of Kamloops TSA. Current western blackheaded budworm defoliation affected 30,475 ha in the West Coast Region, primarily in the Kingcome TSA.

Disease damage continued to be led by Venturia blight, with a record 837,586 ha delineated. Larch needle blight decreased almost five fold from the levels recorded the last two years to 6,304 ha with almost all damage observed in the Kootenay/Boundary Region. Other disease damage that was visible from the height of the aerial overview survey was less than 1,800 ha per disease, provincially and is considered a gross under-estimate of the actual level of damage.

Wildfire damage continued to dominate the abiotic category with 27,291 ha burnt. The new category added last year to describe mortality occurring after wildfires had 14,696 ha delineated, with primarily lodgepole pine and Douglas-fir affected. Yellow cedar decline was mapped on 18,667 ha along the coastal TSAs, and aspen decline was observed on 3,279 ha in the Thompson/Okanagan and Northeast Regions. Flooding damage was scattered across BC with 9,143 ha mapped, down by half since 2012. Recorded windthrow damage also decreased to 4,230 ha, with more than half observed in the Haida Gwaii TSA.

Animal damage is not usually a large factor, but in 2013 black bear damage increased four-fold over 2012 to 4,984 ha of mortality, occurring mainly in the Cariboo and Kootenay/Boundary Regions.

Other damaging agents were documented as causing local damage as well. Locations, extent and intensity of damage by all forest health factors are described in the following section by host tree species.

Forest tent caterpillars

Table 3. Summary of hectares affected by forest damaging agents as detected in 2013 aerial overview surveys in British Columbia.

Damaging Agent	Hectares Affected	Damaging Agent	Hectares Affected
Bark Beetles:		*Diseases:*	
Mountain pine beetle	2,973,936	Venturia blight	837,586
Western balsam bark beetle	1,320,574	Larch needle blight	6,304
Spruce beetle	18,694	Dothistroma needle blight	381
Douglas-fir beetle	10,360	White pine blister rust	1,741
Young pine mortality	1,384	Lophodermella needle cast	181
Twig beetle	28	Cottonwood leaf rust	708
Total Bark Beetles:	4,324,979	Lophodermium needle cast	62
Defoliators:		Root diseases****	2,016
Aspen leafminer	2,577,702	*Total Diseases:*	848,980
Forest tent caterpillar	581,910	*Abiotics:*	
Western spruce budworm	128,038	Fire	27,29
Two-year-cycle budworm	88,760	Yellow cedar decline	18,667
Western blackheaded budworm*	30,700	Post fire	14,696
Unknown defoliators**	8,590	Flooding	9,143
Large aspen tortrix	2,184	Windthrow	4,230
Western hemlock looper***	2,020	Aspen decline	3,279
Lodgepole pine sawfly	1,730	Slides	1,889
Birch leaf miner	1,415	Drought	182
Pine needle sheathminer	281	Douglas-fir decline	130
Balsam woolly adelgid	85	Treatment mechanical	107
Satin moth	234	Treatment chemical	62
Leaf beetles	50	Unknown abiotics	48
Total Defoliators:	3,421,971	*Total Abiotics:*	79,555
Animals:			
Bear	4,983		
Hare	211		
Total Animals:	5,194		
Provincial Total Damage:			8,682,578

* 30,475 ha are current, remaining damage is cumulative mortality.
** Unknown refers to damage that could not be confirmed with ground checks.
*** 842 ha are current, remaining damage is cumulative mortality.
**** Root disease damage is greatly underestimated from aerial overview surveys.

Damaging Agents of Pines

Mountain pine beetle, *Dendroctonus ponderosae*

Provincial

The current mountain pine beetle outbreak peaked in 2007 in BC with just over 10 million hectares of damage (Figure 3). Affected area and severity of mortality has been declining for four consecutive years, though the rate of decrease slowed over the past year. In 2013 infestations covered 2,973,936 ha with damage rated as 1,674,250 ha (56%) trace, 867,533 ha (29%) light, 383,130 ha (13%) moderate, 48,365 ha (2%) severe and 658 ha (<1%) very severe.

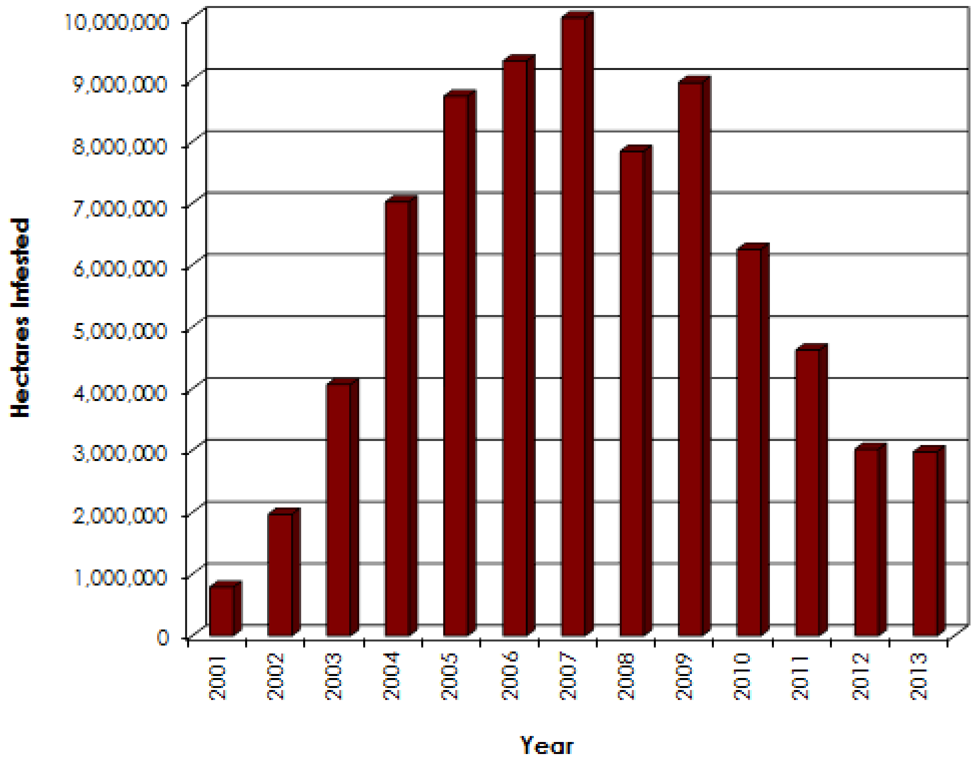


Figure 3. Hectares infested (all severity classes) by mountain pine beetle from 2001 – 2013 in British Columbia.

Infestation expansions in 2013 primarily occurred in the northeastern portion of the province, with minor increases in the southeastern section as well. The Infestations nearest to the Yukon were limited to only three spots south of the Liard River in Cassiar TSA and two spots north of Petitot River in Fort Nelson TSA, all approximately 35 km from the border. Damage in the rest of BC tended to occur in the same general areas as last year, but with reductions in size and intensity (Figure 4). Beetle population growth continues to be slowed by host depletion in central BC, cold weather in the north and mixed stands/topography barriers in the south. Mountain pine beetle attack of young lodgepole pine and pine species other than lodgepole pine continued to decrease as well.

With very little current attack in most accessible areas and few mountain pine beetle treatment zones left in the province, tracking of beetle biology in 2013 was minimal. Some ground surveys were conducted for beetle treatments in Kooteney Lake, Invermere and Cranbrook TSAs, and the results to date indicate a declining beetle population.

Northern Interior Damage

The Northeast and Omineca Regions continued to sustain the bulk of the mountain pine beetle damage with 1,405,143 ha and 1,275,433 ha affected, respectively (Figure 5). This represents 90% of the disturbances mapped provincially. For the first time, infestations in Fort St. John TSA accounted for the most area affected this year at 985,791 ha, up a third over last year and almost

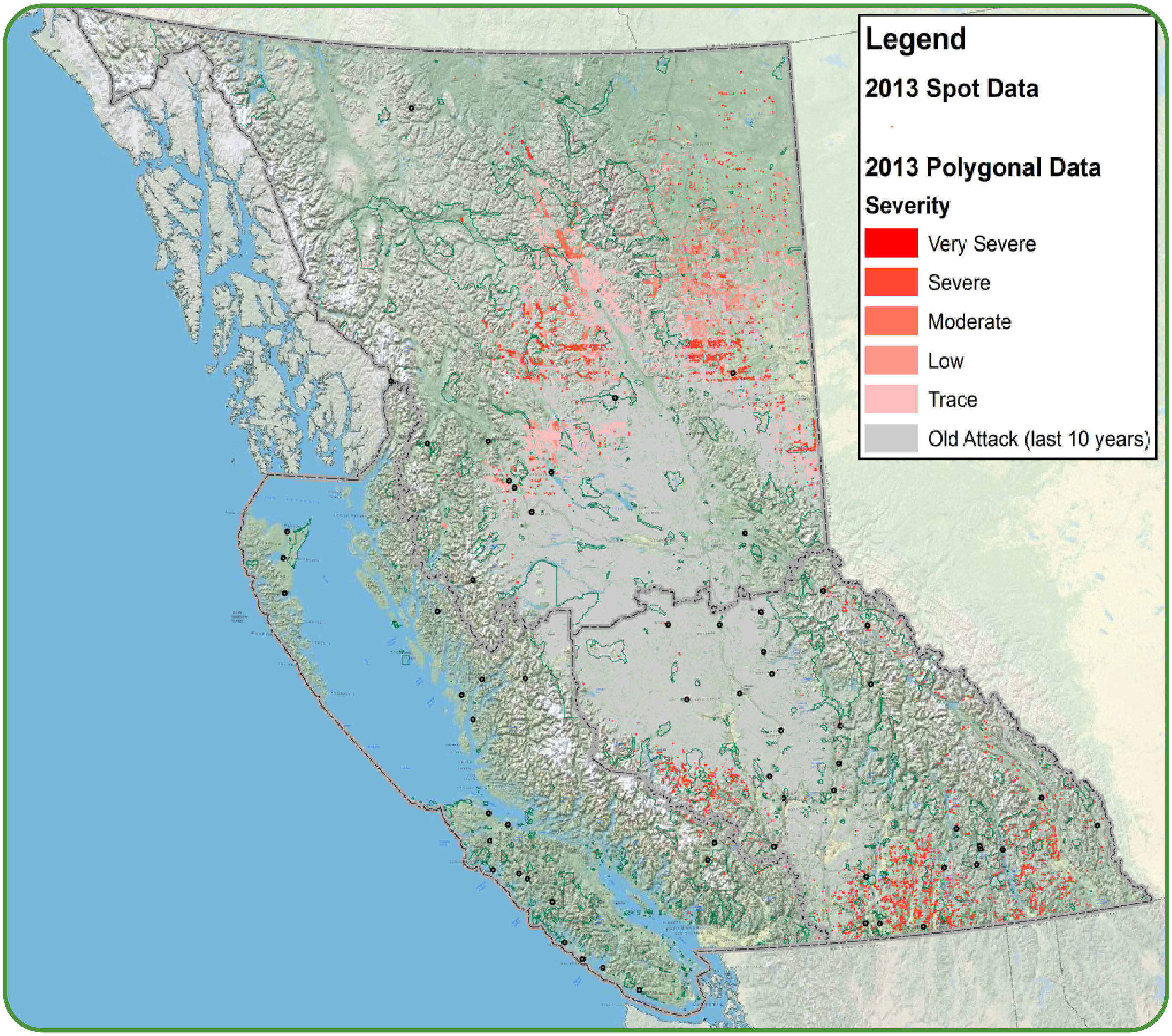


Figure 4. Current mountain pine beetle infestations recorded in British Columbia in 2013 with old attack in grey.

the same as the peak year of 2011. Attack was widespread throughout the same lodgepole pine stands as in 2012 but the size of the attack polygons increased on average while the overall intensity of attack diminished. Stands with the highest rated severity levels were mainly located in the northwestern quarter of the TSA. Infestations in the Mackenzie TSA declined for the fourth consecutive year to 960,102 ha. Mortality intensity also continued to drop, with 85% of the damage rated as trace to light. Except for the Klawli River area, new attack was almost non-existent in the southern third of the TSA. The majority of the heavier infestations occurred in the Ingenika and Fox River areas. The largest expansion of mountain pine beetle in the province occurred in Fort Nelson TSA, where mapped attack grew six fold since 2012 to 222,653 ha. Damage from last year along the southern border of the TSA increased in size and intensity, while new infestations pushed northward, particularly in the Muskwa River area.

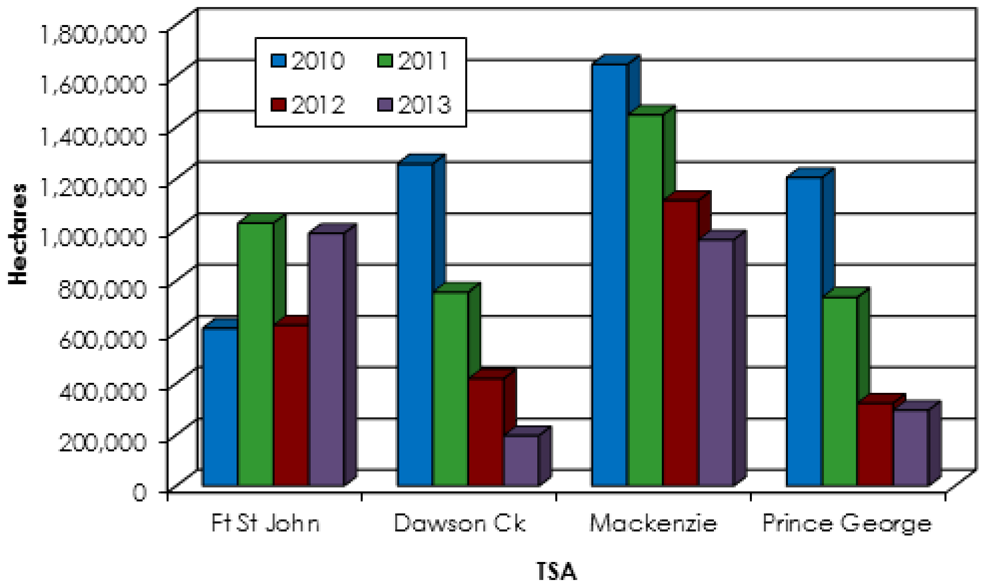


Figure 5. Hectares infested by mountain pine beetle from 2010 – 2013 in the Omineca and Northeast Regions (TSAs with more than 700,000 ha affected in 2011).

In the southern TSAs of the Northeast and Omineca Regions, attack continued to decline. Prince George TSA sustained 294,125 ha of damage, with almost all infestations occurring in the northern two-thirds of the Fort St. James District at trace to light intensities. Infestations were less than half the total recorded last year in Dawson Creek TSA at 196,699 ha. The greatest reductions occurred along the western edge of the attack, and almost all remaining damage was trace to light. Robson Valley TSA mortality also declined by more than half of 2012 levels with 21,206 ha mapped. Attack continued at diminished rates south of McBride along the Fraser River and Kinbasket Lake, with the more recent attack focused in the remote Hugh Allen area of Kinbasket Lake.

Mountain pine beetle damage in the Skeena Region declined to a third of that noted last year with 224,696 ha delineated, despite more of the region being flown in 2013 (Figure 6). Mortality in the Morice TSA declined for a fourth consecutive year but still remained the highest in the region with 101,893 ha mapped. Infestations have receded from the southern three-quarters of the TSA and the remaining mortality (>99%) was rated trace with some light. After peaking at 284,342 ha of damage in 2009 in the Bulkley TSA, area affected dropped dramatically in 2010 and has remained relatively stable in size since though intensities have dropped. Mortality totaled 98,333 ha in 2013 and was highest south of the Hudson Bay Range and around Torkelsen Lake. Attack peaked at 55,423 ha in Kispiox TSA in 2008, with variable damage recorded since. Disturbances dropped to 15,079 ha this year, recorded in areas scattered along the eastern edge of the TSA. During the course of the present mountain pine beetle outbreak, damage was very high in the Lakes TSA for several years, with a peak in 2007 of 758,159 ha. Since 2010 damage rapidly declined and only

3,744 ha were recorded in 2013. Aside from 4 spot infestations, all mortality was assessed as trace and occurred in the northern tip of the TSA. In contrast attack has always been relatively low in the Kalum TSA (under 10,000 ha per year) but damage rose by a quarter since 2012 to 4,034 ha. Most of this mortality was rated as light and occurred in one large polygon south of Lakelse Lake and in a few smaller areas just north of Terrace. Damage in the Cassiar TSA declined from a high of 4,747 ha last year to 1,520 ha, located in small disturbances along the eastern edge of the TSA. For the Nass TSA, 93 ha of attack at trace intensity spilled out of the Prince George TSA near Blackwater Peak.

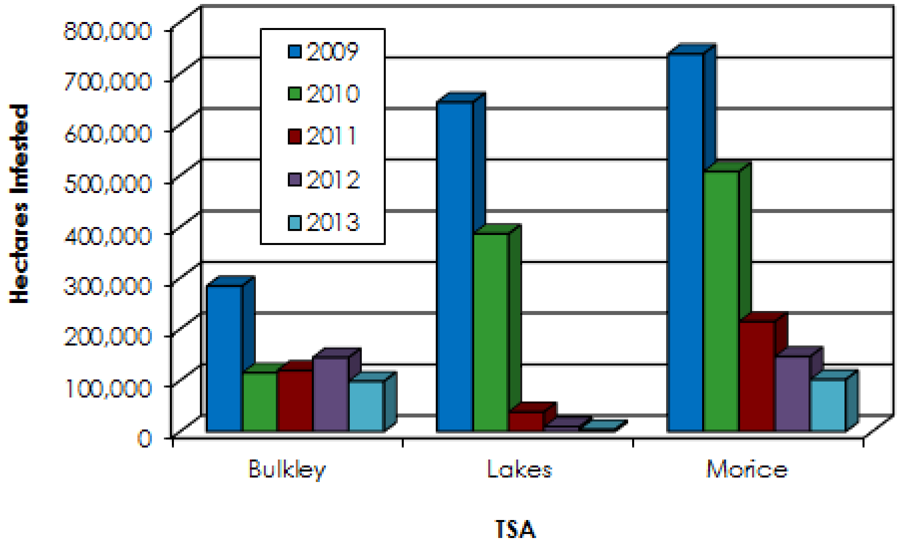


Figure 6. Hectares infested by mountain pine beetle from 2009 – 2013 in the Skeena Region (TSAs with more than 38,000 ha affected in 2011).

Southern Interior Damage

Damage in the Kootenay/Boundary Region TSAs peaked in 2008 followed by a sharp decline the following year (Figure 7). In 2013 damage rose slightly to 41,997 ha, which was the highest level of damage observed across the three southern interior regions. Boundary TSA accounted for 21,449 ha of attack, up from 14,082 ha last year. This is the only southern TSA where damage has expanded for three consecutive years. Infestations that spread from the Okanagan and Arrow TSAs have increased along the boundaries, with additional spot and small scattered polygons of attack now occurring throughout the TSA. Invermere TSA experienced a slight increase in attack over 2012, after two years of sharp declines. Almost all the 10,004 ha of mortality continued

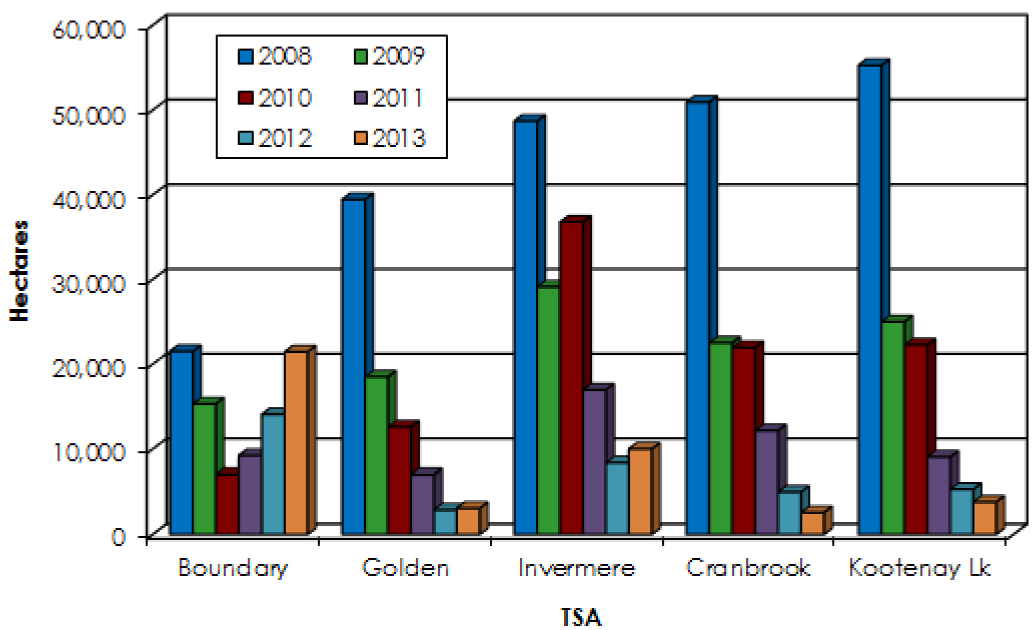


Figure 7. Hectares infested by mountain pine beetle from 2008 – 2013 in the Kootenay/Boundary Region (TSAs with more than 2,000 ha affected in 2013).

to occur in drainages west of the Columbia River. Kootenay Lake and Cranbrook TSAs have experienced similar declines for five consecutive years to 3,814 ha and 2,583 ha, respectively. Kootenay Lake TSA infestations were small and scattered, while Cranbrook TSA damage was more concentrated in the western portion of the TSA. Attack in Golden TSA rose slightly to 3,083 ha. Infestations were small and scattered, with the exception of some larger disturbances from Mt. Laussedat east to Field. Attack in Arrow TSA continued to decline to 910 ha, with spot infestations throughout the TSA and a few larger concentrations, mainly around Lost Mountain on the USA border. The remaining 154 ha in the region occurred in the Revelstoke TSA, primarily south of Mount Sproat.

Mountain pine beetle attack in the Thompson/Okanagan Region dropped to a third of last year's area with 19,251 ha recorded. Most reductions occurred in Okanagan TSA where 10,721 ha of primarily light intensity or spot infestations were mapped, mainly along the Boundary TSA border. Attack in Lillooet TSA remained steady at 4,912 ha. Infestations were small and scattered in mostly small high elevation trees with some concentrations near Bralorne and Bridge River. Mortality in the Merritt TSA dropped to 3,547 ha. Damage was chiefly observed north of Stemwinder Mtn. to Shinish Creek. Only 70 ha of attack was observed in Kamloops TSA in scattered spots and three polygons along the Lillooet TSA border.

Damage dropped five fold in the Cariboo Region to 2,622 ha. With the exception of 6 spot infestations, all attack was mapped in the Williams Lake TSA. Most of this mortality occurred along the Lillooet TSA border, particularly around Taseko River, Lone Valley Creek and Yohetta Valley.

Coastal Damage

Infestations in the South and West Coast Regions declined for the eighth consecutive year. Almost all the damage was contained in the South Coast Region where 4,794 ha were affected. Intensity declined as well with the majority (92%) rated as trace. Area affected in the Fraser TSA actually increased by a quarter over 2012 to 4,091. The rise was primarily due to several large trace polygons being delineated where smaller, more intense polygons were previously mapped. Almost all damage was observed along the Okanagan TSA border. Most of the 702 ha recorded in the Soo TSA occurred north of Whistler and around Lizzie Creek east of Lillooet Lake, with a few small scattered infestations elsewhere. Only 2 spot infestations were noted in the Sunshine TSA.

Damage in the West Coast Region dropped from 342 ha last year to only 1 ha in 2013. Infestations were spot in size, with two in Arrowsmith TSA and one in Strathcona TSA.

Multiple years of mountain pine beetle attack north of Whistler

Ponderosa and Whitebark Pine Mortality

Whitebark pine mortality due to mountain pine beetle declined for a third consecutive year to 3,447 ha across BC, after the peak of 33,460 ha in 2010. Severity of damage was assessed as 1,567 ha (45%) trace, 1,602 ha (47%) light, 173 ha (5%) moderate and 105 ha (3%) severe.

Despite the provincial decline, whitebark pine damage increased for the second consecutive year to 2,387 ha in the Kootenay/Boundary Region. Invermere TSA continued to sustain the majority of the attack, primarily in the north tip and the southwest corner of the TSA. Damage in Cranbrook TSA remained steady at 220 ha, all located in the northwest tip. Scattered attack accounted for 185 ha in Golden TSA. A further 29 ha of mortality was identified in the middle of Kootenay TSA and four spot infestations were recorded in Arrow TSA.

Only Lillooet TSA was affected in the Thompson/Okanagan Region, with 911 ha of whitebark pine mortality scattered throughout the western half of the TSA.

After leading the regions in whitebark pine attack for the past two years, Skeena Region damage dropped substantially. Only 149 ha of mortality was observed in the Bulkley TSA of which all but one spot occurred in one polygon north of Eagle Peak. Lakes TSA contained the only other observed infestations in two spots near Eutsuk Lake.

Ponderosa pine infestations declined for the fourth consecutive year to 110 ha from the peak of 132,929 ha in 2009. Intensity of mortality was rated as 64 ha (58%) light, 21 ha (19%) moderate and 25 ha (23%) severe. It continued to be likely that some of these trees were killed by a complex of bark beetles that included western pine beetle (*Dendroctonus brevicomis*), especially at low elevations.

The majority of the attack continued to occur in the Thompson/Okanagan Region. Okanagan TSA contained 67 ha, primarily in two disturbances near Kelowna and Trout Creek with additional scattered spot infestations. Similarly, Lillooet TSA sustained 23 ha of damage in one 17 ha polygon along Downton Lake, with the remaining damage in scattered spots. The remaining 3 ha were noted in spot infestations in the southern half of the Merritt TSA.

In the Kootenay/Boundary Region, 15 ha of damage occurred east of Carmi in the Boundary TSA, with two spot infestations at Boundary Falls and Tuzo Creek. Kootenay Lake, Cranbrook and Arrow TSAs also had a few spot infestations.

Whitebark pine mortality in Lillooet TSA

Young pine mortality

Young Pine Mortality, Suspected Mountain Pine Beetle
As anticipated, young lodgepole pine mortality caused by mountain pine beetle continued to drop, from the peak of 357,017 ha in 2008 to 21,887 ha last year and only 3,203 ha in 2013. Intensity was rated as186 ha (6%) trace, 2,092 ha (65%) light, 907 ha (28%) moderate and 18 ha (1%) severe.

The majority of the attack continued to occur in the Mackenzie TSA of the Omineca Region with 2,863 ha affected. Most of the mortality occurred northwest of the Omineca Arm of Williston Lake. Along the southern boundary of the Fort St. John TSA in the Northeast Region, 307 ha were affected north of Flatrock and west of Halfway River. A further 33 ha of mortality was identified east of Postill Lake in the Okanagan TSA of the Thompson/Okanagan Region, and one spot infestation was noted in the Lakes TSA of the Skeena Region.

Young Pine Mortality, Unknown Cause
Young pine mortality recorded in this category was most likely caused by secondary bark beetles, but rusts, porcupine, bear and/or Warren's root collar weevil may also have been contributing factors. Damage was not likely to have been caused by mountain pine beetle (recent mountain pine beetle attack in mature stands was not nearby, and the aerial signatures did not suggest mountain pine beetle mortality).

Thirty year old pine killed near Celista in the Okanagan TSA

All of the generic young pine mortality occurred in northern BC in 2013, with a total of 1,383 ha affected. Damage intensity was rated as 664 ha (48%) trace, 557 ha (40%) light, 98 ha (7%) moderate and 66 ha (5%) severe. Disturbances were for the most part widely scattered and mortality was only a quarter of the 4,991 ha recorded last year. Pheromone monitoring traps deployed in the Skeena Region to monitor secondary beetles confirmed this downturn, with far fewer beetle catches than last year aside from a concentration around the large Binta fire that burned in 2010.

Disturbances in Omineca Region totalled 772 ha, with 426 ha located in Prince George TSA and 346 ha primarily in the southern tip of Mackenzie TSA. A further 380 ha of damage were noted in the Northeast Region with the majority (263 ha) in the northern half of Dawson Creek TSA, 74 ha in Fort Nelson TSA and 43 ha in Fort St. John TSA.

The remaining 231 ha of generic young pine mortality was delineated in the Skeena Region, with 168 ha in the northeast corner of the Cassiar TSA and 63 ha in Lakes TSA. In Bulkley TSA ground observations noted Warren's root collar weevil mortality was occurring on the edges of immature pine stands adjacent to mountain pine beetle attacked mature stands. It was estimated approximately 5% of immature stems were being killed up to 100 m from bordering mature stands, though this damage to scattered, very small trees was not visible from the aerial overview survey height.

An additional 28 ha of mortality on young pine were specifically attributed to engraver beetles (*Ips* spp.). Most (24 ha) were trace to light or spot infestations near West Churn Creek in Williams Lake TSA in the Cariboo Region. The remaining 4 ha of light mortality was located near Celista in Okanagan TSA of the Thompson/Okanagan Region.

Dothistroma needle blight, *Dothistroma septospora*

Dothistroma needle blight has been an ongoing problem in the Skeena Region since the early 2000's as documented from ground and helicopter observations. However, it is difficult to detect from the height of the aerial overview survey unless substantial red foliage is visible in damaged areas at the time of the flight. Dothistroma damage was first detected during the overview surveys in 2005 to 2007, when a few thousand hectares were mapped each year primarily in the Kalum, Kispiox and Bulkley TSAs. Visible damage peaked in 2008 at 53,505 ha. Since then, annual damage as recorded during the overview surveys has ranged from 7,400 to 27,300 ha. The vast majority of this damage was observed in the Skeena Region, with minor disturbances noted in Prince George TSA and scattered areas in the Thompson/Okanagan Region.

For the first time in nine years, no Dothistroma needle blight damage was observed in the Skeena Region. Chronic areas are still being affected, but in these stands current damage is difficult to detect by the aerial surveyors as there are fewer needles left to be infected. There has been no significant movement into new areas, where it is easier to see damage since the numbers of infected red needles are much higher (A. Woods pers. comm.). The same scenario was noted for the northeast regions, where very severely damaged sites still have current Dothistroma infections, but other stands appear to be recovering and it does not appear to be spreading (R. Reich pers. comm.). The last two summers have been dry, which most likely has reduced the rate of Dothistroma infections.

The only Dothistroma needle blight damage noted in 2013 occurred in the Thompson/Okanagan Region with 381 ha affected, of which 262 ha (69%) was light, 52 ha (13%) was moderate and 67 ha (18%) was severe. The Okanagan TSA sustained 204 ha of damage, located south of Sugar Lake and north of Mabel Lake. Several sites in the Okanagan TSA were confirmed with ground checks, but three polygons at the north end of Mabel Lake couldn't be checked, and could actually be larch needle blight. In Kamloops TSA 177 ha were affected south of Groundhog Mtn., mainly along the Adams River.

Lophodermella needle cast, *Lophodermella concolor*

Lophodermella (pine) needle cast damage has been low throughout the province for several years though infected stands increased somewhat in the northern interior last year to 1,018 ha. In 2013 no damage was noted in the northern interior from the aerial survey, and was confirmed by ground observations that infection levels have been dropping, in correspondence with dry August weather when sporulation usually takes place, if weather is moist (R. Reich, pers. comm.).

No Lophodermella needle cast damage was noted in the Thompson/Okanagan Region last year, but this year several small plantations totalling 181 ha were lightly damaged around Hedley and east of Friday Mountain in Merritt TSA. Ground checks were conducted to confirm causal agent.

Neodiprion sawfly, *Neodiprion nanulus contortae*

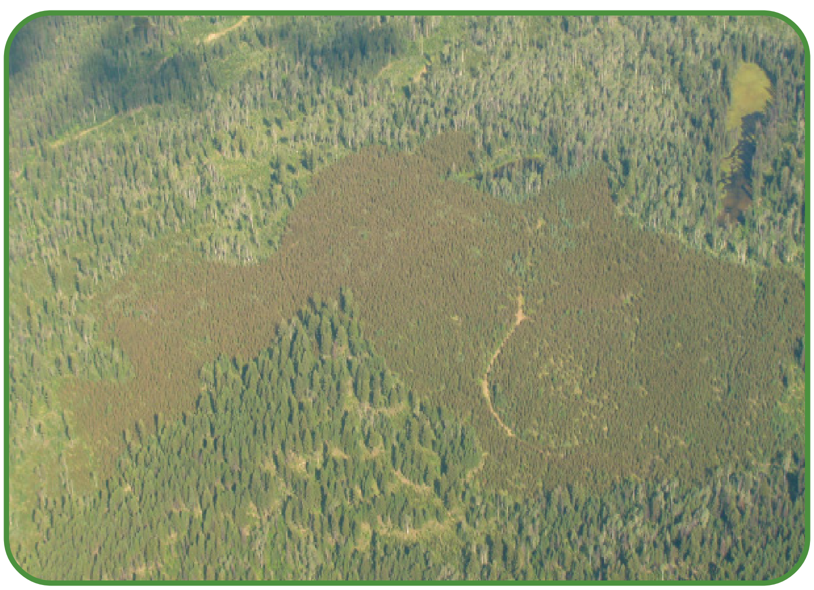
For the second consecutive year, defoliation by Neodiprion sawflies on lodgepole pine was observed in coastal areas of BC with a total of 1,730 ha mapped. Damage was rated as 1,581 ha (91%) light and 149 ha (9%) moderate. The sawfly in question was identified in 2012 as *Neodiprion* spp., but this identification was narrowed down to *Neodiprion nanulus contortae* this year.

Defoliation of lodgepole pine by Neodiprion sawflies

In Haida Gwaii TSA of the West Coast Region 1,034 ha of damage was delineated. The majority of the defoliation occurred at the south tip of Moresby Island around the Yatza Mtn. area. The remaining 696 ha were observed on the east side of Banks Island in the North Coast TSA of the Skeena Region. Surveyors for this area observed from the ground that damage was greater than what could be seen from the air, as primarily only old growth under the new foliage was being fed on.

Pine needle sheathminer, *Zellaria haimbachi*

For the third consecutive year, pine needle sheathminer damage was recorded in the southern interior. Intensity and area affected continued to decline however, with 190 ha (68%) light and 91 ha (32%) moderate damage delineated, for a total of 281 ha.



Pine needle sheathminer damage Kamloops TSA

All the defoliation occurred in the Thompson/Okanagan Region this year in small, scattered polygons. Some of the stands had active feeding all three years, which is relatively unusual. Kamloops TSA sustained the majority of the attack with 159 ha mapped, Okanagan TSA had 83 ha and the remaining 40 ha occurred in the Merritt TSA. Defoliation occurred in the Cariboo Region the last two years, but none was noted in 2013.

Lophodermium needle cast, *Lophodermium seditisiosum*

Lophodermium needle cast damage was observed during the aerial overview surveys for the first time in 2013. Two lightly affected pine plantations south of Tulameen along Podunk Creek in Merritt TSA were mapped, totalling 62 ha. Since several needle casts have similar aerial signatures these blocks were ground checked, with photos sent to a regional pathologist for tentative identification. Evidence of Dothistroma was also found in these areas last year and may also still be affecting the trees, but no infected needles could be found during the ground check in late summer.

Lophodermium needle cast damage in Merritt TSA

White pine blister rust, *Cronartium ribicola*

Only tree mortality caused by white pine blister rust infections are visible during aerial overview surveys. Most of the damage has historically been recorded as spots or small polygons in the coast area and Kootenay/Boundary Region at less than 200 ha annually.

Last year recorded hectares rose substantially to 1,266 ha, but most of the damage was assessed as trace. This trend continued in 2013 with 1,741 ha of mortality delineated in the West and South Coast Regions, but 1,565 (90%) was rated as trace with an additional 94 ha (5%) light and 82 ha (5%) severe (mainly as spot damage).

In the West Coast Region, the southern tip of Kingcome TSA sustained the most damage, with 1,111 ha delineated, particularly along Nimpkish River. Strathcona TSA was the next most affected, with scattered spot mortality and a concentration of polygons north of Mt. Washington totalling 544 ha. Arrowsmith TSA contained 50 ha of mortality in one small polygon near Mt. Arrowsmith and widely scattered spots.

Infection centers in Sunshine Coast TSA of the South Coast Region totaled 34 ha, primarily on Texada Island and around Sechelt Inlet. Soo TSA only had 2 spots of damage recorded, and Fraser TSA one spot.

White pine blister rust infection

Damaging Agents of Douglas-fir

Western spruce budworm, *Choristoneura occidentalis*

Recorded Defoliation

Western spruce budworm defoliation peaked provincially in 2007 with 847,138 ha of damage. Infestations have been on the downturn for the past two years, with damage in 2013 at 128,038 ha (Figure 8). The largest decreases were in the southernmost TSAs. A substantial amount of the defoliation occurred in the lower crowns this year however, which is very difficult to see from the height of the aerial overview survey. Intensity of defoliation continued to increase slightly with 81,055 ha (63%) light, 46,404 ha (35%) moderate and 579 ha (1%) severe.

Damage in the Cariboo Region covered 89,947 ha, which is the lowest level recorded since 2001. The large reduction in damage over the last two years from what was considered the norm over the last decade is suspected to be due to a combination of factors. Weather during most of the larval feeding season in 2012 and 2013 has been consistently cold and wet, which may have led to a population decline in some areas. There was also a change in aerial overview survey personnel from 2012 onwards, which may have resulted in mapping methodology variations.

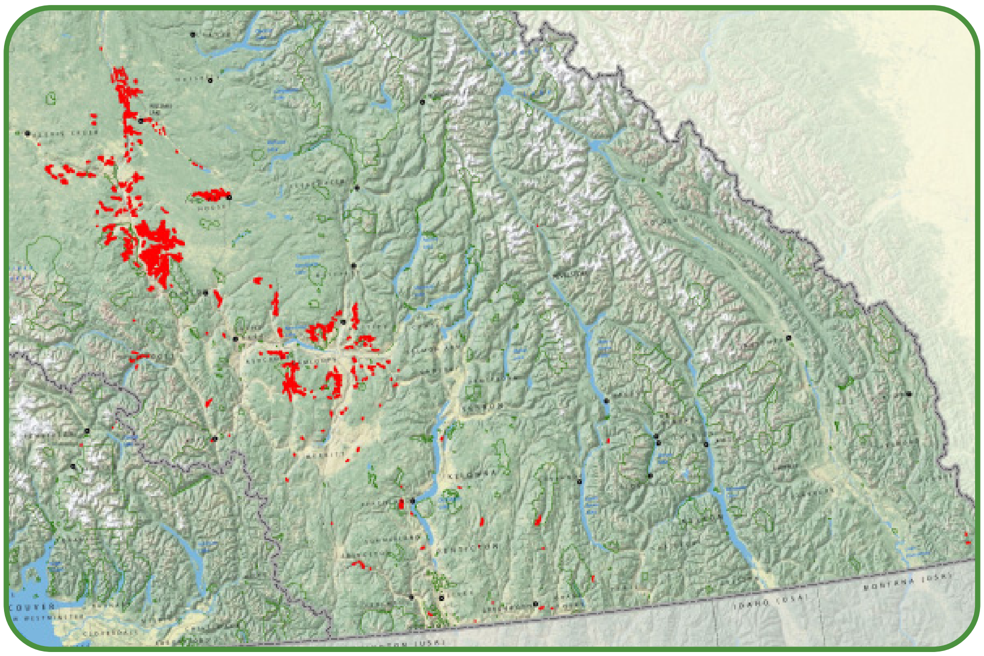


Figure 8. Areas defoliated by western spruce budworm in BC in 2013.

The severity of damage remained primarily (96%) light. For the first time since 2002, 100 Mile House TSA sustained more damage than the Williams Lake TSA, with 53,623 ha of the defoliation, up slightly from 2012 (Figure 9). Infestations continued to grow west of Meadow Lake and new infestations occurred west of 100 Mile House, as well as two small areas of damage near Clinton and Loon Lake. Conversely, infestations in the Williams Lake TSA dropped to half of that recorded last year to 39,693 ha. Defoliation primarily was recorded in the same general areas as last year but was much reduced in size, particularly east of the Fraser River in the southern portion of the district. Quesnel District infestations dropped to only 49 ha of light intensity at the southern boundary along the Fraser River, which is the lowest ever recorded since defoliation was first identified in this district in 2008.

Western spruce budworm defoliation in the Thompson/Okanagan Region dropped more than seven fold since last year to 36,514 ha. The larval densities found during treatment sampling still remained very high for the third consecutive year however, though decreases were noted in chronic budworm areas (see Southern Interior 2013 Forest Health Conditions Report for further details).

Attack in the Kamloops TSA remained relatively stable with 31,411 ha affected in the southern half of the TSA (Figure 9). The largest decrease in the province occurred in Okanagan TSA, down from 110,163 ha last year to only 1,764 ha in 2013. Disturbances in the northern part of the TSA receded but a few scattered polygons were still mapped around Westwold and Okanagan Lake. Dramatic reductions also occurred in Merritt TSA, from 91,795 ha to 1,678 ha of scattered attack. Lillooet TSA contained 1,660 ha of damage, primarily around South Shalalth, Watson Bar Creek and Laluwissin Creek.

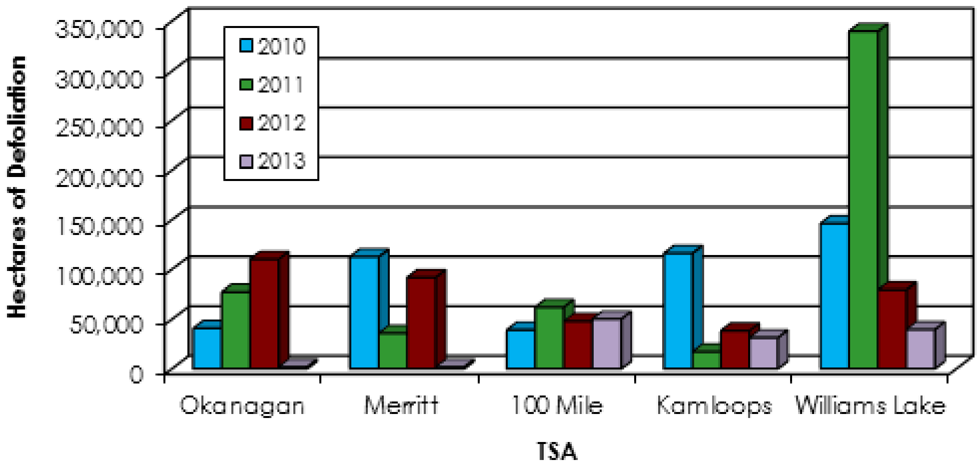


Figure 9. Hectares of western spruce budworm defoliation from 2010 – 2013, for TSAs with over 1,670 ha damaged in 2013.

Infestations in the Kootenay/Boundary Region also dropped substantially since last year from 51,804 ha to 1,518 ha. Most of the damage (1,250 ha) continued to occur in Boundary TSA, though defoliation was down dramatically from a peak of 43,064 ha in 2012. Small infestations remained near Anaconda, Paulson, Mt. Chochrane and Nipple Mtn. Two polygons totalling 172 ha were observed near Cabin Creek in the southeast portion of Cranbrook TSA. The remaining 15 ha where mapped near Carnes Creek in Revelstoke TSA.

Western spruce budworm defoliation in 100 Mile House TSA

Damage in the South Coast TSA was minimal with only 59 ha mapped along Green River and Joffre Creek in the Soo TSA. No defoliation was noted in the Fraser TSA, which sustained 1,520 ha of attack last year in the northeast portion of the TSA.

2013 Treatment Program

High value Douglas-fir stands that were predicted in the 2012 egg mass surveys to sustain moderate to severe defoliation in 2013 were targeted for treatment in the spring of 2013. The biological control agent *Bacillus thuringiensis* var. *kurstaki* (Btk) in the formulation Foray 48B® was applied aerially in a single application per stand at a rate of 2.4 litres/ha. A total of 76,884 ha were treated in the southern interior, down from a record 116,235 ha last year. Both bud flush and larval development were carefully monitored to determine optimal treatment timing. The spring weather prior to and during the treatment program was wet and cool, but application dates did not deviate much from previous years' treatments. With this kind of weather finding appropriate treatment windows was challenging, and some days were lost entirely due to poor weather.

Budworm larva preparing to mine Douglas-fir bud

In the Thompson/Okanagan Region treatment was completed on 51,009 ha. Two UH12ET Hiller and two AS315B Lama helicopters from Western Aerial Applications Ltd. conducted the application from June 12th to July 2nd. Areas spayed were 25,446 ha in Kamloops TSA near Kamloops and Anderson Lake, 18,258 ha in Merritt TSA in Kane Valley, Peter Hope and Bush Lake areas, 5,244 ha in Lillooet TSA near Gun Lake, Tyaughton and Marshall Lake and 2,061 ha in Okanagan TSA near Westwold and Onion Road.

Treatment in the Cariboo Region was conducted over 25,875 ha with two fixed wing AT 802 Air Tractors from the Provincial Air Tanker Center. Application began on June 21st and was completed by the 28th on eleven blocks ranging from 541 ha to 5,520 ha in size. Treatments were done on 15,781 ha south and east of Williams Lake in Williams Lake TSA and on 10,094 ha just west of 108 Mile House and in the Jesmond area of 100 Mile House TSA.

After the first ever treatment of stands in Kootenay/Boundary Region last year, no further treatments were required in this region in 2013.

Population Monitoring 2013 and Proposed Treatments 2014

Egg mass surveys were conducted in the fall of 2013 to predict expected western spruce budworm defoliation in the spring of 2014 (Table 4). These predictions are one of the key criteria used for prioritizing treatment areas

AT 802 Air Tractor treating a Cariboo Region site

Table 4. Summary of western spruce budworm defoliation predictions for 2014 based on 2013 egg mass survey results.

Region	TSA	Number of Sites by Defoliation Category				Total Sites
		Nil	Light	Moderate	Severe	
Cariboo	100 Mile House	8	60	21	0	89
	Williams Lake	21	104	13	2	140
	Quesnel	4	7	0	0	11
Thompson/ Okanagan	Kamloops	12	135	45	3	195
	Lillooet	1	3	0	0	4
	Merritt		6			6
	Okanagan		8	1		9
Kootenay/ Boundary	Boundary	24	31	0	0	55
	Cranbrook	10	16	0	0	26
	Revelstoke	6	0	0	0	6
	Total	80	370	80	5	535

(only areas with moderate to severe predicted defoliation are considered). Other factors such as values at risk, stand recovery capability and previous damage levels are also considered.

For the second consecutive year fewer sites were surveyed and average predicted severities decreased as well. Sites with moderate predictions dropped to 80 (15%) and severe to 5 (1%). Sites with at least some (light) defoliation predicted were 370 (69%) and those with nil were 80 (15%).

The number of sites with moderate to severe defoliation predicted for the Thompson/Okanagan Region dropped to only a third of last year to 49. Most of the sites were located in Kamloops TSA around Logan Lake and Kamloops. One site near Finlay Creek in Okanagan TSA was predicted to sustain moderate defoliation, and none were anticipated to be a problem in the Merritt or Lillooet TSA.

In the Cariboo Region, sites with moderate to severe defoliation predicted actually rose from 29 to 36. The majority of these sites (21) were located in 100 Mile House TSA west of 100 Mile House, around White Lake and east of Loon Lake. An additional 13 sites were identified in the Williams Lake TSA north of Big Creek, west and south of Williams Lake and along Gaspard Creek. No sites of concern were found in the Quesnel TSA.

Surveys in Kootenay/Boundary Region resulted in only light to nil predictions and no areas were surveyed in the South Coast Region this year since aerial detection of 2013 defoliation was minimal.

A total of approximately 60,000 ha are proposed for treatment in the Thompson/Okanagan and Cariboo Regions in the spring of 2014.

Douglas-fir beetle, *Dendroctonus pseudotsugae*

After a peak of 100,726 ha in 2009, Douglas-fir beetle damage in BC has not been higher than the 21,001 ha recorded last year. In 2013, infestations decreased to 10,359 ha (Figure 10). The intensity of mortality increased though to 2,591 ha (12%) trace, 4,782 ha (25%) light, 1,712 ha (46%) moderate and 1,274 ha (17%) severe.

An additional 2,044 ha were identified as post wildfire mortality that most likely included Douglas-fir beetle attack as a factor (noted in database comments). The Douglas-fir beetle populations in these fires have expanded and are now expanding into green timber, often several kilometers away from the fires. The majority of this damage (1,617 ha) was located in the Williams Lake TSA, with minor amounts in Quesnel, Prince George and Mid Coast TSAs as well.

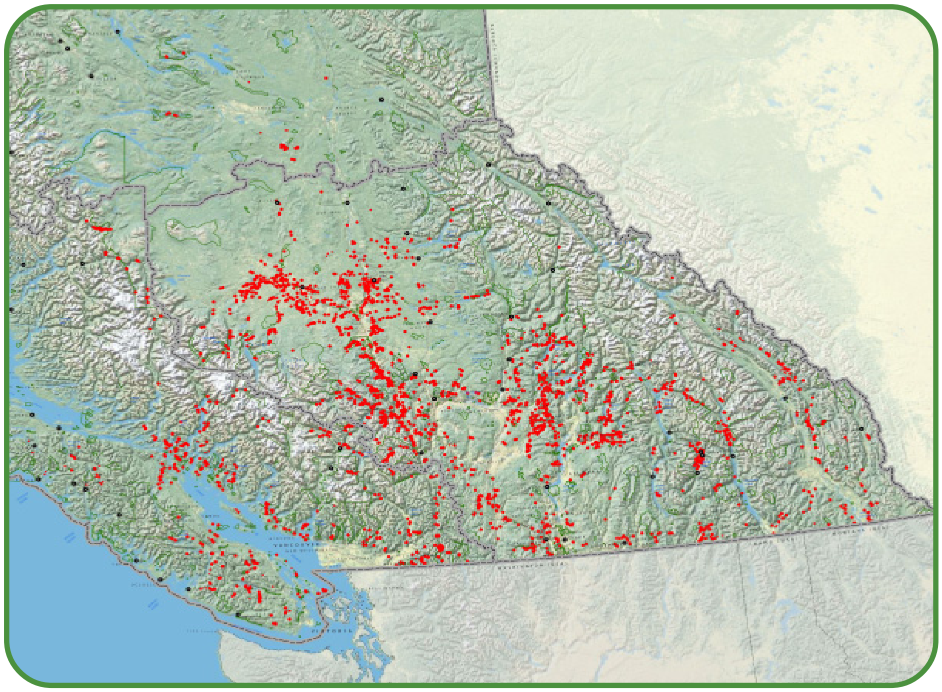


Figure 10. Douglas-fir beetle mortality recorded in BC in 2013.

Attack in the Cariboo Region dropped to less than a quarter of that recorded last year to 2,659 ha. Ground surveys indicated stable populations in Quesnel and 100 Mile House TSAs (i.e., even green to red attack ratios) but rising populations in Williams Lake TSA with an average green to red attack ratio of 5:3, where sites of 40:1 were relatively common.

The majority of the infestations in the Cariboo Region continued to occur in Williams Lake TSA, where 2,182 ha were affected. Concentrations of attack occurred along the Chilko and Taseko Rivers and around The Dome, with scattered primarily spot infestations recorded throughout the TSA. 100 Mile House TSA sustained 312 ha of mortality chiefly around China Gulch and Mt. Bowman, with scattered spots elsewhere. Most of the 165 ha recorded in Quesnel TSA occurred near Taharti Lake and Tingley Creek in the south, with a few spots mid TSA and along the Blackwater River in the north.

Damage in the Thompson/Okanagan Region rose slightly to 1,938 ha. Lillooet TSA contained 528 ha and Kamloops TSA 299 ha. The remaining attack in this region occurred in the Merritt TSA, where 92 ha were delineated. Infestations were very small (many spot size) and were widely dispersed throughout the TSAs with the exception of Kamloops TSA where most of the attack was in the southern half. Ground observations generally noted a population increase. An aggressive trap tree and salvage program in Kamloops TSA appears to be successfully managing infestations.

Conversely, many of the infestations in Okanagan and Lillooet TSA are on steep, difficult access sites so control is challenging. Okanagan TSA sustained the majority of the damage with 1,019 ha mapped.

Douglas-fir beetle caused mortality in Lillooet TSA

Kootenay/Boundary Region infestations rose twenty percent over last year to 1,714 ha. Invermere TSA continued to be the most affected, chiefly along the Kootenay River. Douglas-fir beetle mortality was mapped on 491 ha in the Arrow TSA, primarily at the north end of Kootenay Lake and east of Creston. The other TSAs in the region sustained <240 ha each in dispersed infestations.

Douglas-fir beetle attack observed in the West Coast Region totalled 1,551 ha. Arrowsmith TSA contained 786 ha of the damage with concentrations on Walbran Creek, east of Trevor Channel and west of Nanaimo. A total of 580 ha were mapped in Kingcome TSA, primarily in the Vernon Lake area. Strathcona and Mid Coast TSAs had 146 ha and 39 ha of damage, respectively, along the eastern edges of the TSAs.

South Coast Region mortality decreased slightly to 1,360 ha. It was noted that damage was generally associated with laminated root disease or windthrow. The Sunshine Coast TSA contained 853 ha of attack, mainly in the western half. Infestations in the Fraser TSA were widely dispersed and totalled 431 ha. Soo TSA damage occurred chiefly in the eastern half with 77 ha of attack.

Area affected in the Omineca Region was less than a third of that recorded in 2012, with 611 ha mapped. All the attack occurred in Prince George TSA, primarily along the Blackwater River and around Naltesby, Norman and Francois Lakes.

Douglas-fir tussock moth, *Orgyia pseudotsugata*

A recent Douglas-fir tussock moth outbreak in the Thompson/Okanagan Region damaged 16,303 ha to 17,512 ha annually from 2009 to 2011, with a sharp decline to only 87 ha last year. In 2013, no Douglas-fir tussock moth defoliation was recorded.

Douglas-fir tussock moth populations are monitored each year with six-cluster pheromone traps at permanent monitoring sites in the 100 Mile House, Boundary, Kamloops, Lillooet, Merritt and Okanagan TSAs. Outbreaks of this defoliator usually develop rapidly so this system is designed to provide early warning of rising populations to expedite treatments.

As the latest outbreak subsided in Thompson/Okanagan Region trap catches dropped as well, with average trap catches per TSA recorded this year at the lowest level in eight years (Table 5). All sites in the Okanagan, Boundary, Merritt and Lillooet TSA reported very low numbers. A few sites in the Kamloops TSA still had relatively higher moth catches per trap, at Heffley Creek (28 moths/trap), Monte Creek (18 moths/trap) and three sites around Veasy Lake (17, 28 and 29 moths/trap). Some discrete pockets of egg masses have also been found near Heffley Creek and Robbins Range area.

Table 5. Average number of Douglas-fir tussock male moths caught per trap, 2006 – 2013 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)	2.0 (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)
2012	1.4 (31)	1.0 (9)	12.8 (19)	3.2 (1)	5.5 (11)	9.1 (11)
2013	3.6 (30)	0.2 (9)	8.5 (19)	0.7 (1)	0.7 (10)	0.2 (10)

Interestingly, average trap catches in the 100 Mile House TSA of the Cariboo Region rose this year. Three sites on the southern boundary with Kamloops TSA caught more than 15 moths/trap for the second consecutive year. A record catch of 17 moths/trap for one site east of French Bar near the Fraser River was by far the furthest north and highest numbers ever recorded in that general area.

Based on trap catches in 2013, no treatment program is planned for 2014.

Laminated root disease, *Phellinus sulphurascens*

Laminated root disease infections are located throughout southern British Columbia, though most are not discernible during the aerial overview surveys. Damage changes due to root disease are relatively slow, so large differences in recorded damage are most likely a factor of differing visibility conditions and varying surveyor knowledge. Most of the infection centers identified during the surveys have been in the West Coast Region from local knowledge of the surveyors. Observed damage was only from *Phellinus sulphurascens* that causes root disease in Douglas-fir.

Identified laminated root disease damage in the West Coast Region increased from 127 ha in 2012 to 603 ha this year. Three quarters of the damage (460 ha) was rated as light, with 127 ha moderate and 16 ha severe (mostly in spots). Fraser TSA sustained the highest level of damage with 437 ha mapped. Most of the damage was recorded in two large polygons in Sunshine Valley, with the remaining infections centers scattered and very small. In Sunshine Coast TSA, two polygons on Quatam River and one polygon on Goat Island accounted for most of the 159 ha delineated. Damage was scattered in small spots totalling 6 ha in Arrowsmith TSA, with an additional 2 spots in Strathcona TSA and 1 spot in Soo TSA.

Douglas-fir decline

For the first time in the history of the aerial overview surveys, Douglas-fir decline was identified in Okanagan TSA on the west side of Sugar Lake. Six small polygons totalled 130 ha of light damage. The damage to these stands was first observed last year, but was recorded as drought.

As with other declines, a combination of factors seem to be working together to cause a general decrease in health of the stands. In this case it is suspected to be a mixture of Armillaria root disease, Delphinella needle cast and possibly chronic drought stress related to thin rocky soils. Symptoms included thin crowns, dying tree tops and scattered tree mortality. These symptoms may be indicative of changing climatic effects on dry transitional sites. Ground observations noted similar symptoms over the last several years in the Kootenays, particularly near Trout Lake, but as damage was less extensive it was not visible from the aerial overview surveys.

Damaging Agents of Spruce

Spruce beetle, *Dendroctonus rufipennis*

Spruce beetle damage was mapped at a peak of 315,953 ha in 2003. Attack was subsequently low until last year when mortality rose to 42,892 ha. In 2013 damage subsided again to 18,694 ha, with intensity levels lower as well at 8,302 ha trace (44%), 5,187 ha light (28%), 4,508 ha moderate (24%) and 697 ha severe (4%).

Damage in the Omineca Region rose substantially to 7,653 ha but most (94%) was rated as trace mortality. Some of the ground checked infestations were found to be mainly balsam bark beetle attack. The majority (7,208 ha) of attack was mapped in the Prince George TSA, primarily in the north tip along the Skeena River and a few scattered smaller polygons around Averil Creek/McEwan Lake and Parsnip River. Widely scattered infestations in the Robson Valley TSA accounted for the remaining 445 ha in the region. Although nothing was seen during the aerial overview surveys, ground reconnaissance in the Mackenzie TSA reported some spruce beetle mortality. One infestation of 120 ha was confirmed in the Nation River area, which will be treated with harvesting. A second area of attack of approximately 110 ha was observed in the Burden Lake area, which will be ground checked to assess the beetle population and if necessary provide treatment recommendations. A small infestation (<5 ha) was also noted within a woodlot on the east side of Williston Lake.

Spruce beetle mortality decreased six fold in the Cariboo Region since 2012, with 4,686 ha affected. Williams Lake TSA continued to sustain most of the damage with 4,686 ha affected, mainly along the eastern reaches of Horsefly Lake and Quesnel Lake. Infestations in 100 Mile House TSA continued at a much decreased level in the Mt. Hendrix area, with 417 ha mapped. A further 170 ha of attack were delineated north of Flat Top Mtn. in the Quesnel TSA.

Damage levels in the Thompson/Okanagan Region remained relatively static at 3,011 ha. Kamloops TSA continued to lead this region, with 1,502 ha of mortality noted, primarily around Falls Creek and Silwhoiakun/Todd Mountains. Mortality continued to occur in isolated stands at high elevations near Flat Top Mountain in the southern tip of the Merritt TSA and a few other scattered locations, totalling 869 ha. The Flat Top Mountain infestation also spilled into Okanagan TSA, causing 350 ha of damage. The remaining 290 ha of attack in the region occurred in scattered locations in Lillooet TSA.

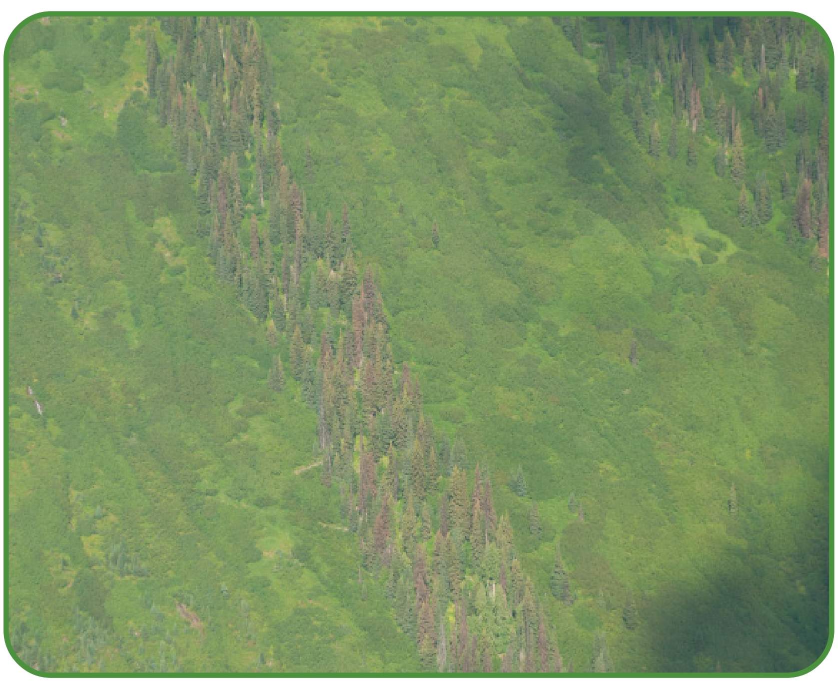
Infestations in Kootenay/Boundary Region almost quadrupled over last year, with 2,194 ha recorded. Almost all of the 2,130 ha damage continued to be mapped in Invermere TSA around Franklin Peaks. Attack in Golden TSA covered 64 ha, primarily north of Moonraker Peak. One spot infestation was also noted in Cranbrook TSA.

South Coast Region damage remained relatively constant at 897 ha. Most of this continued to be spillover from the Flat Top Mountain infestation into the southeast corner of Fraser TSA, where 879 ha were affected. The remaining 18 ha were west of D'Arcy in the Soo TSA.

Infestations in the West Coast Region remained small and scattered with 47 ha in Arrowsmith TSA, 43 ha in Mid Coast TSA and a few spots in Kingcome TSA.

Skeena Region infestations remained very low with only a total of 90 ha of damage recorded. Widely dispersed attack accounted for 66 ha in the Lakes TSA, with an additional 20 ha observed in one polygon along Kitsuns Creek in Kispiox TSA. All other infestations were minor with less than 3 ha per TSA. Monitoring around the large 2010 wildfires and blowdown confirmed that spruce beetle activity is very low in the region.

Spruce beetle attack in the Northeast Region affected 71 ha. One spot infestation was recorded in the Fort Nelson TSA, with the remaining hectares located in Dawson TSA around the Mt. Anderson area.



Spruce beetle mortality along Quesnel Lake in Williams Lake TSA

Damaging Agents of True Fir

Western balsam bark beetle, *Dryocoetes confusus*

After a sharp decrease in 2011, western balsam bark beetle damage doubled for the second consecutive year to 1,320,574 ha provincially (Figure 11). Intensity levels decreased slightly, with the bulk (98%) of the mortality intensity rated as trace. Balsam bark beetle mortality tends to occur at chronic levels in the same general stands, year after year. The low attack levels are reflected in the high percentage of trace intensity that is mapped. If levels swing slightly in a given stand, surveyors may change from mapping large trace polygons to small spots, or visa-versa. This can result in large swings in hectares that do not actually reflect significant population changes.

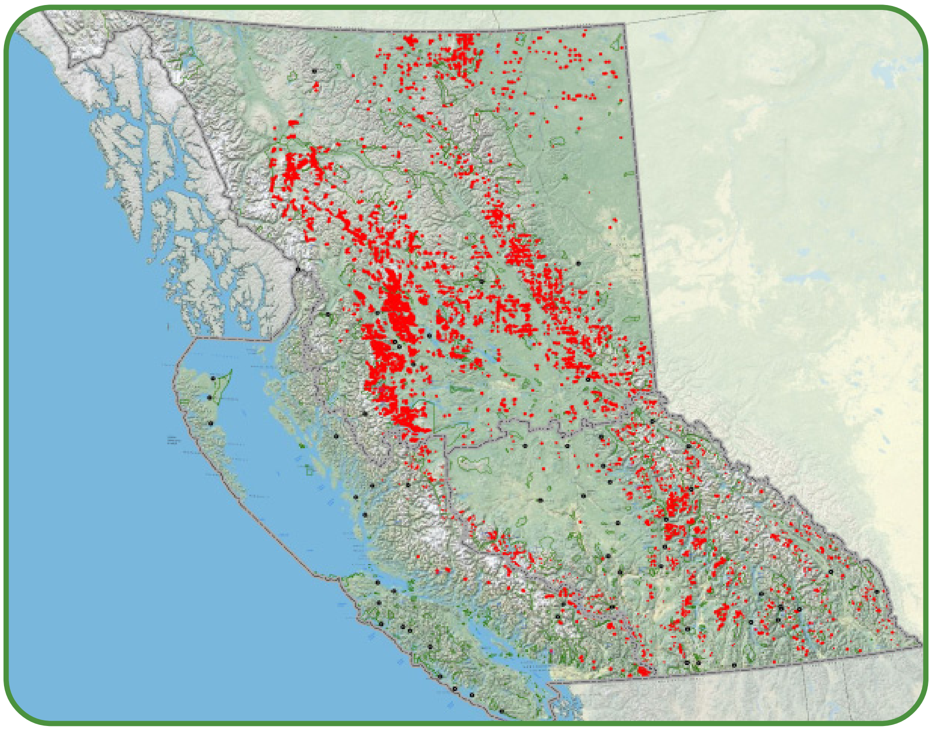


Figure 11. Western balsam bark beetle damage mapped in 2013.

The amount of area surveyed in the northern interior changes year to year and greatly affects the total area of damage recorded each year. The northern interior is where the majority of the western balsam bark beetle attack occurs. An increase in area flown in the Skeena Region partially accounted for damage more than doubling over last year to 833,003 ha. Attack was widespread in the Bulkley, Morice and Kispiox TSAs with 196,904 ha, 185,225 ha and 172, 724 ha affected, respectively. Infestations were in the same general areas as 2012, but had expanded. Mortality in Cassiar TSA was primarily mapped mid TSA in the southern portion, with 135,910 ha delineated. Almost all of the 75,155 ha observed in Lakes TSA occurred in the southwest tip of the TSA. Conversely, 59,335 ha mapped in Nass TSA was all along the northern boundary. The remaining attack in the region occurred in Kalum TSA where over 7,751 ha of damage was mapped north of Pillar Peak.

Area damaged by western balsam bark beetle doubled in the Omineca Region since last year with 250,614 ha recorded. Prince George TSA continued to be most affected, with 131,887 ha, primarily located in Fort St. James District. Disturbances in Mackenzie TSA rose to 111,136 ha, with concentrations of attack occurring north of Peace Reach in Williston Lake. Infestations actually decreased in Robson Valley TSA, where 7,591 ha were mapped along the western edge of the TSA.

Infestations in the Thompson/Okanagan Region decreased by 14% since 2012 to 135,533 ha. Scattered attack in Kamloops TSA continued to cause the most damage in the region with 71,783 ha mapped. Mortality in Okanagan TSA totaled 50,771 ha with concentrations around Jubilee, Tahetkun, Mara and Pukeashun Mountains. Infestations mostly located along the western boundary of Merritt TSA accounted for 10,353 ha of damage. Scattered polygons in Lillooet TSA totalled 2,625 ha.

Northeast Region contained 41,524 ha of damage. Area of attack increased substantially in Fort Nelson TSA to 24,687 ha, mainly north of the Liard River Grand Canyon to the Alaska border. Dawson Creek TSA decreased to 13,226 ha in small disturbances dispersed along the western edge of the TSA. Fort Nelson TSA had 3,611 ha of attack, located around Mt Ludington and east of Buick on Beatton River.

Infestations in the Cariboo Region declined to 25,898 ha, almost half the level recorded last year. Disturbances in Williams Lake TSA totaled 19,036 ha and continued to be found along the southwest border and in the northeast tip east of Horsefly. Quesnel TSA damage fell to 4,944 ha with concentrations mainly around Bald Mountain and the Bowron Lakes chain.


Western balsam bark beetle mortality in Invermere TSA

Western balsam bark beetle damage almost quadrupled in the South Coast Region with 13,998 ha affected. Almost all (13,507 ha) occurred along the eastern edge of the Fraser TSA. A few disturbances along Sockeye Creek, near Halymore Creek and north of Arrowhead Mountain accounted for 434 ha of mortality in the Soo TSA. The remaining 40 ha were mapped south of Good Hope Mountain in the Sunshine Coast TSA.

Infestations totalling 11,294 ha in the Kootenay/Boundary Region were small and widely scattered throughout all TSAs. Most affected was Invermere TSA where 4,025ha were recorded.

The West Coast Region sustained 8,710 ha of damage of which almost all (8,483 ha) was contained in the northern tip of the Mid Coast TSA. Kingcome and Strathcona TSAs sustained 224 ha and 3 ha of attack, respectively.

Two-year-cycle budworm, *Choristoneura biennis*

Two-year-cycle budworm damage in BC generally peaks north of Prince George during odd years, and is highest during even years south of Prince George, when the larvae are large. In 2013 defoliation rose slightly over last year to 88,760 ha, with virtually all the damage rated as light intensity (<1% moderate). Despite 2013 being a peak year for northern BC damage, all disturbances were recorded in the south (Figure 12). This is in contrast to the peak of the recent outbreak in 2009 (the largest by far ever recorded since the province has been responsible for the aerial overview surveys) of 396,855 ha, with a record 65% of the defoliation assessed as moderate to severe.

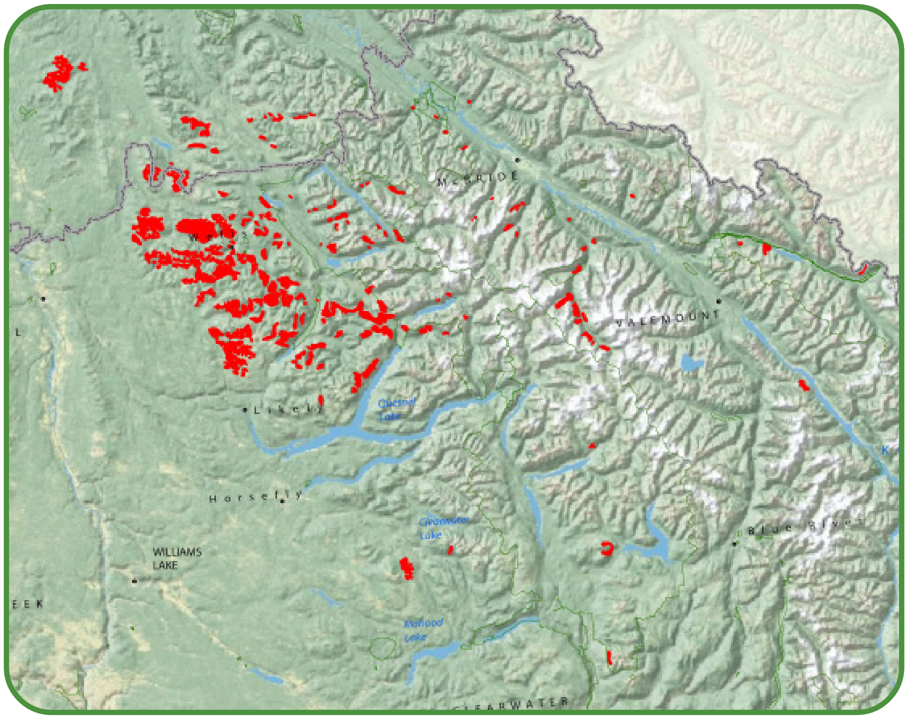
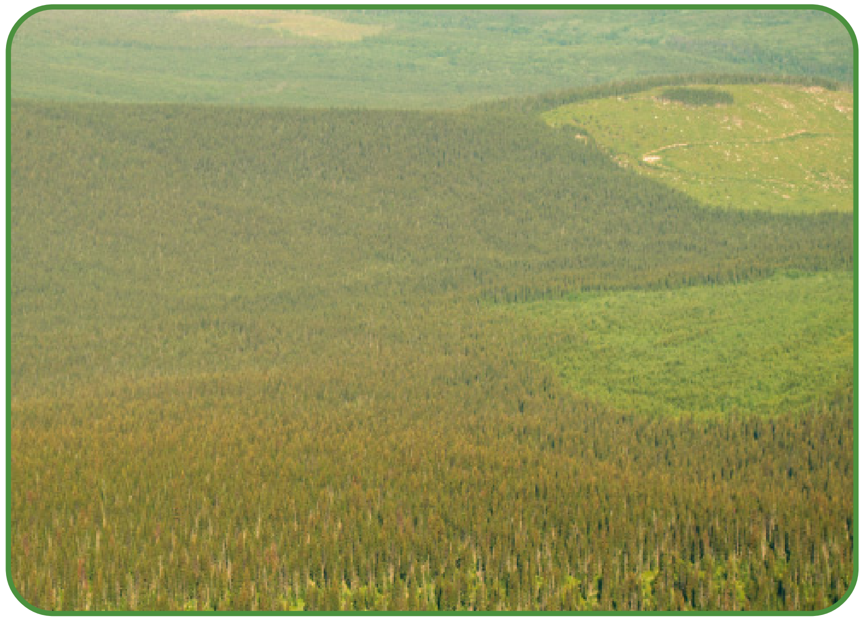


Figure 12. Two-year-cycle budworm defoliation mapped in 2013.

Two-year-cycle budworm egg masses

Despite 2013 being in the first year of the two-year-cycle budworm cycle, damage in the Cariboo Region almost doubled over last year to 71,823 ha. Defoliation in Quesnel TSA totalled 54,250 ha, which was all mapped east of Coldspring House. This infestation spilled into Williams Lake TSA, affecting 16,802 ha primarily northeast of Quesnel Forks and a small area south of Bosk Lake. Around Hendrix Lake in the northeastern tip of 100 Mile House TSA, a further 771 ha of damage was delineated. Licensees in Quesnel TSA are becoming concerned about the effect of two-year-cycle budworm damage combined with western balsam bark beetle mortality. Treatment with Btk is being considered in modified harvest areas to protect key habitat values. Where a trial spray program was conducted last year near Mt. Tom, egg mass sampling was conducted in the three treatment blocks and in a control area this summer. The results of this survey showed that treatment reduced egg mass deposition by 83 – 88%.

In the Omineca Region infestations increased a quarter over 2012 to 15,803 ha. Prince George TSA sustained 9,836 ha of the attack along the southern border east of Teapot Lake and around Mt. George. Scattered defoliation in the Robson Valley TSA accounted for the remaining 5,967 ha mapped in the region, with one concentration along Raush River. All the damage delineated in the Thompson/Okanagan Region was in Kamloops TSA with 1,134 ha recorded. This defoliation was mapped in three polygons west of Trophy Mtn., west of Murtle Lake and at the northeast tip of Azure Lake.



Two-year-cycle budworm defoliation around Mt. George

Ground observations in the Skeena Region concurred that the outbreak there has subsided to endemic levels, with very little defoliation noted anywhere.

Balsam Woolly Adelgid, *Adelges piceae*

After a peak of 415 ha mapped in the coastal regions last year, balsam woolly adelgid damage fell to 85 ha in 2013. Severity was noted as 76 ha (90%) light, 7 ha (8%) trace and 2 ha (2%) severe. The South Coast Region continued to sustain the majority of the damage, with 39 ha recorded north of Toba Inlet in Sunshine Coast TSA and 24 ha east of Cheam Peak in Fraser TSA. The remaining 22 ha of disturbances were delineated in South Island TSA of the West Coast Region. Most of the damage was along the Moyeha River, with a few spots further south along Carmanah Creek and near Sproat Lake.

It is unlikely that balsam woolly adelgid infestations have dropped as dramatically as the numbers would indicate. It is a difficult forest health agent to identify from the air, and it is most likely that not as much foliage was red this year (the same polygons identified last year were specifically re-checked in 2013).

For the first time, balsam wooly adelgid occurrence was confirmed on subalpine fir in and around Rossland and Red Mountain in the Arrow TSA.

Damaging Agents of Hemlock

Western blackheaded budworm, *Acleris gloverana*

The current western blackheaded budworm outbreak continued this year, with 30,475 ha defoliated in the West Coast Region. This was down 13% from last year although damage intensity was higher with 14,666 (48%) light, 10,761 ha (35%) moderate and 5,048 ha (17%) severe.

The majority of the attack occurred in Kingcome TSA, with 28,421 ha affected. This was similar to the damage recorded in this TSA last year, though the heaviest impacted polygons have shifted from Holberg Inlet to the southeast and are now centered around Port Alice and Quatsino Sound. Severe polygons were mapped east of Alice Lake towards Port McNeill.

Western blackheaded budworm defoliation near Holberg Inlet

Infestations in Strathcona TSA increased to 1,331 ha, located along the boundary of the Kingcome TSA from Power River east to Pinder Peak.

The Haida Gwaii TSA outbreak peaked in 2009 at 87,497 ha and continued to decline as expected this year to 723 ha of primarily (83%) light defoliation. Small scattered polygons were delineated from Masset Inlet south to Puffin Cove. An additional 225 ha of mortality caused by repeated western blackheaded budworm defoliation was mapped at Alliford Bay on Skidegate Inlet.

Western hemlock looper, *Lambdina fiscellaria lugubrosa*

Recorded Defoliation

A western hemlock looper outbreak reached a peak last year in BC with 8,103 ha of damage. In 2013 the outbreak declined rapidly, with only 841 ha of current defoliation recorded in the Kootenay/Boundary Region. Severity was rated as 674 ha (80%) moderate and 167 ha (20%) severe.

Revelstoke TSA sustained 502 ha of damage along Revelstoke Lake near Carnes Creek. Defoliation in Golden TSA was along Beaver River and Ursus Creek, totalling 150 ha. On the south edge of Trout Lake, an infestation straddled the Arrow and Kooteney Lake TSAs, causing 107 ha and 82 ha of damage, respectively.

When a defoliator outbreak is finished in a particular area and mortality has occurred, it is delineated once as polygons with rough percentages of dead trees. In 2013 1,094 ha of mortality were recorded in Williams Lake TSA of the Cariboo Region. Mortality ranged from 5% to 40% within mapped disturbances, which were observed along Quesnel Lake. A further 84 ha of 15% mortality were delineated in three polygons in Okanagan TSA in the Thompson/Okanagan Region, near Canoe and Seymour Arm.

Population Monitoring

Pheromone traps have been used annually since 2003 (the end of the last outbreak) to monitor western hemlock looper populations in areas of the southern interior where chronic damage has occurred. Trap catches were subsequently low until 2008, then rose for four consecutive years. These catches combined with ground observations from tree beatings, egg counts and visible defoliation in small areas indicated an outbreak was imminent last year. The damage peak last year was much lower than the 39,400 ha reported in 2003, in part due to a successful treatment program last year with B.t.k. on 8,769 ha in the Kootenay/Boundary Region.

Trap catches began to decrease last year and continued to decline substantially in 2013, reflecting the collapse of the western hemlock looper population (Table 6). All individual site catches were down in all areas. The highest site catches were in the Revelstoke TSA, with an average of 170 moths per trap at Tangier and 137 at Begbie Creek. This was still far below the 2011 peak catches. Three tree beatings for larval counts were also conducted at permanent sample sites throughout the Kootenay/Boundary and Thompson/Okanagan Regions, and both species and abundance of defoliators were found to be very low this year. Neither monitoring traps nor three tree beatings were conducted in the Cariboo Region in 2013.

With the low expected populations, no treatment program is planned for 2014.

Table 6. Average number of western hemlock looper male moths caught per trap at various MFLNRO monitoring sites (6-trap clusters per site), 2006 - 2013.

Year	TSA (# sites)		
	Kamloops (6)	Okanagan (10)	Revelstoke (11)
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
2012	130.1	564.9	483.9
2013	6.4	74.9	80.2

Damaging Agents of Larch

Larch needle blight, *Hypodermella laricis*

After relatively low levels of damage from 2007 to 2010, disturbances caused by larch needle blight infections rose to just over 30,000 ha for the past two years in the southern interior. This year damage subsided again to only 6,043 ha. Intensity was lower as well, with 5,281 ha (84%) light, 1,006 ha (16%) moderate and 17 ha (<1%) severe. Declines occurred in all affected TSAs, and most of the mapped disturbances were small and widely dispersed. Species affected were evenly split between alpine larch and western larch. Ground observations noted that needle blight damage in western larch was primarily confined to the lower half of the trees this year, which made it very difficult to see from the air.

Larch needle blight damage Okanagan TSA

The majority (6,043 ha) of larch needle blight damage continued to be observed in the Kootenay/Boundary Region. Cranbrook and Kootenay Lake TSAs sustained similar levels of damage, with 2,554 ha and 2,255 ha affected, respectively. Infections in the southern half of the Arrow TSA totalled 676 ha of damage and disturbances along the southern edge of Invermere TSA affected 353 ha. The remaining damage in the region occurred in Boundary and Golden TSAs, with 133 ha and 72 ha mapped, respectively.

Larch needle blight damage Okanagan TSA

Damage in the Thompson/Okanagan Region remained relatively static, with 261 ha recorded. Stands affected by larch needle blight in Okanagan TSA were primarily around the Shuswap River area with 258 ha of damage observed. Kamloops TSA contained the remaining 3 ha in one stand east of Raft Mtn.

Damaging Agents of Cedar

Yellow-cedar decline

Observed yellow-cedar decline damage almost doubled over the past two years to 18,667 ha along the coastal TSAs of Skeena and West Coast Regions (Figure 13). Intensity of damage also increased to 4,770 ha (26%) trace, 11,052 ha (59%) light, 2,423 ha (13%) moderate and 422 ha (2%) severe. Most of the polygons mapped this year occurred in the same general drainages as previous disturbances, but very few overlapped previously recorded damage.

Skeena Region was the most affected with a total of 10,608 ha delineated. Most (10,198 ha) occurred in the North Coast TSA all along the coastline and on a few islands. This is more than four times that recorded last year when surveyors suspected that drought damage was masking the yellow-cedar decline signature. A further 409 ha were detected in Kalum TSA around Kitimat Arm and Kowesas River areas.

West Coast Region contained 8,059 ha of damage, primarily in the Mid Coast TSA where 6,347 ha were mapped. Most of the mortality was observed around the Don Peninsulaa and Burke Channel areas. The remaining 1,712 ha of yellow-cedar decline damage were delineated in Kingcome TSA, with concentrations south of Seymour River and north of Knight Inlet.

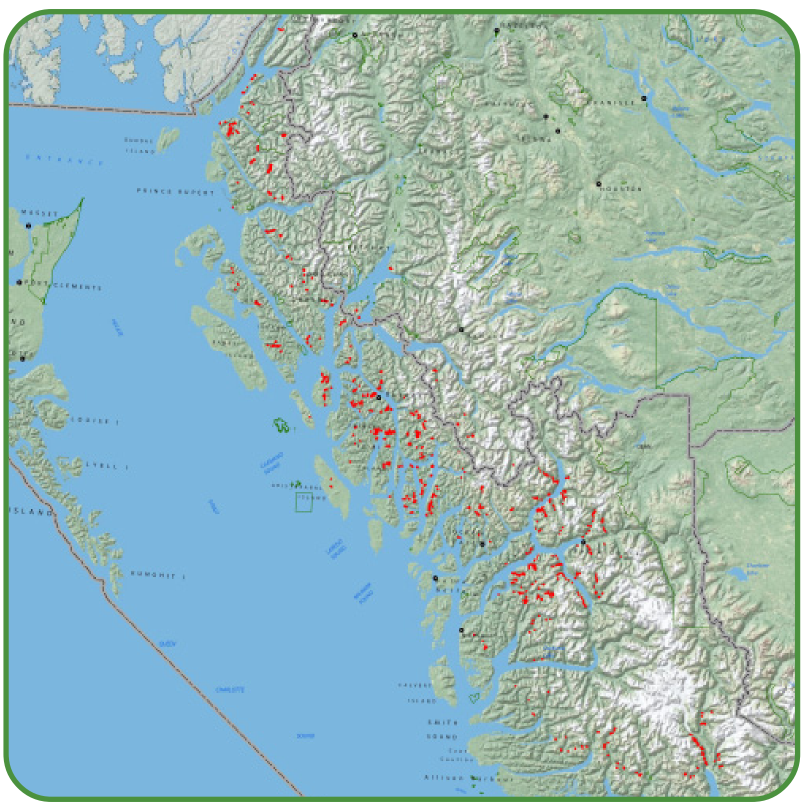


Figure 13. Yellow-cedar decline damage mapped in 2013.

Damaging Agents of Deciduous Trees

Aspen (serpentine) leaf miner, *Phyllocnistis populiella*

The present aspen (serpentine) leaf miner outbreak has resulted in large areas of damage throughout the interior of the province since 2009 when 109,609 ha were affected. Infestations have risen annually since then to a record peak of 2,577,703 ha in 2013 (Figure 14). For the third consecutive year aspen leaf miner has affected more hectares than any other damaging agent except the mountain pine beetle.

Trembling aspen continued to be the primary host but cottonwood stands were also damaged. A total of 1,599 ha of leading cottonwood stands were affected, with a further 351 ha of stands containing a cottonwood component damaged as well.

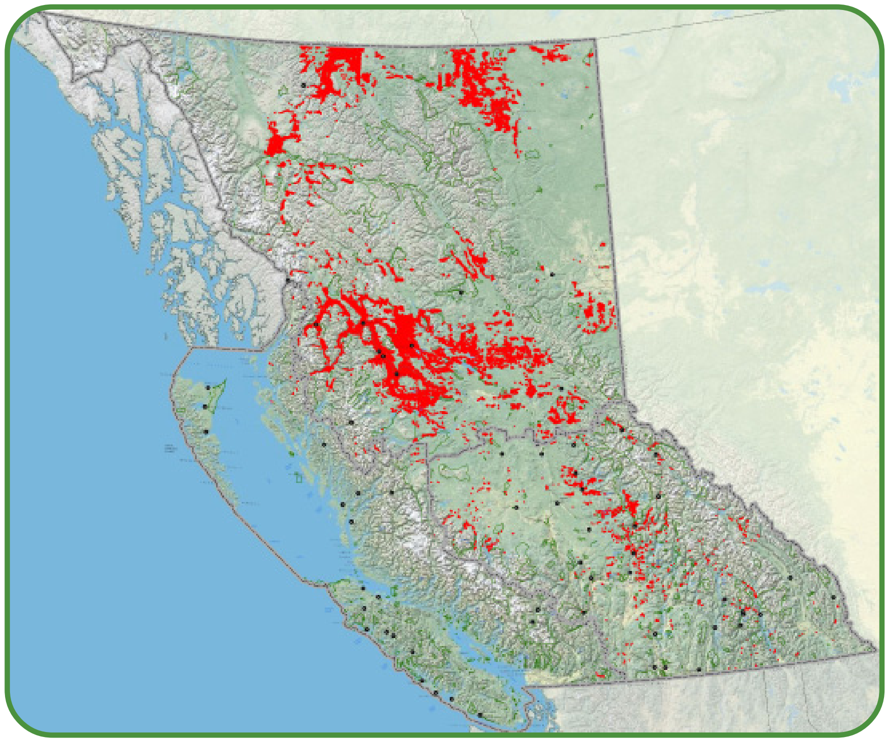


Figure 14. Aspen leaf miner defoliation mapped in 2013.

Intensity of attack (mapped in relation to host component of the stand, for example, light was usually due to a leading conifer component) was assessed as 1,260,622 ha (49%) light, 885,760 ha (34%) moderate, 431,321 ha (17%) severe. In several areas aspen leaf miner damage was mixed with other damaging agents such as Venturia leaf blight, forest tent caterpillar, or satin moth. In these cases it was somewhat difficult to differentiate between the types of damage from the air, as the typical aerial signatures for each agent were mixed.

Aspen leaf miner damage

Aspen leaf miner damage tripled in the Skeena Region over last year to 1,572,645 ha of attack. Damage to many trees was so severe that trembling aspen leaves were dropping by the end of July and re-flushing, although poorly. This type of tree response usually only occurs after severe stripping of leaves by agents such as forest tent caterpillar. It was noted that attacked cottonwood leaves did not drop until the fall, perhaps because they were larger and thicker, and able to survive attack better than aspen. Ground observations noted that the moth flight in late April was massive; it was difficult to walk in the evening in Smithers without inhaling the small moths. Defoliation was highest and increased the most since 2012 in Cassiar TSA to 495,578 ha, particularly in the northeast quarter. Part of the increase was due to greater coverage of the TSA in 2013. Damage in Morice TSA tripled to 356,513 ha mapped throughout the northern two-thirds of the TSA. Infestations along the Skeena, Bulkley, Kispiox and Babine Rivers expanded somewhat to damage 220,815 ha in Kispiox TSA and 204,220 ha in Bulkley TSA. Defoliation in Lakes TSA more than doubled to 192,634 ha, and was mostly located mid TSA around the Francois Lake area. Damage was prevalent in the Skeena and Nass River areas of the Kalum TSA, where 71,579 ha were delineated. Smaller, more dispersed infestations were noted in Nass and North Coast TSAs, with 27,147 ha and 4,157 ha mapped, respectively.

Aspen leaf miner damage more than doubled over 2012 in the Omineca Region to 467,575 ha. Most of the defoliation (390,930 ha) continued to occur in the Prince George TSA. Infestations were most prevalent mid TSA, particularly from McLeod Lake south to Coffeepot Mtn. and north of Prince George. Area damaged in the Mackenzie TSA doubled to 67,071 ha, with expansion primarily along Williston Lake and Mesilinka River. Defoliation scattered along the Fraser River in Robson Valley TSA accounted for the remaining 9,574 ha of damage in the Omineca Region.

Aspen leaf miner and Venturia blight damage in Bulkley TSA

Northeast Region sustained 420,548 ha of aspen leaf miner defoliation in 2013. Most of the damage (384,720 ha) continued to occur in Fort Nelson TSA, though infestations moved to mid TSA and west along the Liard and Kechika Rivers. A total of 34,295 ha were mapped in Dawson Creek TSA, mainly from Pine River south to Thunder Mountain. Defoliation actually decreased in Fort St. John TSA to 1,533 ha, located along the Peace River and northwest of German Lake.

Defoliation in the Cariboo Region rose slightly to 49,408 ha. The majority of the damage (32,408 ha) continued to occur in Williams Lake TSA, particularly in the Quesnel Lake area. Infestations continued to affect stands in the eastern half of 100 Mile House TSA, with 8,905 ha delineated. Damage in Quesnel TSA decreased slightly, to 7,818 ha.

The Thompson/Okanagan Region sustained 54,787 ha of damage, up a third from last year. The majority of the attack continued to be in Kamloops TSA, with 44,104 ha recorded, primarily mid TSA. Scattered infestations in the northern two-thirds of Okanagan TSA covered 8,129 ha. Small disturbances in the Merritt and Lillooet TSAs totalled 2,049 ha and 505 ha, respectively.

Infestations in Kootenay/Boundary Region decreased somewhat to 10,271 ha. Patches of defoliation were small and scattered, with Golden TSA sustaining the most damage with 3,686 ha affected, primarily mid TSA along the Columbia River. Defoliation in the remaining TSAs ranged from 2,130 ha to 178 ha.

Of the 2,028 ha recorded in the West Coast Region, most (1,999 ha) continued to be observed in the northern tips of the Mid Coast TSA. The remaining 29 ha were mapped near Trophy Lake in Kingcome TSA.

For the first time aspen leaf miner was recorded on 441 ha in the Fraser TSA of the South Coast Region. Damage occurred to cottonwood stands along Silverhope Creek and Skagit River, and was combined with cottonwood leaf rust.

Aspen leaf miner damage on cottonwood in Fraser TSA

Venturia blight, *Venturia spp.*

Venturia blight damage, also known as aspen and poplar leaf and twig blight, has been mapped annually during the aerial overview surveys in the northern interior to some extent since the Provincial government has been conducting the surveys, with the exception of 2005 and 2006. Until 2011, total area damaged annually remained below 82,000 ha and from 2005 to 2010, less than 9,000 ha were affected each year. As of 2011, damage leapt dramatically to a record 125,314 ha and continued to rise to 641,982 ha last year. In 2013 this trend continued with a record 837,586 ha of Venturia blight damage mapped provincially (Figure 15). Intensity increased as well, to 357,655 ha (43%) light, 422,950 ha (50%) moderate and 56,981 ha (7%) severe. Most of the affected stands were trembling aspen, but cottonwood was also damaged, particularly in Dawson Creek and Fort St John TSAs. In heavily infected TSAs, polygons were vast and usually followed the host types along river valleys.

Venturia blight and serpentine leaf miner damage, combined

Damage continued to be highest in the Northeast Region, where 439,875 ha were delineated. Fort Nelson TSA sustained 234,421 ha of the damage, particularly around the confluence of the Liard and Toad Rivers, and along the Prophet River. A large increase occurred in Dawson Creek TSA, where 149,787 ha were affected, primarily in the northeast. Infections in Fort St John TSA remained relatively stable with 55,667 ha damaged.

Skeena Region contained 389,127 ha of Venturia blight damage. Although the total for the region went up since last year, damage in some of the TSAs actually went down. Kispiox TSA continued to be the most affected in this region, with 197,589 ha mapped primarily along the Skeena and Bulkley Rivers. This damage continued down into Bulkley TSA where 105,442 ha were mapped. Infections mainly along the Skeena and Nass Rivers in Kalum TSA totalled 56,534 ha. All remaining Skeena Region TSAs had some level of Venturia blight damage, ranging from 600 ha to 11,000 ha.

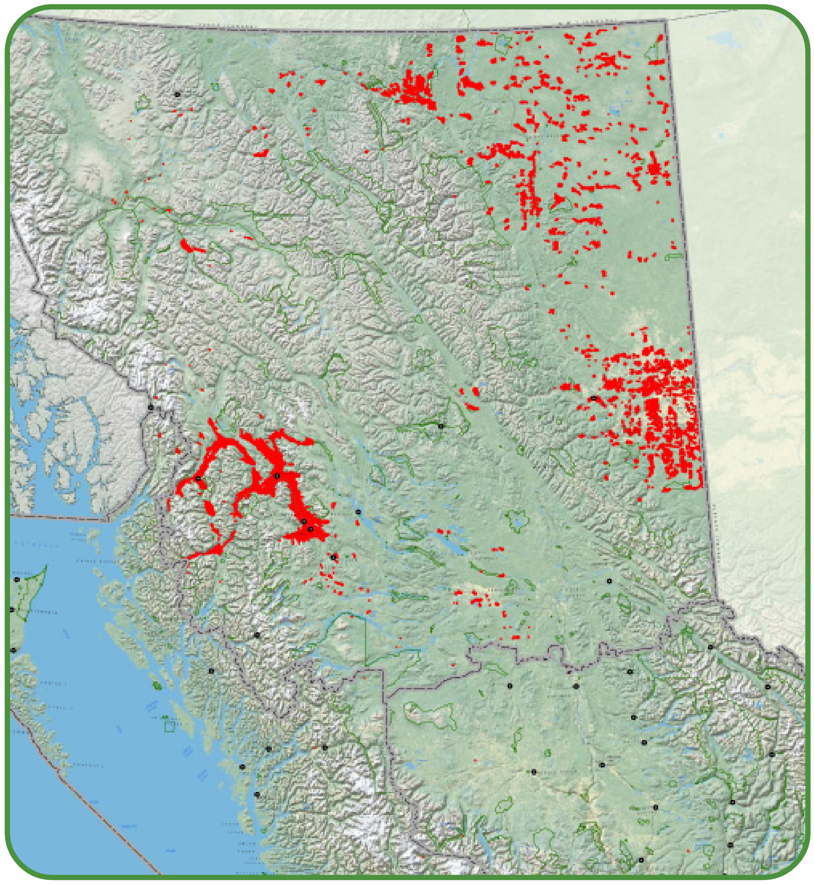


Figure 15. Venturia blight damage mapped in 2013.

Ground observations in the Bulkley Valley noted that because of Venturia blight and serpentine leaf miner damage, there wasn't a traditional leaf colour change in the fall because 90% of the leaves (particularly from Topley to Hazleton) were either gone or very small and brown. Some clones that were heavily affected with Venturia last year were initially thought to be dead in the spring though they did eventually flush with a few sickly leaves, much later than less affected stands.

A total of 8,443 ha of damage was observed in the Omineca Region. Mackenzie TSA had a large increase to 5,742 ha which was all located between Ospika Arm and Manson Arm of Williston Lake. Damage actually declined in Prince George TSA to 2,701 ha, most likely because aspen leaf miner and forest tent caterpillar activity was so prevalent.

Venturia blight damage in Prince George TSA

For the first time, Venturia blight damage was also mapped in small discrete pockets in the southern portion of the province. Damaged stands in the Cariboo Region totalled 68 ha, with 31 ha in Williams Lake TSA, 26 ha in 100 Mile TSA and 12 ha in Quesnel TSA. In the Thompson/ Okanagan Region, 34 ha were affected in Kamloops TSA. Mid Coast TSA of the West Coast Region contained an additional 33 ha of damage.

Forest tent caterpillar, *Malacosoma disstria*

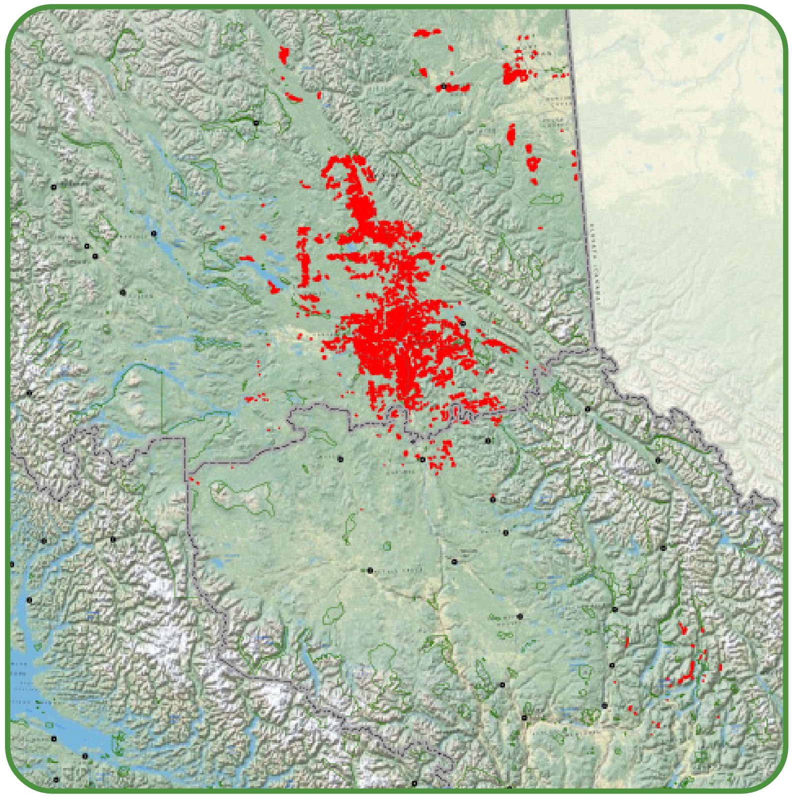


Figure 16. Forest tent caterpillar defoliation mapped in 2013.

The current forest tent caterpillar outbreak began around 2008, with most of the defoliation occurring in the Omineca Region. The outbreak reached a peak in 2011 of 453,139 ha and damage contracted last year to 198,932 ha. Interestingly, damage expanded again this year to a peak of 581,910 ha, with defoliation spreading outward again into the same general areas as 2011, plus additional new areas further northward (Figure 16). Overall intensity was assessed as 118,960 ha (20%) light, 329,564 ha (57%) moderate and 133,387 ha (23%) severe.

The majority of the defoliation continued to occur in the Omineca Region with 507,863 ha affected. Prince George TSA sustained 439,344 ha of damage, primarily in the western portion of the Prince George District, with some expansion into the southern end of the Fort St. James District. Defoliation also expanded substantially into the southern portion of Mackenzie TSA, where 68,249 ha were affected. The remaining 270 ha of attack extended from the Prince George TSA into Robson Valley TSA along the Fraser River, where 270 ha of defoliation was recorded.

Infestations grew substantially in the Northeast Region, with 51,747 ha of damage observed. Dawson Creek TSA contained 43,974 ha of defoliation, mainly along the Peace River and mid TSA east of Murray River. All infestations in Fort St. John TSA were along the southern boundary, totalling 7,773 ha.

Forest tent caterpillar egg mass

Forest tent caterpillar pupal cocoon

Forest tent caterpillar damage in the Cariboo Region grew to 17,570 ha in 2013. Almost all (17,250 ha) were located along the northern edge of Quesnel TSA, and down as far south as Dragon Mountain mid TSA. The remaining 320 ha in the Cariboo Region were located in Williams Lake TSA in two locations near Tezla Lake and north of Likely.

Thompson/Okanagan Region sustained 4,724 ha of attack. Defoliation expanded in the northern tip of Okanagan TSA, with 3,390 ha affected. A total of 1,334 ha of damage was recorded in Kamloops TSA, primarily south of Mt Morrisey and on Harper and Cayenne Creeks.

In the West Coast Region, a small polygon of 7 ha of defoliation was noted in the Arrowsmith TSA near Nanoose Bay.

Aspen decline

Aspen decline symptoms in Dawson Creek TSA

Deciduous declines are difficult to detect from the height of the aerial overview surveys and are hence probably under-estimated. Aspen decline is becoming more obvious however and damage was mapped for the first time in 2011 at 374 ha, with an increase to 4,308 ha last year. In 2013, observed disturbances decreased somewhat to 3,279 ha across the province. Intensity was noted as 1,986 ha (60%) light, 981 ha (30%) moderate and 312 ha (10%) severe. Aspen decline is suspected to be caused by the cumulative damage of defoliators and pathogens exacerbated by drought stress, possibly as a result of climate change.

Noted disturbances in the Thompson/Okanagan Region dropped by more than half of last year's to 1,867 ha. Small scattered polygons in Merritt TSA accounted for 1,580 ha of the damage. Kamloops TSA sustained 151 ha of damage southwest of Cache Creek. Small disturbances along the east edge of Lillooet TSA totalled 110 ha, and the remaining 27 ha were noted in Okanagan TSA.

Observed aspen decline damage of 1,329 ha was recorded for the first time in the Northeast Region. Most of the damage was located in the Peace River area along the borders of Dawson Creek and Fort St. John TSAs, where 1,004 ha and 325 ha were affected, respectively.

The remaining 82 ha were mapped in the Cariboo Region, with 70 ha in 100 Mile House TSA and 12 ha in Williams Lake TSA.

Aspen stand affected by aspen decline in Dawson Creek TSA

Large aspen tortrix, Choristoneura conflictana

For the third consecutive year, large aspen tortrix has caused defoliation of aspen stands in Fort Nelson TSA of the Northeast Region. Damage totalled 2,184 ha, of which 1,887 ha was rated as severe with the remaining 297 ha light. Most of the infestations were located in four polygons at the confluence of Prophet River and Tsachehdza Creek. The remaining 28 ha were recorded south of Dall Lake. The disturbances were not ground checked but large aspen tortrix has historically been the most common defoliator in this TSA.

Birch leaf miner, *Fenusa pusilla*

Birch leaf miner damage decreased to the lowest level observed in four years to 1,415 ha across the southern interior. Intensity of defoliation reduced somewhat as well to 784 ha (55%) light and 631 ha (45%) moderate.

Aside from last year, historically damage has usually been greatest in the Kootenay/Boundary Region, and this trend continued in 2013 with 1,016 ha affected. A total of 439 ha were mapped in Revelstoke TSA, mainly east of Mt. Cartier, south of Goldstream Mtn. and along Nagle Creek. Infestations in Golden TSA accounted for 315 ha located along Wood Arm and around the Citadel Mtn. area. One polygon in Arrow TSA along South Fosthall Creek accounted for 105 ha. Small infestations in the northern tip of Kootenay Lake TSA totalled 82 ha, and the remaining 75 ha were recorded east of Mt. Bleasdell in Cranbrook TSA.

Defoliation in the Thompson/Okanagan Region was a quarter of last year’s total, with 400 ha recorded. Kamloops TSA contained the majority of the attack, with 308 ha affected south of Mt. Morrisey, along Fadear Creek and north of Harp Mtn. The remaining 92 ha of damage was reported in Okanagan TSA in small scattered polygons.

Cottonwood leaf rust, *Melampsora occidentalis*

Cottonwood leaf rust damage covered 708 ha in the Thompson/Okanagan Region in 2013, with intensity assessed as 404 ha (57%) light and 304 ha (43%) moderate. This was up from 159 ha last year, which was the first time this forest health factor was recorded during the aerial overview surveys.

A total of 489 ha of foliage damage was noted in the north half of Okanagan TSA, primarily along Eagle River, Shuswap Lake and south of Mabel Lake. The remaining 219 ha were mapped at the north end of Adams Lake and along Adams River in Kamloops TSA.

Ground checks of damaged cottonwood stands along Silverhope Creek and Skagit River in Fraser TSA found the primary damaging agent to be serpentine leaf miner, though cottonwood leaf rust was also a contributing factor.

Satin moth, Leucoma salicis

Satin moth damage remained low in the southern interior in 2013, with a total of 234 ha mapped. Two-thirds of the defoliation was rated as moderate (153 ha), 62 ha (26%) as severe and the remaining 19 ha (8%) light. The majority of the damage (169 ha) was located in small scattered pockets in the southern half of Okanagan TSA. 100 Mile House TSA sustained 26 ha of attack in the Vidette/ Deadman area on the border with Kamloops TSA where an additional 20 ha were mapped. The remaining 19 ha were recorded in Merritt TSA west of Kingsvale near Maka Creek.

Several of these infestations were ground checked, as the defoliation's aerial signature was had an unusual pinkish hue. Most satin moth infestations result in complete tree defoliation by the time of the aerial survey and are recognized by their grey signature. Ground observations attributed the odd coloration to trees that were also infected with Venturia blight. Infected leaves seemed to be avoided by the satin moth, hence the trees were only partially defoliated.

Satin moth egg mass with larvae

Satin moth adult

Satin moth cocoon

Cottonwood leaf beetle, *Chrysomela scripta*

Cottonwood leaf beetle caused light damage in two adjacent polygons totalling 50 ha. The stands were located in the Arrow TSA of the Nelson Region, in-between Castlegar and Grassy Mountain. Species affected were cottonwood, aspen and willow. Minor aspen skeletonizer (*Phratora purpurea pururea*) activity was also noted, as was aspen leaf miner.

These sites were confirmed with a ground check, as the stand signature from the air was unusual: brownish as opposed to the common silver cast caused by just aspen leaf miner in many nearby stands.

Another unidentified leaf beetle (species unconfirmed) was also observed to be severely skelotonizing scattered clumps of willow in Kamloops and Okanagan TSAs of the Thompson/Okanagan Region.

Cottonwood leaf beetles

Gypsy moth, *Lymantria dispar*

For several decades pheromone traps have been used for monitoring incursions of gypsy moth (both North American strain of European (NAGM) and Asian) into British Columbia. In 2013, several thousand Canadian Food Inspection Agency (CFIA) and the BC FLNRO traps deployed during the summer caught 13 male gypsy moths, compared to only 3 in 2012 (Figure 17). All positive traps contained NAGM. All but one moth were caught in the same general areas where moths have been located over the last 10 years suggesting that these areas are prone to re-introductions or there is a very low level population that may be persisting in these areas but trapping grids cannot accurately locate their origin. The lone moth located in the interior was caught at a rest stop at McCleese Lake in the Cariboo Region and is likely from a recreational vehicle. Fortunately, two other interior locations that had positive results (Revelstoke and Kaslo) in 2011 and 2012 did not have any new finds reported in 2013 and these populations are assumed to have died out on their own. More intense trapping will occur in the summer of 2014 to obtain more accurate information on the location of the infestations detected in 2013 which may lead to treatments in spring 2015. Trapping results and any treatment announcements are posted on the MFLNRO web site at: www.for.gov.bc.ca/hfp/gypsymoth/

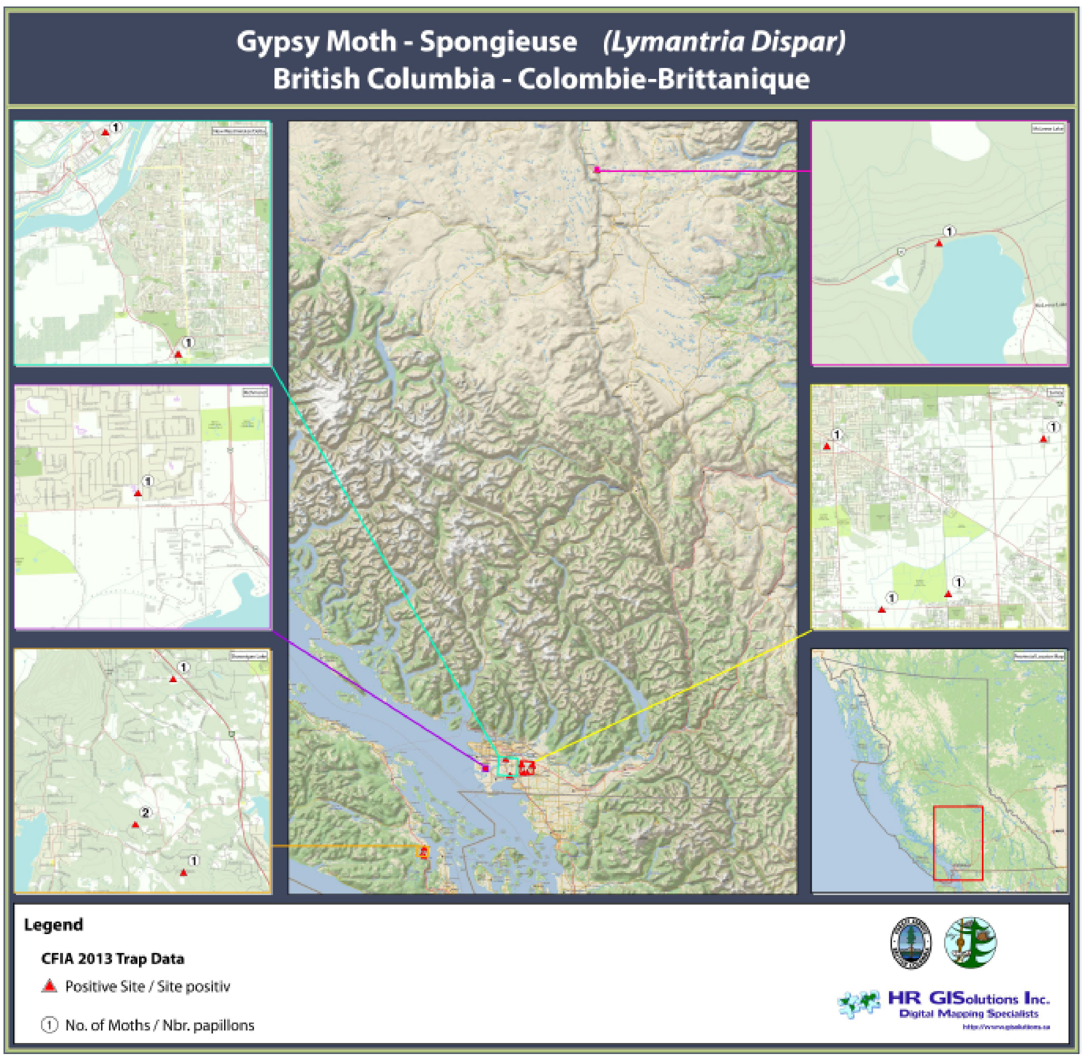


Figure 17. British Columbia gypsy moth trap catch locations in 2013.

Damaging Agents of Multiple Host Species

Abiotic injury and associated forest health factors

Wildfire damage was less than a third of last year with a total of 27,291 ha burnt. Severity was assessed as 6,675 ha (25%) moderate, 16,703 ha (61%) severe and 3,913 ha (14%) very severe. Most were small and scattered, with at least some fire activity in every region. Of the 508 reported fires, 465 (92%) were less than 100 ha in size. Only eleven fires were over 500 ha.

Northeast Region continued to sustain the most fire damage, with 10,208 ha mapped. Almost all (9,134 ha) of the damage was in Fort Nelson TSA, with the largest fires in the west near Kechika River. Skeena Region had 7,118 ha of damage recorded. Cassiar TSA had 3,255 ha burnt, primarily in one fire between Skeeter and Mess Lakes. Lakes TSA contained 3,435 ha of damage which was also mainly in one fire along Tetachuck Lake. Some planting of fires in the Skeena Region is planned for the spring of 2014. The risk of black army cutworm damage to seedlings was determined through pheromone traps placed in the summer. Resulting catches were low, so seedlings should not be endangered (K. White, pers. comm.). Wildfires in the Thompson/Okanagan Region caused 3,372 ha of damage with most (2,943 ha) located in Kamloops TSA. The majority of this damage was caused by one fire between Ashcroft and Spatsum. Cariboo Region had 2,801 ha burnt, primarily in Williams Lake TSA (2,488 ha). The largest fires in this TSA were near Riske Creek. The only other significant wildfire damage in 2013 occurred in Omineca Region, where 2,102 ha were burnt. Of this, 1,169 ha were mapped in small scattered fires in the Prince George TSA. Small wildfires in the rest of BC accounted for no more than 570 ha of damage per TSA.

Post-Wildfire damage was a new category added last year to capture mortality occurring in the survey year within areas damaged by previous wildfires. The post burn mortality may be related to partial fire damage as well as other forest health agents attacking the weakened trees. All ages of trees were killed. This year lodgepole pine was the primary species affected in most areas. Douglas-fir was also damaged, particularly in the Cariboo Region, where Douglas-fir beetle was suspected to be a contributing agent on older trees. Mortality also occurred to spruce and balsam, particularly in the northern portion of the province.

Very similar to last year, a total of 14,696 ha were reported to contain post wildfire damage in 2013. Intensity of mortality was rated as 671 ha (4%) trace, 4,674 ha (32%) light, 4,636 ha (32%) moderate and 4,715 ha (32%) severe. Cariboo Region contained 5,929 ha of damage, mainly in Williams Lake TSA (4,457 ha) located mid TSA and east of Baldy Mountain. Quesnel and 100 Mile House TSAs sustained 995 ha and 477 ha of mortality, respectively. Skeena Region had 5,379 ha mapped, with most of the damage (3,692 ha) observed in Cassiar TSA in the northeast corner and around Mount Meehaus. Lakes TSA had 1,385 ha of damage chiefly in the Alasa Mtn. area. The remaining Skeena Region mortality occurred over 302 ha in Morice TSA along Morice Lake. All the damage in the Omineca Region was noted in the Prince George TSA, with 1,585 ha mapped in the southwest corner. The only disturbances in the Northeast Region occurred north of Solitary Lake on the west edge of Fort Nelson TSA, where 1,507 ha were damaged. Minor damage was delineated in Thompson/Okanagan TSA, with 100 ha in Lillooet TSA and 64 ha in Kamloops TSA. Mid Coast TSA in the West Coast Region contained the remaining 132 ha of damage.

Flooding damage was half that recorded in 2012, with 9,143 ha mapped across BC. Severity however increased with 1,990 ha (22%) light, 1,777 ha (19%) moderate, 5,372 ha (59%) severe and 4 ha (<1%)

very severe. The main species affected were conifers, primarily lodgepole pine and Douglas-fir. Disturbances were commonly small and scattered.

Flood damage White River

The Northeast Region continued to be the most affected, with 3,253 ha of damage. Most of this (2,346 ha) was again located in the eastern half of Fort Nelson TSA. The remaining damage in the region was split between Fort St. John and Dawson Creek TSAs with 488 ha and 419 ha affected, respectively. Flooding damage in Cariboo Region remained stable at 2,764 ha. Most of this damage continued to occur in the western third of the Williams Lake TSA, where 2,764 ha were mapped. The West Coast Region contained 1,403 ha of flooding mortality, mainly in the eastern third of Kingcome and Mid Coast TSAs, with 614 ha and 564 ha affected, respectively. Kootenay/Boundary Region had 713 ha of damage recorded with 399 ha concentrated in the north tip of the Cranbrook TSA. All other flood caused mortality was scattered throughout the province at under 300 ha per TSA.

Windthrow damage was 40% less than the last two years with 4,230 ha recorded provincially. Mortality intensity was assessed as 105 ha (3%) light, 62 ha (1%) moderate, 4,055 ha (96%) severe and 8 ha (<1%) very severe. More than half of the damage occurred in Haida Gwaii TSA in the West Coast Region with 2,363 ha of western hemlock and Sitka spruce severely affected. Disturbances in the rest of BC were small and scattered with less than 360 ha per TSA recorded. A variety of conifers and some trembling aspen stands were damaged. Usually only substantial windthrow is identified due to the height of the survey: scattered windthrow under the main canopy cannot be seen.

Slides damaged half of the area affected last year, with 1,889 ha mapped across BC. Of this, 220 ha (12%) were identified as caused by avalanches. Most (98%) of the damage continued to be rated as severe. All disturbances were small and scattered. A variety of conifers were affected. West Coast Region continued to sustain the majority of the damage with 1,189 ha mapped. Haida Gwaii TSA had 715 ha of damage, with levels under 180 ha for other TSAs in the region. Damage in the Kooteney/Boundary Region decreased to 315 ha, with damage under 140 ha per TSA. Slides in Skeena Region damaged 250 ha in total, with each TSA sustaining less than 100 ha each. All the damage in Omineca Region occurred in Robson Valley TSA, with 96 ha mapped. The remaining Regions only had 15 ha or less of damage per region.

Drought severely affected 182 ha in the Dawson Creek TSA of the Northeast Region this year. All disturbances were on the Alberta boundary with one polygon near Tupper Creek and three polygons near Doe River.

Mechanical treatment was conducted in two young (approximately 25 year old) lodgepole pine stands with a total of 107 ha of mortality mapped. Since the aerial signature was unusual, both sites were ground checked. The damage in both cases was confirmed to be caused by mechanical girdling of the stem at about 1m above ground.

Mechanical wounding of lodgepole pine near Norman Lake

In Williams Lake TSA in the Cariboo Region, 7 ha of light mortality southeast of Gavin Lake were recorded. This girdling was part of a UBC research project for testing whether clumps of spruce surrounded by lodgepole pine would be less affected by spruce weevil than those in a uniformly spaced mixed spruce and lodgepole pine stand. The other 100 ha of damage, rated as trace, occurred just north of Norman Lake in Prince George TSA in the Omineca Region. Investigations with local forestry staff did not discover the reason for this treatment.

Chemical injury was suspected to be the cause of damage to stands along Spahats Creek northeast of Raft Mountain in Kamloops TSA. A total of 62 ha of primarily mature Douglas-fir with a minor component of cedar were affected at an intensity of 18 ha severe, 30 ha moderate and 14 ha light. Bright red foliage was observed from the air, and subsequent ground investigations found no insect or pathological reason for the damage. However, it was discovered that these stands were in line from a helicopter staging site to young stands that were being fertilized earlier in the year.

Suspected fertilizer burn damage near Raft Mountain

A **Hail** event on September 2nd damaged trees from 108 Mile House south to 100 Mile House in the Cariboo Region, primarily west of highway 97. Local observations reported hail up to the size of golf balls, caused damage to vehicles, windows and patio furniture. In the forest, primarily Douglas-fir stands of all ages were affected, though minor lodgepole pine, aspen and various shrubs were also damaged. Some stands were completely stripped of foliage. Since the hail storm occurred after aerial surveys were completed, accurate area measurements were not possible and the damage was not recorded.

Carpet of branches caused by hail storm near 100 Mile House

Animal damage

Animal damage is known to be underestimated in the aerial survey data as it is difficult to detect from the height the survey is flown. The exceptions tend to be significant damage that has resulted in tree mortality, usually caused by bear feeding.

Black bear (*Ursus americanus*) damage increased four-fold over 2012 to 4,984 ha of damage. Mortality was assessed as 1,074 ha (21%) trace, 3,723 ha (75%) light, 141 ha (3%) moderate and 46 ha (1%) severe. All the damage was observed scattered throughout young to intermediate age lodgepole pine stands, with the exception of a 44 ha polygon in a whitebark pine stand in Arrow TSA. This damage to young stands in a scattered fashion is marginally visible from the height the survey is flown, hence the lower the survey height, the more this disturbance is observed.

The Cariboo Region continued to sustain the most damage, with 3,236 ha recorded. Most (2,821 ha) were mapped in the eastern portion of Williams Lake TSA, particularly near Wartig Lake. The damaging agent was confirmed with ground checks in several of these stands. 100 Mile House TSA mortality was clumped along Deception Creek in the northeast tip of the TSA and the remaining attack in the region was 176 ha located in one polygon in Quesnel TSA near Ghost Lake.
Black bear damage in the Kootenay/Boundary Region increased substantially to 1,514 ha.

Bear damage to intermediate age lodgepole pine in Williams Lake TSA

Stand level bear damage in Williams Lake TSA

Disturbances were small and scattered, with the majority located in Cranbrook TSA (405 ha), Invermere TSA (396 ha) and Arrow TSA (384 ha). Minor damage (under 170 ha per TSA) was also observed in Kootenay, Golden and Boundary TSAs.

The 218 ha of black bear damage mapped in the Thompson/Okanagan Region was evenly split between Okanagan and Kamloops TSAs. The largest disturbance was south of Mosquito Lake in Okanagan TSA.

West Coast Region contained 15 ha with 14 ha in the Kingcome TSA and 1 ha in Strathcona TSA. Only one spot of black bear damage was noted in the South Coast Region in the Sunshine Coast TSA.
Snowshoe hare (*Lepus americanus*) damage in northern BC continued to be reported from ground

observations in the Prince George and Lakes TSAs this year. Damage primarily occurred from feeding on tree boles in the winter in young, densely stocked pine stands. It is extremely rare to see this damage from the aerial survey, but in 2013 four polygons were delineated east of Maxan Lake in the Lakes TSA. The majority (204 ha) of the damage was rated as light, with one small polygon and one spot of 7 ha recorded as severe. Ground checks were conducted and it was confirmed to be hare in 12 to 15 year old pine stands, scattered throughout the blocks but with concentrations along small game trails. In the southern interior, general observations indicated that hare populations and their damage remained at low levels.

Red squirrel (*Tamiasciurus hudsonicus*) damage continued to be relatively minor in 2013. Some site-specific squirrel damage in sapling sized lodepole pine west of Summerland in the Okanagan TSA was reported from the ground.

Porcupine (*Erethizon dorsatum*) feeding is known to be causing ongoing damage in dispersed locations throughout much of the province, though it is rarely recorded during the aerial overview surveys. Damage was present in much of the area attributed to bear damage in the Cariboo Region the past two years, although it did not appear to be the primary factor. Porcupine damage incidence was noted in the bear damaged polygons in the database comments.

Armillaria root disease, *Armillaria ostoyae*

The actual area of Armillaria root disease damage is greatly underestimated during the aerial overview surveys due to its subtle signature at the height flown. Of the few infection centers that have been recorded, most are noted by surveyors with local ground knowledge of the areas.

For over a decade less than 100 ha of Armillaria root disease damage has been mapped across the province annually. This year, 1,413 ha were recorded at intensities of 415 ha trace (29%), 475 ha (34%) light, 514 ha (36%) moderate and 9 ha (<1%) severe. Armillaria root disease is not a quick moving forest health agent: this large increase is most likely a factor of increased ground knowledge of the survey crew and/or better visibility.

Most of the disturbances (1,408 ha) were mapped in the West Coast Region. Kingcome TSA sustained 688 ha of trace to light damage in the south tip of the TSA along the Nimpkish River. Armillaria root disease damage in Arrowsmith TSA totalling 515 ha was documented in two light polygons west of Port Alberni and a few scattered spots. Damage in Strathcona TSA of 205 ha consisted of one light polygon south of Owen Bay and scattered spots along the eastern boundary. The remaining 5 ha in the South Coast Region were mapped in one small polygon on Dewdney Creek in Fraser TSA and scattered spots in Sunshine Coast TSA.

Miscellaneous Damaging Agents

Unknown foliage damage was recorded on 8,590 ha in the Skeena Region in 2013, with intensities of 3,585 ha (42%) light, 4,724 ha (55%) moderate and 281 ha (3%) severe. The agent(s) of this defoliation could not be confirmed due to stand inaccessibility. Primarily western and mountain hemlock were affected, as well as minor spruce and subalpine fir. All but two damaged stands were mature.

Cassiar TSA sustained the most damage with 5,812 ha affected. The majority of these disturbances occurred in the Unuk River area at the south tip of the TSA in hemlock stands. A total of 1,407 ha were delineated in the North Coast TSA, primarily around Kitkiata Lake. The remaining 1,371 ha were mapped in the Kalum TSA, mainly around the Dala River.

Alder canker, caused by the fungus *Valsa melanodiscus*, was noted to be killing alder in the north-east (R. Reich, persn. comm.). The north-east survey crew also noted discoloured alder in a few areas, though it was hard to distinguish from the air and as a non-commercial species, it was not mapped as damage. Alaska has been reporting this damage since 2003, and it is now widespread throughout western, interior and south-central Alaska.

Fir engraver beetle, *Scolytus ventralis*, is becoming a problem in the Sunshine Coast TSA. Mature Douglas-fir forests (both urban and on vacant crown land) are being attacked. The branches of leaders are attacked and up to 50% of the trees' crowns are damaged. It is particularly prevalent in the Lois and Aslam Lake areas.

Spruce needle rust, caused by the fungus *Chrysomyxa ledicola*, was noted to be very prevalent in the Cassiar and Mackenzie TSAs in the northern interior this year. Damage was not visible from the air but was observed in several areas on the ground. Survey observers noted waves of the orange spores coming off trees in the Spatsizi, Tatogga, Edziza and Dease Lake areas of the Cassiar TSA, which subsequently settled in the lakes so heavily that the water turned orange along the shore. This same phenomenon has also been reported in Alaska over the last several years. Spruce plantations in the northern portion of the Mackenzie TSA have been reported to have sustained such heavy damage that district stewardship staff don't think free growing status will be achieved. This would be the first time this disease would be the sole reason for a plantation's failure to achieve free-growing status.

Spruce needle rust spores in lake, Cassiar TSA

China fir borer adult found in planter box

China fir borer, an invasive alien wood borer, was found in some wooden plant stands bought in Prince George at Liquidation World. A customer brought the plant stands (with some bark attached) home and before removing them from the plastic shrink wrap, he noticed a beetle in the bottom of one. The regional entomologist was notified and found mines in the wood as well. The adult was sent to taxonomists for identification, with tentative initial identification as the China fir borer, *Semanotus sinoauster*. The Canadian Food Inspection Agency is tracking down how these plant stands arrived in Canada. It is always appreciated when someone brings potentially invasive insect signs into professionals for diagnosis.

Fall webworm (*Hyphantria cunea*) was tentatively identified as the damaging agent observed to be defoliating primarily alder (but other shrubs and aspen as well) at low elevations throughout the Thompson/Okanagan and Cariboo Regions. The larvae fed gregariously in large conspicuous webs, sometimes completely stripping the affected tree/shrub of foliage.

Fall webworm in Williams Lake TSA

Willow leaf blotch miner (*Micurapteryx salicifoliella*) damage continued for the fourth consecutive year in Fort Nelson, Fort St. John and Dawson Creek TSAs. However, defoliation was observed to be in the second year of a decline phase, with damage reduced to smaller, scattered patches of willow. At the infestation's peak in 2011, virtually every willow leaf in northeastern BC was damaged. This defoliation was not mapped since willow is not a commercial tree species.

Swiss needle cast (*Phaeocrytopus gaeumannii*) is continuing to affect young Douglas-fir stands in the Fraser TSA. Ground observations note that damage is heaviest on the western side of the TSA and extends north to about half way up and on both sides of Harrison Lake. Occurrence is light in the Chilliwack valley. Construction of a spatial incidence map of the damage is presently underway. In the Quinsam Lake area of Strathcona TSA, district staff have observed young Douglas-fir stands that appear to have the symptoms attributable to Swiss needle cast, though positive identification has not yet been made.

An unknown forest health factor was discovered to be causing very unusual swellings and galls on greater than 85% of ten year old planted lodgepole pine on a block on the No Fish Road system in the Merritt TSA of the Thompson/Okanagan Region. The factor was not present on natural subalpine fir or whitebark pine regeneration in the area or in the adjacent mature lodgepole pine stand. Two nearby blocks with similar site conditions planted with the same seedlot (2 years later) were also checked and only one very small incidence of this factor was found.

One tree found in the affected area had both a western gall rust infection and the unknown factor. The western gall rust infection was observed to be very different, with roughened bark and bright orange spore production at the time, which seemed to confirm that the unknown factor was not caused by western gall rust.

The severity of the factor increased with increasing elevation on the block and it increased on trees that were in slope positions more susceptible to snow press/sweep. The more vigorous trees tended to have less intensity of this factor. In general, swellings seemed to be most severe at the nodes. A few trees had snapped off at the swellings and the investigating foresters felt this form of damage will become more prevalent as the stand increases in height.

Unknown forest health factor swellings on stem, compared to western gall rust blooming on branch

Forest Health Projects

Armillaria root disease trials: gaining 33 years of insight

Michael Murray, Forest Pathologist, Kootenay/Boundary Region

Root disease caused by *Armillaria* is one of the most widespread and impactful forest health agents in Southern Interior BC. In the Kootenay/Boundary Region, this disease challenges forest management due to its ability to increase following harvest, reduce tree growth and cause mortality, especially in young regeneration. In unmanaged forests, where *Armillaria* is endemic, it plays an important role in forest ecosystems through its ability to weaken or kill trees, and contribute to stand structure, forest succession, decomposition, and nutrient cycling processes. However, from a timber production perspective, *Armillaria* can reduce volume within plantations by 25% or more. Because smaller trees tend to be most prone to rapid mortality from this disease, young plantations (5-20 years old) are especially vulnerable.

A young western redcedar killed by Armillaria *root disease.*

The removal of stumps soon after harvest has been commonly practiced in the southern interior of BC since the early 1990s. Until recently, the effectiveness of stumping in limiting root disease had been under-studied. Although some evaluative trials were established in the

1980s, results have been limited. This is because *Armillaria*-induced mortality within a plantation tends to peak between 12-20 years old, thus requiring considerable time for relevant findings to emerge.

Since the 1980s, the Southern Interior and adjacent northwestern USA have accumulated the largest collection of root disease research trials in the world. Each trial is typically divided spatially into separate treatments (stumps removed and stumps retained) with some variations (e.g. roots raked, trees planted 1.5m from any stump) at a few trials. At several sites, an additonal treatment relies on the application of a potental biocontrol (*Hypholoma fasiculare*) on stumps. The most commonly measured tree responses are growth (height and diameter) and forest health, especially root disease. A considerable number of plantation trials are now of sufficient age to yield measurable amounts of *Armillaria* incidence. During 2011-2013, twelve trials were surveyed in the Kootenay/Boundary and Thompson/Okanagan regions (Table 7). Trees were examined for *Armillaria* root disease and other agents as well as diameter and heights. The resulting dataset is composed of nearly 30,000 trees representing eight conifer species. Analysis began in December, 2013. The earliest findings indicate that there is less root disease wherever stumps were removed. Subsequent analysis of this dataset will help answer questions such as: Which tree species are more resistant to root disease? Which treatment is most beneficial to height and diameter growth? How does treatment affect stocking levels? How much less root disease occurs in stumped treatments? Answers to these questions will provide useful guidance for plantation managers.

Table 7. Research trials surveyed between 2011 and 2013.

Trials and (approximate location)		
Big White (Beaverdell)	Knappen Creek (Grand Forks)	Phoenix Creek (Grand Forks)
Boundary (Westbridge)	Marl Creek (Golden)	Rover LTSP (Nelson)
Columbia West (Golden)	McPhee LTSP (Castlegar)	Sutherland (Christina Lk)
Gates Creek (Golden)	Nine Mile (Canal Flats)	Zibin's Woodlot (Christina Lk)

Assessment of the Prince George site of the range-wide white pine trial

<u>Richard Reich,</u> *Forest Pathologist, Omineca and Northeast Regions*

This trial was established by Dr. Rich Hunt in 1986 and 1987 with replications on a total of 8 different sites in BC to evaluate western white pine survival on root disease sites. Fifteen different provenances of white pine, ranging from Arizona to Central BC, were planted on the Prince George (PG) site. The PG site was selected for its incidence of Tomentosus root rot, caused by *Onnia tomentosa*, which occurred on approximately 15% of the stumps, based on a stump top survey.

A few observations stand out at the PG site at the 26 year measurement. The first is that although the white pine blister rust (WPBR) infection level was very high, the majority (12/14) of the surviving Major Gene Resistance (MGR) trees are still without infection. The other 66 seedlings died relatively shortly after establishment due to abiotic damage (repeated growing season frost and winter desiccation) prior to WPBR becoming established in the mid 1990's.

The very low level of infection on MGR trees contrasts sharply with the non-MGR trees, which rough estimates indicate ~ 85% cumulative mortality, with anticipated mortality reaching ~95% in the near future. All treatable branch infections were pruned in both 2004 and 2005, without which current mortality would currently be ~ 95%. Although there was considerable early mortality due to abiotic causes (~65%), once WPBR became established on site after approximately age 15, virtually all of the remaining white pine became infected over the next 10 years. Once again, most of the treatable branch infections present in 2013 were pruned during the 2013 assessment.

An interesting finding regarding the spruce control seedlot was that after 26 growing seasons the mean height of the shortest 79% of the population of all surviving spruce was 61% shorter than the top 21% (Figure 18, red bars). Repeated spruce weevil attack by *Pissodes strobi* appears to have had a considerable negative impact on both height growth and stem form of the spruce. Tomentosus has likely killed 20% (8/40) of the planted spruce. Some of the white pine seedlings may have also been killed by tomentosus at a very early age, but no direct evidence of this was found.

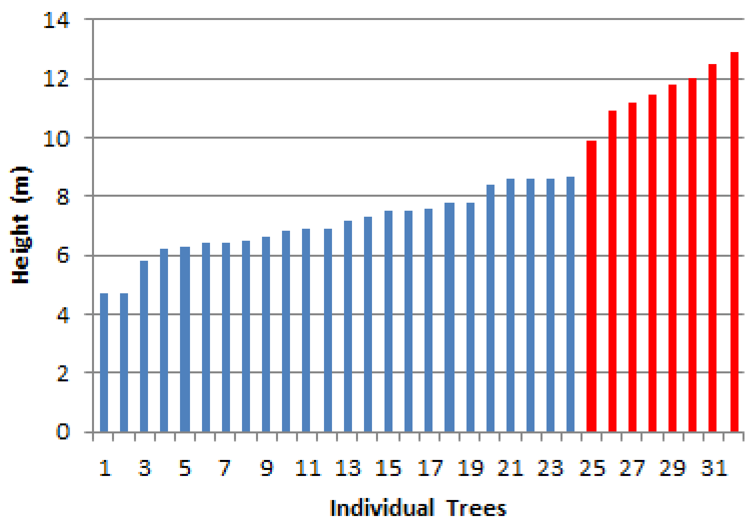


Figure 18. Individual spruce tree heights after 26 growing seasons, Beaver site.

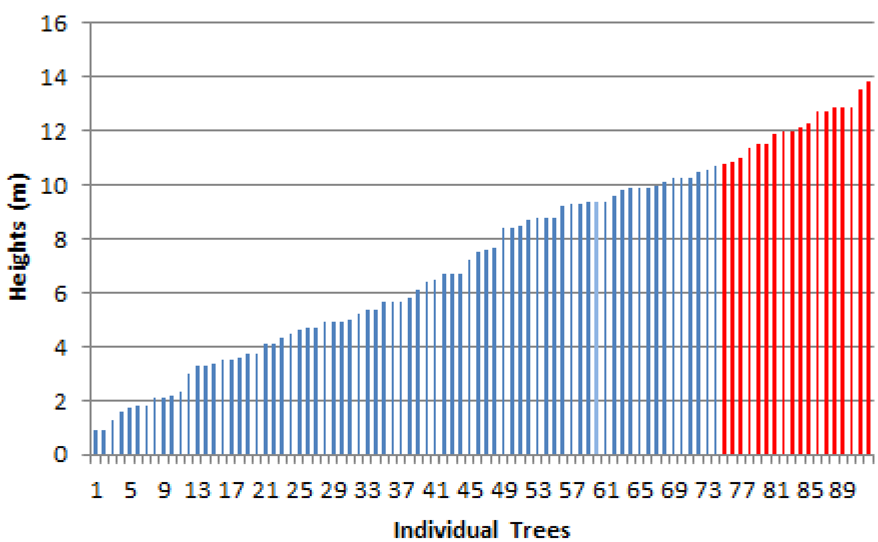


Figure 19. Individual white pine heights after 26 growing seasons, Beaver site

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Although overall white pine survival has been extremely poor, the height growth of some of the surviving trees was remarkable. The mean height of the shortest 80% of the population is only 51% shorter than the top 20% (red bars in Figure 19). No damage by the white pine weevil, *P. strobi* was confirmed on any white pine, although the odd leader had died, likely due to abiotic causes. The wide range in height growth is likely a result of provenance based suitability to this site, which is well north of the natural range of white pine in BC.

Bulkley Orchard #228 graft screening trial (update of trial first reported on in the 2010 annual report)

Richard Reich, Forest Pathologist, Omineca and Northeast Regions

The purpose of this unique trial is to expand and complement the existing pathogen screening data for the Bulkley#228 lodgepole pine orchard, established in the late 1980's. Although this Prince George Tree Improvement Station (PGTIS) orchard was at very high risk for certain pathogens, resulting in successful screening for those agents, other pathogens couldn't be evaluated due to their low risk there. This trial utilized grafted material in an effort to reduce the number of trees required for screening, and to reduce the variability of results associated with open pollinated seedlings.

Scions from a selection of 25 clones, representing the range of susceptibility to various pathogens, were collected for grafting in early spring 2008. A maximum of 16 ramets per clone were planted in May 2010 on 5 different sites in the central interior that were at high risk for one or more of the following pathogens: comandra blister rust (CBR), stalactiform blister rust (SBR), western gall rust (WGR), Elytroderma needle and shoot disease, and Dothistroma needle blight. The grafts have been assessed annually since establishment in 2010. Of particular note to date is that none of the grafts have shown evidence of infection by any of the pine stem rusts. Seedlings were also planted on two of the five sites in 2010. Rust infection by all three rusts occurred at both of these sites both in 2010 and in 2011. Although premature, the total lack of infection on the grafts is unexpected and may be an early indication that an age based resistance to pine stem rusts may be partially responsible.

This material includes many clones that are known to be highly susceptible to WGR, and the comandra trial reported on in this report has demonstrated a general lack of resistance in lodgepole pine to CBR. From an operational screening perspective, this early result may indicate that grafted lodgepole pine may not be as suitable for disease screening as seedlings. Annual monitoring will continue.

Comandra resistance trial (update of trial first reported on in the 2010 Annual Report)

Richard Reich, Forest Pathologist, Omineca and Northeast Regions

This very large trial was established in 2004 as a collaborative effort led by Dr. Sally John to test putative resistance to comandra blister rust (CBR), which she had previously identified in the Chowsunket progeny test site. The resistance trial tested 89 unique families from the Bulkley #219 orchard on three very high risk sites in the Sub Boreal Spruce dry cool (SBSdk1) BEC subzone/variant.

Detailed annual assessments have been conducted on the three fully replicated sites since the rusts became evident in 2006/2007. Data collected include: condition (survival class), severity for the most severe infection per tree (for each of the three rusts), cause of mortality, year of infection for WGR stem infections, other pest incidence, forking data, and 10 year height (in 2013).

The CBR infection level has reached an extremely high level on two of the three fully replicated sites, well exceeding the target threshold for resistance evaluation of 50% (Figure 20).

Nine year results show that a very low frequency of moderate resistance exists within the tested population, but that the overwhelming majority of families tested are highly susceptible.

Cumulative incidence of new infection, on previously uninfected pine, by all three hard pine stem rusts (comandra blister rust, stalactiform blister rust, western gall rust), has apparently leveled off. Continued annual monitoring will occur to confirm this preliminary, but expected finding.

The infection rate information for all three rusts will be included in the development of a hard pine rust calculator tool to be used to determine risk of accepting Free Growing declarations. Other outcomes will be reported on in the future.

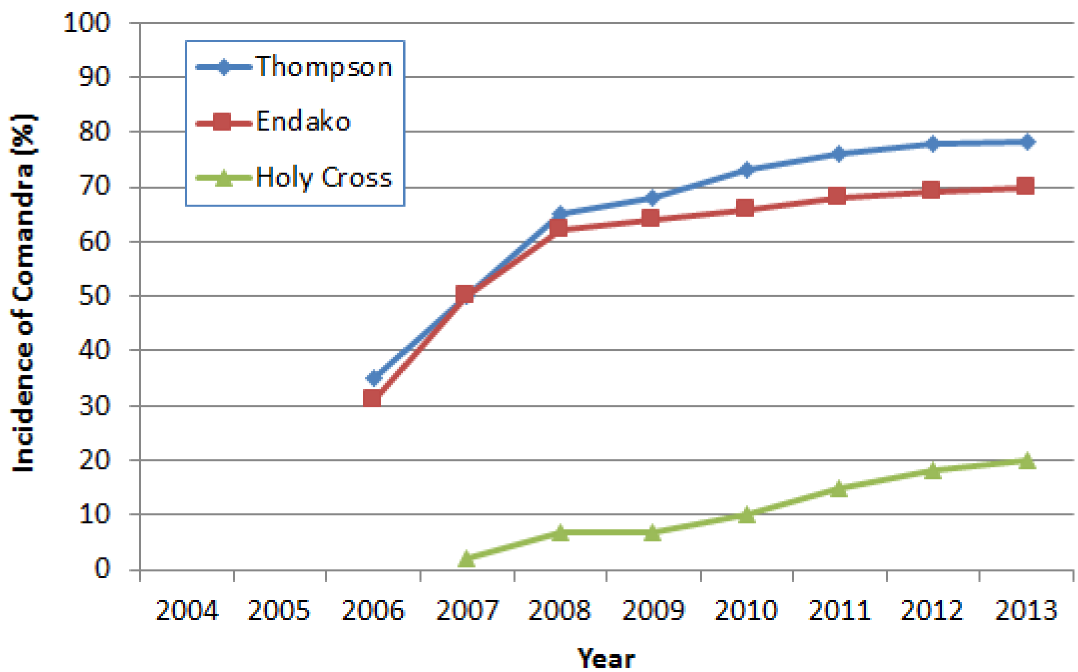


Figure 20. Incidence of comandra blister rust over time on three trial screening sites, est. 2004.

Development of a hard pine rust calculator for lodgepole pine plantations

<u>Richard Reich,</u> Forest Pathologist, Omineca and Northeast Regions

A tool allowing the calculation of risk associated with accepting Free Growing declarations on rust infected sites is in the final stage of development. In 2013, data from nine long term installations was compiled to validate the initial version of the western gall rust calculator, which was based on data from 3 long term installations. This calculator was presented in the Omineca Rust Management Strategy. The validation exercise demonstrated that the initial calculator performed reasonably well. The entire trajectory for most stands fell within the mean infection curve, with only a minor adjustment required to accommodate the broader spectrum of risk associated with all nine installations.

Figure 21 shows the cumulative rate of infection by western gall rust stem infections. The notable feature is that approximately 90% of the total infection occurs by age 10. This provides a reasonable degree of certainty that Free Growing declarations at age 15 will capture the vast majority of unacceptable rust infection in most lodgepole pine plantations. The calculator allows the free growing data to be used to project how much rust is expected in addition to what has already occurred for early free growing declarations. Input variables include: stand age at time of survey, well spaced (uninfected) stocking and rust incidence on total conifer stocking.

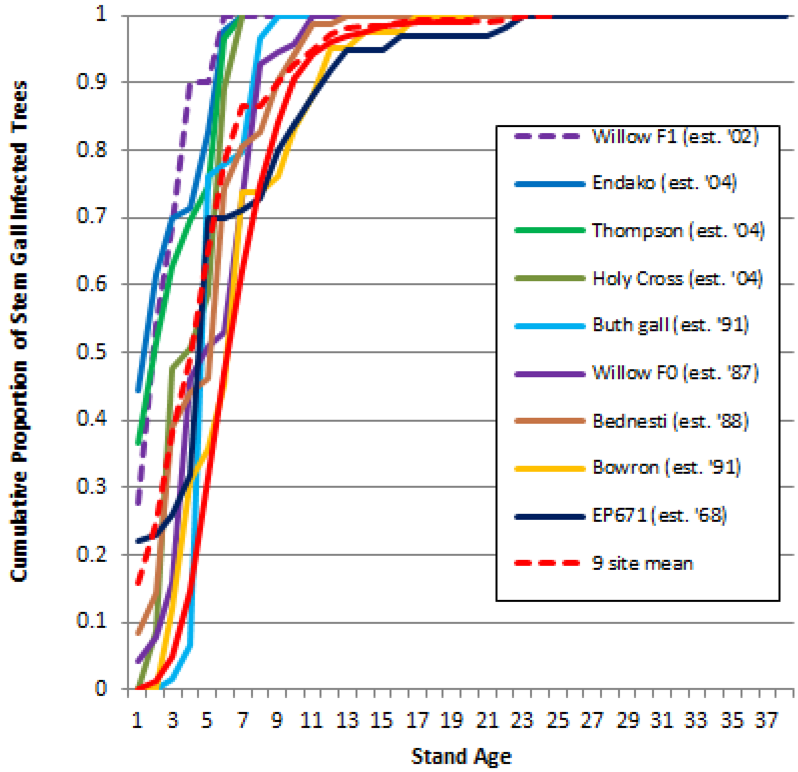


Figure 21. Cumulative rate of western gall rust infection for stem infected trees on 9 long term trial installations.

Elytroderma needle cast surveys in the 100 Mile and Cariboo/Chilcotin Districts

David Rusch, Forest Pathologist, Cariboo and Thompson Okanagan Regions

Needles infected with Elytroderma needle cast

Systematic road side surveys were conducted in 2013 in 35 young lodgepole pine stands in the south-western and eastern portions of the Central Cariboo District and eastern portions of the 100 Mile House District. The intent of the surveys was to measure the incidence and severity of Elytroderma needle cast on lodgepole pine in the south central part of the Cariboo Region in order to better delineate the areas most heavily impacted by the disease.

Hard pine rust monitoring

Alex Woods, Regional Pathologist, Skeena Region

Two rust monitoring trials established in 1995 and 1997 respectively in stands that were free-growing age were re-assessed in the summer of 2013. The two trial sites consisted of the Pinkutt (840+ trees) and Parrot (2500+ trees) sites. Each site contained six replicates of two treatments (control and pruned) in 25 X 25 m treatment units. All trees were assessed for rusts; comandra, stalactiform and western gall rusts. For comandra and stalactiform infections it was noted whether the infections were branch or stem infections, which branch whorl they were located on, which cardinal direction the infected branch in an impacted whorl faced and then the distance the canker was from the main stem. The trial was set up to see the distance that branch cankers can grow over time to see how far out a branch canker had to be to be considered non-life threatening. The trial was also a pruning trial to see if pruning off infected branches would help save trees. Prior to any pruning the distance to the stem for any branch infections was measured and recorded so that we could tell after pruning what a safe distance was for trees with prunable branch infections. Data analysis is still underway. Early indications are that by stand age 35+ most stem infections of comandra blister rust have proven fatal. Early indications also suggest that pruning stands at age 15 to control hard pine stem rusts may not be effective.

How lodgepole pine non-structural carbohydrate root reserves are affected by mountain pine beetle attack

Bruce Rogers, Research Forest Ecologist, Omineca & Northeast Regions
Simon Landhausser, Assoc. Prof. & NSERC Research Chair, University of Alberta
Robert Hodgkinson, Forest Entomologist, Omineca & Northeast Regions
Erin Wiley, Ph.D. post doc., University of Alberta

In the Mackenzie Forest District a pure lodgepole pine (Pl) stand partially attacked by mountain pine beetle (MPB) was chosen and a series of unattacked Pl were either baited with pheromone or tagged with verbenone to attract or repel, respectively, MPB attack in 2011. Pheromone baited Pl were covered with heavy gauge polyethylene from the ground line up the bole to 4 m except for a 2 m high exposed portion. The adjacent verbenone tagged Pl in a nearby check area were completely tarped up the bole to 4 m. All pheromone baited Pl were attacked by MPB in 2011 and all check trees were protected from attack.

Five post-attack entries were been made in the past 30 months to sample sugars in phloem, root, and fine twig samples. Phloem samples were taken at 20, 90, 140 & 210 cm up the boles. Fine twig samples were removed from the crown with a 12 gauge shotgun. Fourth order root clippings along with the rest of the samples were placed into a dry ice cooler for transport to Prince George. Samples were then oven dried and shipped to the University of Alberta for further analysis. The final entry was made in Oct. 2013 where cross sections of all the trees were taken for dendrochronological analysis. The attacked portions of the pheromone baited Pl were also removed to determine MPB attack densities. Further results from the project will be reported at the end of 2014.

Quesnel rust surveys

David Rusch, Forest Pathologist, Cariboo and Thompson Okanagan Regions

Bio-Geo Dynamics Ltd. conducted detailed stem rust surveys in 20 lodgepole pine stands aged 10-15 years in the SBS and SBPS zones in the Quesnel TSA in 2013. The surveys included detailed information on the presence of alternate hosts and site factors. This information will be used to monitor levels of stem rust, compare the measured rust incidence to values reported in RESULTS, and identify key site factors related to rust hazard in the Quesnel TSA, and compare the finding with previously conducted surveys in the nearby Prince George TSA.

Revised Appendix 4 of the Cruising Manual

Richard Reich, Forest Pathologost, Omineca and Northeast Regions

The Pathological Indicator section (Appendix 4) of the Cruising Manual has undergone a major revision to the functionality of the guidance section and a major update of photos and text descriptors of pathogens to better distinguish between path indicators, which may or may not result in a loss factor. Updated copies of the manual are available at: www.for.gov.bc.ca/hva/manuals/cruising.htm

Rust maps

Richard Reich, Forest Pathologist, Omineca and Northeast Regions

A RESULTS query was done in 2013 by consultant Ms. Mei-Ching Tsoi, courtesy of Ralph Winter, Resource Practices Branch, to allow the creation of rust maps using Free Growing survey data for silviculture openings in BC (Figure 22). The rust maps are 1:250,000 scale, include a topographic base, and show regional trends and local hot spots by rust class, by rust, and for all rusts combined. The 2011 rust maps are currently being used for planning by districts lacking rust hazard rating.

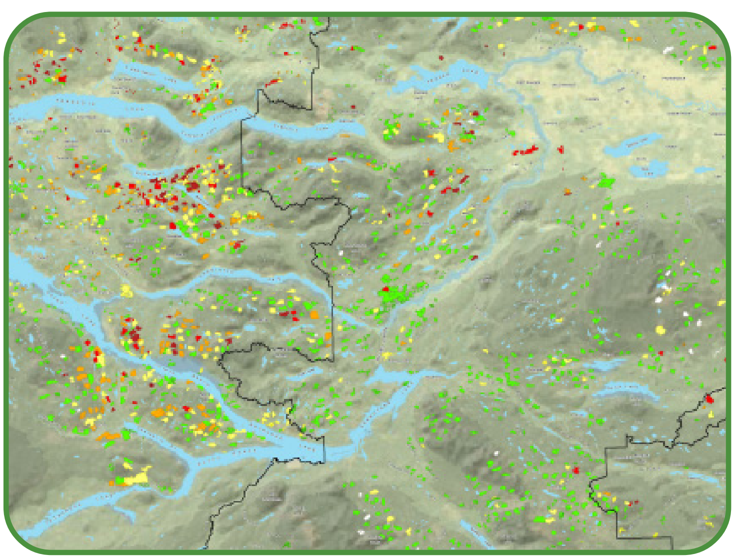


Figure 22. Example of portion of rust map showing display.

Septoria leaf spot and canker of poplar in the upper Fraser Valley of British Columbia

Harry Kope, *Forest Pathologist, Resource Practices Branch*

Septoria musiva Peck (teleomorph *Mycosphaerella populorum* G. E. Thomps.), causes leaf blight and, more importantly, necrotic lesions (cankers) that often result in stem breakage. Previous surveys in the province have found, to date, that the disease is localized in the Fraser Valley. *Septoria musiva* infection levels on leaves of native *Populus trichocarpa* is very low, approx 1.2% of the spots sampled of over 1000 trees. Hybrid poplars are known to be much more susceptible to the disease.

In 2013 a survey of 21 hybrid plantations in the Fraser Valley (Figure 23) was carried out. It was found that 16 (76%) of the plantations were infested with *S musiva* (187 trees sampled, 105 infested with *S. musiva*; approx 56% incidence, Table 8). The affected plantations occur from Richmond to Agassiz, on both the north and south sides of the Fraser River. Affected plantations ranged in age from 15 to 30 years. These plantations can be assumed to act as epi-centers from which inoculum can spread. The longer these plantations continue to grow the higher the likelihood that the disease will spread to other hybrid poplars, as well as, put greater disease pressure on the native poplars species.

Table 8. Results of hybrid plantations survey.

Location	No. of trees tested	Positive only S. musiva	Positive only S. populicola	Positive for both species	Negative for both species
Ashton	12	12 (100%)	0	0	0
Carey Island	16	12 (75%)	2 (12.5%)	0	2
Cut block 14 B2	8	3 (37%)	0	0	5
Clark	4	0	0	0	4
Cromarty	12	5 (41%)	0	0	7
Cut block 14 B3	3	2 (66%)	0	0	1
Hennig	8	5 (62%)	0	0	3
Herrling	20	9 (45%)	0	0	11
Kerkhoven	16	13 (81%)	0	0	3
Kruger Dewdney	4	4 (100%)	0	0	0
Lee	8	8 (100%)	0	0	0
Matsqui Hog Farm	8	0	2 (25%)	0	6
Matsqui Indian Reserve	8	0	1 (12.5%)	0	7
MacInnes	15	14 (93%)	0	0	1
Metro Vancouver	4	3 (75%)	0	0	1
Multerer	8	1 (12%)	0	0	7
Ohamil Indian Reserve	4	0	0	0	4
Richmond Land Fill	8	0	0	0	8
Seabird Island Indian Reserve	12	8 (66%)	4 (33%)	0	0
Strawberry Island	4	4 (100%)	0	1 (20%)	0
Weinfurtner	5	2 (40%)	0	1 (0.5%)	2
Total	**187**	**105 (56.1%)**	**9 (4.8%)**	**1 (0.5%)**	**72**

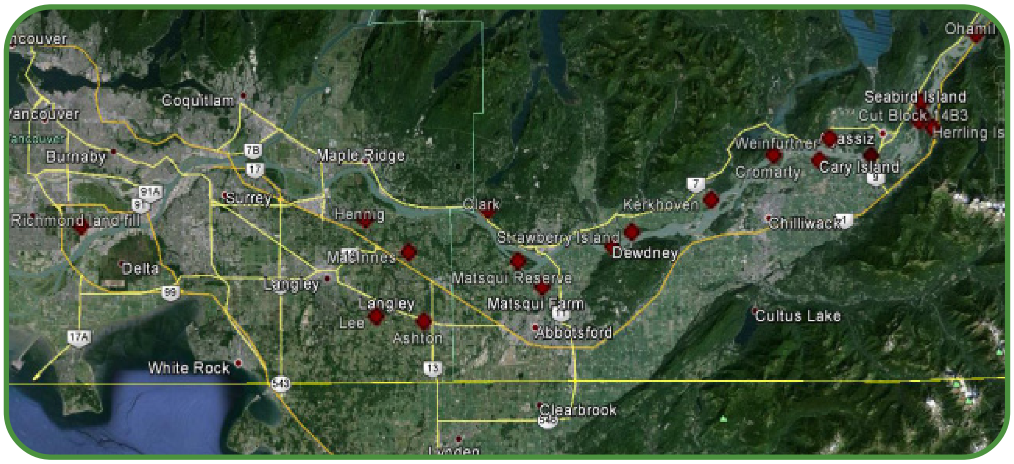


Figure 23. The location of Populus hybrid plantations in the Fraser Valley, BC.

Survival of MGR western white pine in coastal test plantations

Stefan Zeglen, Forest Pathologist, Coast Area

Since its discovery, the presence of major gene resistance (MGR) in western white pine has allowed foresters to replant areas with some confidence that the majority of stock would not be killed by white pine blister rust (WPBR). However, since the source of MGR material is from the US Forest Service Tree Improvement Center in Dorena, OR and the parent trees for the resistance come primarily from southern Washington State and California, it was unclear how both the disease resistance and the tree provenances would perform in BC.

Small quantities of MGR white pine seed were purchased by the Ministry in 1999 from Dorena and made available for operational use. We initiated a trial to test the susceptibility of this resistant seed against the best BC coastal material available at the time from Texada Island. In 2002, seven plots were planted on three sites (Beavertail, Eagle Heights and Slesse Creek), the first two on Vancouver Island and one near Chilliwack. Three Dorena seedlots were compared against two Texada control seedlots.

The 10-year results indicate that overall the Dorena seedlots average 67% canker-free trees while the Texada controls average 29%. Since infection is still continuing on these trees it is also important to note that currently infected trees are more than twice as common in the Texada seedlots (44%) as the Dorena ones (20%). This clearly indicates that the MGR trees are surviving WPBR better than the local non-MGR trees. The most dramatic example of this is at Slesse Creek which has an extremely high rust infection pressure. In the two Slesse plots, survival of Texada seedlot trees is just under 5% while the Dorena seedlots average 55% canker-free. No tree growth data is available yet but the uninfected Dorena trees do not appear noticeably disadvantaged compared to the BC trees.

Since the trial was established, seed is no longer directly purchased from the Dorena facility. Instead coastal BC seed orchards use Dorena pollen to pollinate superior BC white pines thus retaining local growth characteristics while also conferring MGR resistance to at least 50% of the offspring. This trial and others suggest that field survival of these MGR trees will meet this target and perhaps do somewhat better even on rust prone sites.

Western gall rust direct control test: Bowron Site

Richard Reich, *Forest Pathologist, Omineca and Northeast Regions*

A pilot test plot (400m²) was established in an eight year old lodgepole pine plantation in the fall of 2000 to evaluate direct control of western gall rust by branch gall pruning and stem gall excision. Re-evaluation of the trial in 2013 showed that the majority of treated trees responded well to treatment. The majority of treatment wounds were successfully healed up 13 years later (Figure 24). However, many of the highly susceptible trees were later re-infected at a higher position on the stem. Trees of low susceptibility were not re-infected. The surrounding plantation has an estimated 60 to 70% infection by stem gall and therefore represents extreme hazard for gall rust. Rust severity and mensuration will be assessed on a 5 year periodic basis using the Young Stand Monitoring (YSM) protocol for Continuous Monitoring Inventory (CMI) plots.

It is hoped that modelling of potential treatment gains can be compared to actual volume measured on a periodic basis. Projected losses associated with the no treatment option will be compared to a projection of mortality effects for the treated plot, as well as to actual and projected mortality effects for a control plot.

Figure 24. a)Tree 16 before treatment, b) immediately after, c) 5 years later, d) 13 years later.

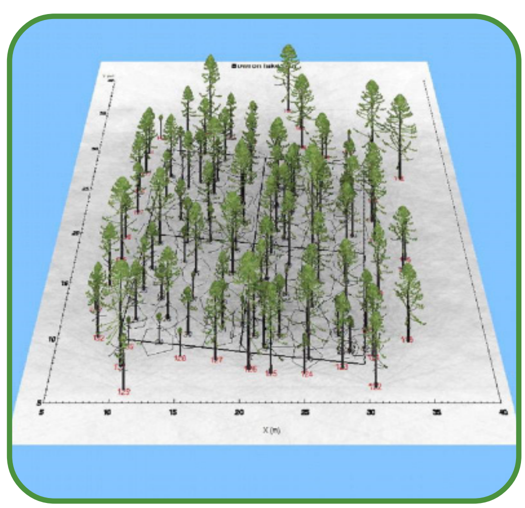


Figure 25. Bowron plot output from TASS 3 showing plot trees and nearest neighbours outside the plot boundary (image courtesy of Jim Goudie, FAIB).

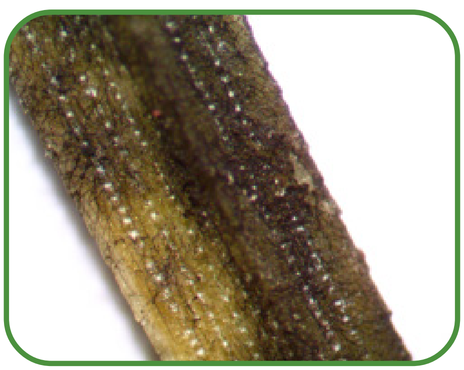
White pine blister rust inoculation trials for Whitebark Pine

Michael Murray, Forest Pathologist, Kootenay/Boundary Region

During the past several years, demand for disease resistant whitebark pine (*Pinus albicaulis*) seedlings has grown in Canada. Seedlings are used for restoration by Parks, mines, and First Nations. Burned, disturbed, and harvested Crown land (public acreage) is increasingly being re-planted with whitebark pine. In 2012, whitebark pine was designated as a federally endangered species in Canada. With a federal recovery strategy being drafted now, it is likely that the dissemination of disease-resistant trees will be a key component of the strategy.

Michael Murray prepares seedling chamber for an inoculation run

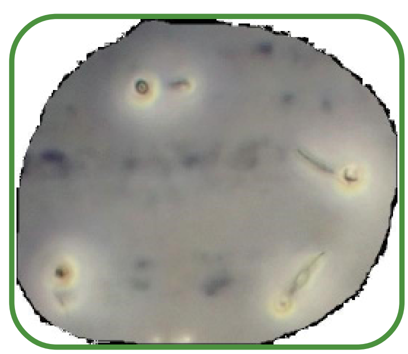
The artificial inoculation of seedlings is a commonly applied step in the screening process to identify genotypes (or parent trees) of pines that are resistant to the blister rust fungus (*Cronartium ribicola*). The successful white pine (*P. monticola*) program has resulted in re-establishment of this valuable species. Although applied operationally in the USA, there have been no artificial inoculations of whitebark pine conducted in Canada until the effort reported here. During August a team gathered at Kalamalka Forestry Centre (KFC) near Vernon, BC consisting of Randy Armitage (Research Technician), Vicky Berger (Research Technician), Michael Murray (Forest Pathologist), Ward Strong (Research Scientist), and Nick Ukrainitz (Research Scientist) – all MFLNRO staff.



The web-like mycelia of Sooty Mold on ponderosa pine needle

Seedlings representing 10 whitebark pine families were entered into screening. An additional family represents a susceptible 'control'. Each family consists of 50 individuals. To produce inoculum (basidiospores), we relied on leaves collected from a cultivated currant hedge of *Ribes nigrum* (Ben variety) located at the Ministry's nearby Skimikin Seed Orchard (Tappen, BC).

A successful inoculation run was achieved in the greenhouse chamber meeting the target spore load of approximately 3,000 spores/cm^2. These methods were replicated for the same 10 families at the US Forest Service Genetic Resource Center, Dorena, Oregon. Thus, we will be able to compare results by annually assessing these seedling families for signs of blister rust over the next several years. Seedlings from an additional 30 families are ready to be inoculated during the summer of 2014.



Deadly basidiospores associated with white pine blister rust with germination tubes

White bark pine PSP at Charlotte Lake

David Rusch, Forest Pathologist, Cariboo and Thompson Okanagan Regions

A whitebark pine permanent sample plot (PSP) was established in 2013 north of Charlotte Lake in the Chilcotin. The purpose of the permanent sample plot will be to monitor the survival and growth of white bark pine over time. Many of the whitebark pine overstory trees had been killed by the mountain pine beetle but there were very low levels of white pine blister rust on the understory trees.

Forest Health Meetings

AmeriDendro meeting

Jodi Axelson, Forest Entomologist, Cariboo Region

Venue:
Tucson, Arizona, May 12-17th, 2013.

Summary:
The AmeriDendro meeting, sponsored by the Tree-Ring Society, is held approximately every four years and brings together a diverse and multi-disciplinary research community from across North America, South America and Europe. The 2013 meeting started each day with a one hour plenary session on topics such as: ecology, decision making, fire management, climatology, tropical dendrochronology, wood anatomy and isotopes, reflecting the diverse nature of the scientific program.

Pinus ponderosa and P. arizonca forest

Scrub oak forest

Old fire near the top of Mt. Lemmon

In the middle of the week the scientific program was punctuated by excursions in and around the Tucson area. I opted to take the Lemmon Highway trip, where a natural history tour traversed 2000 m of elevation on the sky island of Mt. Lemmon. A number of ecological gradients were travelled through starting with saguaro cactus "forests" at low elevation moving through scrub oak, to ponderosa and alligator pine forests to high elevation Douglas-fir forests. Various dendrochronology projects were visited, and wildland fire management was a featured topic.

Forest health training workshops

David Rusch, Forest Pathologist, Cariboo and Thompson / Okanagan Regions

Venue:
Root Rot Workshop, Okanagan Shuswap District Office, Vernon, March 25 & 26th, 2013
Root Rot Workshop, 100 Mile House District Office, May 13th, 2013
Forest Health for Silviculture Surveyors, Quesnel District Office, March 29th, 2013
Forest Health for Silviculture Surveyors, Raven Lake, Mar 30th, 2013
Forest Health Training for Forest Analysis and Inventory Branch contractors, May 1st & 2nd, 2013

Summary:
A number of training sessions were held in the Cariboo and Thompson/ Okanagan Regions. One day root rot training sessions were held in Vernon & 100 Mile. The Vernon session was organized by Heather Rice and had to be held over two days to accommodate demand. The biology, identification, and management of Armillaria, laminated, and tomentosus root diseases were covered.

Vernon root rot workshop

The "forest health for silviculture surveyors" training was offered in Quesnel and in the Chilcotin. The Quesnel session included an office component while the Chilcotin session was held entirely in the field. A number of pests of young pine stands were covered.

Forest health for silviculture surveyors training

The inventory training was held over two days. The first day was mostly a classroom session that ended up with a look at Douglas-fir beetle in the field. The second day involved a trip out to the Alex Fraser Research forest to look at various forest health factors including root diseases.

To request forest pathology/forest health training in Thompson / Okanagan or Cariboo Regions in 2014 please contact David Rusch at 250-398-4404.

Forest health training and quality assurance for the Young Stand Management Program

Richard Reich, Forest Pathologist, Omineca and Northeast Regions

Venue:
Training session for contractors and Forest Analysis Inventory Branch specialists responsible for the Young Stand Monitoring (YSM) program, Prince George, BC, May 28, 2103.

Summary:
Several field sites were prepared in settings representative of stands sampled by the Continuous Monitoring Inventory (CMI).

- The primary purpose of the training was to conduct training for the recognition of damaging agents, and the measurement of their tree level severity using a brief teaching followed by extensive field testing exercise format.
- The secondary purpose was to learn from the participants what worked best for future training, and how to best measure severity for each damaging agent.
- The group agreed that a brief teaching element combined with an extensive testing format was very useful for each damage agent/stand age complex.
- A key example of one point of protocol development was to:
    - Replace the recommended visual estimation of stem disease severity with an actual measurement using a diameter tape, of the circumference affected by each stem disease out of the total circumference at that same position.
    - It was concluded that an actual measurement was almost as fast, would better facilitate Quality Assurance activities, and provided surveyors with certainty regarding the precision requirement.

A two day accreditation style training session will be held in May of 2014 in Prince George. Participants receiving accreditation will be highly competent in the FH recognition and measurement protocol for YSM/CMI.

Pine and moose tour

Alex Woods, Forest Pathologist, Skeena Region

Venue:
Nadina District, BC, May 15-16, 2013

Summary:
The Assistant Deputy Minister (ADM) for the North Area, Kevin Kriese, organized a series of discussions regarding silvicuture practices and the interaction with habitat and riparian values within the Nadina District. The field tour took place close to Nora Lee Resort, where attendees spent the night, at the west end of Francois Lake. The purpose of the tour was to bring together the provinces leading experts on silviculture, habitat and riparian management with members of FLNRO Executive to engage in dialogue about some of the most pressing forest management issues of the day. There was much discussion around how we account for forest health impacts in managed stands using field examples from the Nadina District's Stand Development Monitoring (SDM) population and data from other SDM samples from across the North Area. The similarities between SDM and FAIB's Young Stand Monitoring (YSM) results were discussed. The timber supply implications of these monitoring programs require more analysis but there appears to be an underlying cause for concern in managed stand yield projections for pine leading stands. It was recognized that the implications of these findings should be reflected in the upcoming Forest Stewardship Plan renewals in the Nadina District. The Nadina staff came away from this ADM tour understanding that there was a good level of support for them to seek solutions collaboratively with licensees to ensure sufficient trees are planted to account for the forest health losses that are taking place in post-free-growing stands. The tour also focused on post-mountain pine beetle attacked stands that were currently considered unmerchantable to harvest. What are the timber supply and wildlife habitat implications of harvesting these areas or not? There is significant pressure to harvest young merchantable stands in the mid-term but the impacts to timber and habitat supply of harvesting these stands prematurely is not well quantified. The tour also included discussions about riparian habitat management in bark beetle impacted TSAs. Data indicate a need to improve forest practices adjacent to small streams. 38% of the streams assessed in the Lakes TSA and 26% in the Morice TSA rated as 'borderline' or 'poor' functionality. About 50% of stream crossings assessed for water quality were rated as 'borderline' or 'poor' in preventing sediment generation. 63% of the stand-level retention is not sufficient to provide the range of habitat and attributes understood as necessary for maintaining species dependent on wildlife trees and coarse woody debris.

Pine and moose tour field discussion

Forest Health Presentations

Are biotic disturbance agents challenging basic tenets of growth and yield and sustainable forest management?

Alex Woods, Regional Pathologist, Skeena Region

Venue:
Western International Forest Disease Work Conference, Waterton Lakes, AB, October 7 – 11th, 2013.

Abstract:
Forests have the potential to provide one of the greatest mitigation efforts in the battle against anthropogenic climate change. Traditional forest management theories were developed prior to the knowledge of climate change and its impacts on forests yet these theories are still at the basis of site productivity projection in managed plantations globally. We examined the performance of plantations in British Columbia, Canada and assessed the validity of three of the most fundamental tenets of forest site productivity; assessment of dominant stand height (the height-age site index), Eichhorn's rule and the thinning response hypothesis. We assessed the condition of over 14,000 trees in 60 randomly selected even-aged plantations that had previously met stocking obligations, on average 11 years earlier, to determine if crop tree mortality, damage and yield were following expectations based on the three tenets of site productivity and TASS/TIPSY model projections. We recorded trees according to health status based on biotic and abiotic damage agents as well as their height class using three height classes (<2m, 2-4m and >4m). We found strong evidence that these older managed plantations are subject to damage agents that are targeting dominant trees, rapidly decreasing well-spaced and free-growing densities, and threatening yield projections. Our findings were clearly in conflict with assumptions of low and stable levels of loss of dominant trees in aging plantations. Competition induced mortality was not the dominant driver of managed stand density. We also found, unexpectedly, that natural ingress was not filling voids created by missing well-spaced trees. The current tendency of forest growth models to emphasize stability and predictability needs to be reconsidered in light of these findings. If forest growth models are an abstraction of our understanding of forest dynamics then our emerging understanding of uncertainty due to global change, especially climate change and its impacts calls for a re-assessment of the guiding principles of forest site productivity.

Baited Lindgren Trap Clusters for Douglas-fir Beetle Control

Robert Hodgkinson, Forest Entomologist, Omineca & Northeast Regions

Venue:
Omineca-Cariboo Region Douglas-fir beetle Meeting in Quesnel District Office, April 23, 2013.

Abstract:
The presentation included objectives, equipment and configuration, challenges, results of previous U.S. trials, results of the 2008 program in Prince George District, advantages and disadvantages, and conclusions and recommendations. At 10 trapping sites in 2008, 3 pheromone-baited Lindgren traps captured a mean of 20,057 + 2,445 (S.E.) Douglas-fir beetle (DFB) adults per site. That was enough to save a mean of 15.1 + 1.9 (S.E.) susceptible Douglas-fir (Fd) within 200m of the sites from being attacked and killed. At treated sites, 10.2% of susceptible Fd adjacent to the site were attacked compared to 34.0 % at untreated sites. Baited Lindgren trap clusters can effectively absorb emerging DFB adults and reduce damage to adjacent standing Fd. They can serve as a substitute for sanitation harvesting, trap trees, and/or fall & burn in areas with constraints. They may also be used in conjunction with MCH repellents.

BC Report at the National Pest Forum

Tim Ebata, Forest Health Officer, Resource Practices Branch

Venue:
National Pest Forum, Ottawa, ON, December 3rd, 2013.

Abstract:
The Provinces and Territories provide short summaries of forest health conditions recorded during the year at this annual national level forest health specialists' meeting in Ottawa, hosted by the Canadian Forest Service. This year's presentation on BC's forest health situation highlighted the current conditions for the province's major and more notable disturbance agents (mountain pine beetle, spruce beetle, Douglas-fir beetle, western spruce budworm, two-year cycle budworm, gypsy moth, aspen defoliators, Venturia twig blight, larch needle blight, bear damage, and severe hail damage) obtained from the provincial overview survey program. The presentation also included a more detailed look at the current status of the mountain pine beetle, particularly in its northern range and proximity to the Yukon and Northwest Territories. Northern expansion, particularly with the concerns of climate change, is a major concern of B.C.'s northern neighbours. The threat of continued expansion eastward into Alberta has lessened considerably with the steady decline of the beetle outbreak in the Peace region as host depletion regulates the population.

Exploring the effects of western spruce budworm outbreaks on the wood anatomy of Douglas-fir

Jodi Axelson, Forest Entomologist, Cariboo Region

Venue:
AmeriDendro, Tucson, Arizona, May 12-17th, 2013.

Abstract:
The western spruce budworm (WSB) is the most destructive defoliator of coniferous forests in western North America. Although numerous studies have reconstructed WSB outbreaks, there has been no prior research on how outbreaks affect the anatomical structure of the stem. In this study we examine the response of Douglas-fir to sustained WSB outbreaks, hypothesizing that anatomical characteristics such as cell wall thickness, cell size, and/or lumen area, change during WSB outbreaks. To test this we sampled four stands with annual defoliation data: 2 in the coastal transition zone of the Fraser Canyon and 2 in the extremely dry areas of the Nicola valley. Micro sections (10-15 µm) were created, dyed (safranin and astablue), dehydrated and embedded in Canada balsam to create permanent slides. Each slide was photographed using a microscope mounted camera (40 x magnification) and measured using WinCell. Up to 14 radial files were measured per ring, and 12 rings were measured in each micro section, resulting in approximately 6000 measured cells per sample. Results for the coastal transition zone in the Fraser Canyon indicate that earlywood anatomical parameters remain relatively stable during WSB outbreaks, while statistically significant results were obtained for latewood parameters: proportion of latewood, secondary cell wall thickness and radial cell diameter. All of these parameters decrease during defoliation periods as compared to non-outbreak (control) years (Figure 26).

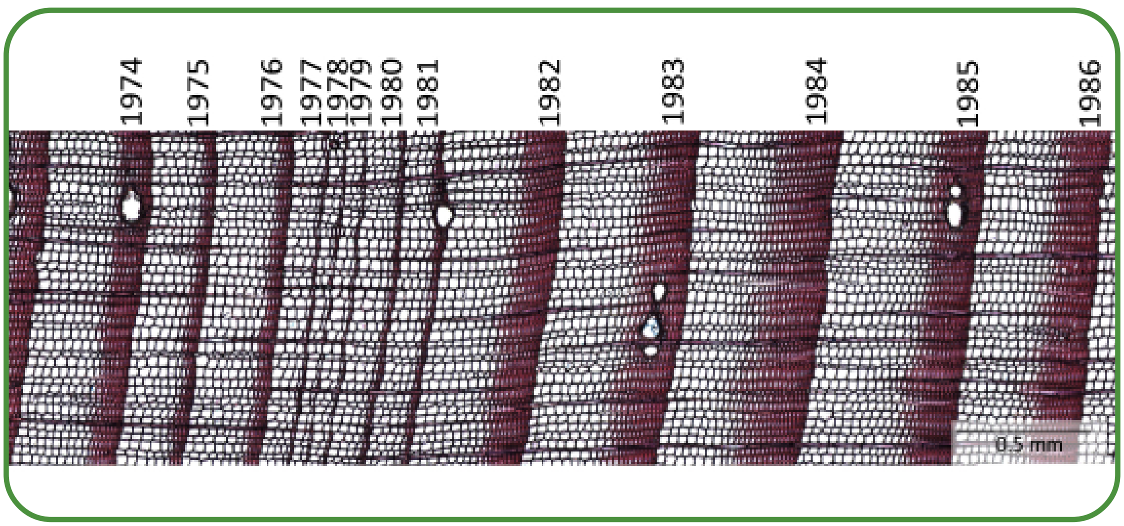


Figure 26. A digital composite of a micro section (magnified 40x) sampled in the Fraser Canyon area during the analysis period, 1974 to 1986. Visual estimates of defoliation were the highest in 1977 although growth and anatomical parameter reductions were lagged by 2 years with the lowest values occurring in 1979.

Forest Health Legislation in B.C. in 2013

Robert Hodgkinson, Forest Entomologist, Omineca & Northeast Regions

Venue:
University of Northern B.C. 3rd Year forest health class guest lecture, Prince George, B.C., November 20, 2013.

Abstract:
A lecture on forest health legislation included: 1) licensee requirements for forest health under the Forest and Range Practices Act (FRPA) and the Forest Planning and Practices Regulation (FPPR), 2) forest stewardship plans, 3) forest health emergencies, 4) invasive plants, 5) the Environmental Protection and Management Regulation (of the Oil & Gas Activities Act), and other related legislation. The students then divided into workshop groups to address a scenario regarding section 108 of FPPR which allows the Minister to grant relief to a person obligated to establish a free growing stand if the obligation cannot be met for financial reasons, and the person: 1) did not cause or contribute to the damage, 2) exercised due diligence in relation to the cause of the damage, or 3) contributed to the cause of the damage but only as a result of an officially induced error.

Forest Tent Caterpillar

Robert Hodgkinson, Forest Entomologist, Omineca & Northeast Regions

Venue:
Ministry of Environment Office, Prince George, B.C., June 27, 2013.

Abstract:
The presentation included the life cycle and hosts, the current infestation and outbreak cycles, natural population regulation, and targeted control. In 2012 some 178,866 ha were infested in the western and northern halves of the Prince George District. Natural population reduction factors include various insect parasites, birds, NPV virus, fungal pathogens, starvation and adverse weather. Control options include various tree barriers, hand picking, dormant oil, insecticidal soap, Bacillus thuringiensis, synthetic pyrethroids, and chemical insecticides.

Forest tent caterpillars on garbage can

Northern Silviculture Committee field trip presentations

Richard Reich, Forest Pathologist, Omineca and Northeast Regions

Venue:
Northern Silviculture Committee field trip, Burns Lake, BC, June 18th, 2013.

Abstract for eight year results for the Endako Site of the Comandra Resistance Trial :
Highlights included the:

- general lack of resistance to comandra blister rust of most of the tested families,
- proximity relationship with the spread of CBR from the alternate host Geocaulon lividum,
- rapid rate of mortality (~65%) by CBR due to the overwhelming majority of infection occurring in the first few years after planting,
- dramatic difference between infection between the two highly infected western sites and the low infection eastern site located 100 km to the east, which are likely due to differences in climate.

Abstract for the presentation of 38 year results of the EP671 Dog Creek Lodgepole pine Espacement Trial, (site of the 13 year old Maxan Espacement trial, established by Dr. Sally John):
Highlights included:

- virtual leveling off of mortality due to western gall rust at around age 20, for operational establishment densities, compared to steadily increasing cumulative mortality rate for the treatment established at close to 3000 sph initial establishment density.
- Relatively low cumulative mortality (~20%) by western gall rust by age 38
- Comparison of the rate of mortality of comandra blister rust under the same establishment densities.

The point of the discussion was that we can't assume a high level of mortality from WGR, and that we will need to monitor using the Young Stand Management (YSM) program through the Continuous Monitoring Inventory (CMI) in order to determine the rate of mortality in order to model losses for TSR.

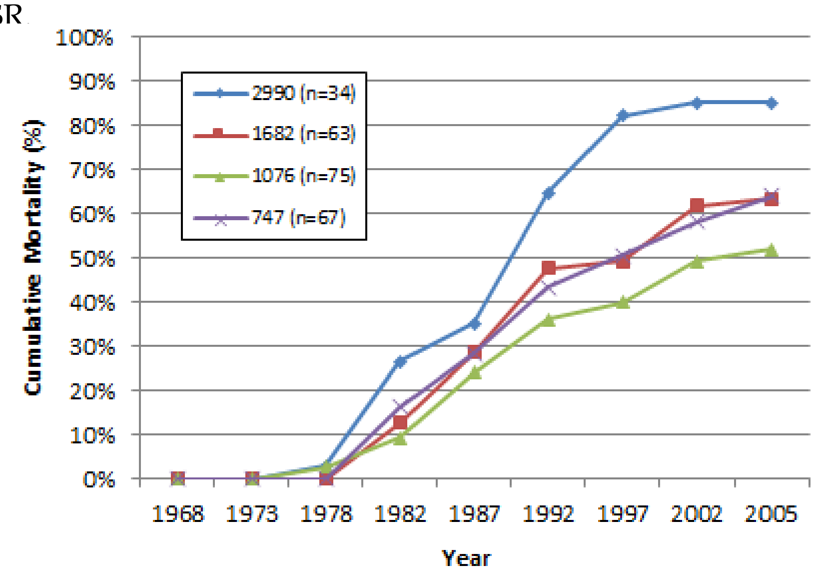


Figure 27. EP671 cumulative rate of mortality of comandra blister rust stem infected trees by establishment density.

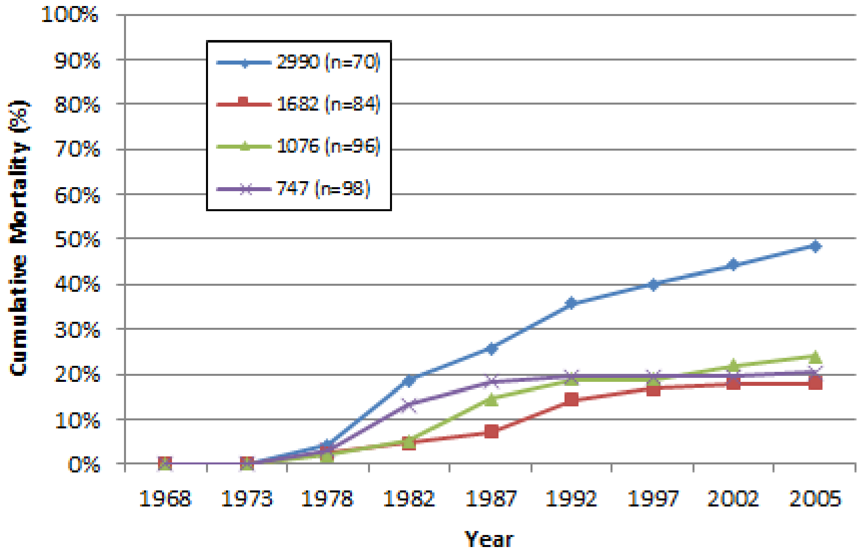


Figure 28. EP671 cumulative rate of mortality of western gall rust stem infected trees by establishment density.

Regional management team presentation

Richard Reich, Forest Pathologist, Omineca and Northeast Regions

Venue:
Regional Management Team Meeting, Prince George, BC, May 13th, 2013.

Abstract:

- Highlights of Major Initiatives/ Priorities:
- Cross Border Issues
- District Rust Working Groups
- Surveyor Training for Rusts/FH
- Pine Stem Rust Hazard Rating
- Provincial Silv Database ("RESULTS") Rust Map & Analysis
- Progeny Trials & Rust Screening Trials Assessments
- Climate Change & Rust Monitoring
- Building Bridges

Saga of the Spruce Beetle Outbreak in the Bowron

Robert Hodgkinson, Forest Entomologist, Omineca & Northeast Regions

Venues:
Northern Silviculture Committee Winter Workshop, Prince George, B.C., February 20, 2013.
Natural Resources and Environmental Sciences Institute Research Colloquium, University of Northern B.C., November 20, 2013.

Abstract:
Strong winds approaching 150 km/hr in October 1975 caused widespread spruce blowdown and breakage in the upper Bowron River valley and to a lesser extent in adjacent valleys. Several warm winters with heavy snow packs and early springs set the conditions for one-year life cycle spruce beetles. Overlapping one and two-year cycle beetles resulted in huge beetle flights and dramatic expansion and intensification of the infestation. The subsequent outbreak killed 40-60% of the mature spruce and, in response, approx. 5 million m3 of timber was logged from 1981-1987. Licensees were compelled to harvest 25-30 years of normal annual allowable cut in this compressed timeframe. Within the 175,000 ha outbreak area, 48,000 ha were harvested and all openings were reforested by 1999. The management response and lessons learned from the outbreak were outlined. Following this presentation, the 30 minute Westland video presentation of The Biggest Clearcut from 1992 was played.

Shade tree and shelterbelt disease situation report for 2013

Harry Kope, Forest Pathologist, Resource Practices Branch,
Stefan Zeglen, Forest Pathologist, Coast Regions, and
Richard Hamelin, Professor with Department of Forest Sciences, University of BC

Venue:
Western committee on plant diseases, Winnipeg, MB, October 8th, 2013 (Authors did not attend).

Abstract:
Septoria Leaf Spot and Canker of Poplar in the Upper Fraser Valley
Septoria musiva Peck (teleomorph *Mycosphaerella populorum* G. E. Thomps.), which causes leaf blight and, more importantly, necrotic lesions (cankers) that often result in stem breakage, was first confirmed at a hybrid poplar nursery in British Columbia (BC) in 2006. The BC Ministry of Forests, Lands and Natural Resource Operations in cooperation with the University of BC has conducted field surveys to assess the distribution of *S. musiva* in British Columbia on native and hybrid *Populus* spp.

- Native *Populus trichocarpa* – Leaf collections made in 2008, 2009 and 2012 along the Fraser River, from over 1200 young and mature trees detected leaves positive for *S. musiva* on 14 different trees (approximately 1.2% incidence).
    - The distribution of trees with *S. musiva* was spread along the Fraser River between Dewdney and Hope.
    - This could indicate either, multiple introductions, rapid spread from a single introduction, or undetected slow spread over a long period.

- Hybrid *Populus* spp. – An assessment of leaves from 21 hybrid plantations in the Fraser Valley during 2013 found that 16 (76%) of the plantations were infested with *S. musiva* (187 trees sampled, 105 infested; approximately 56% incidence).
  - The affected plantations occur from Richmond to Agassiz, on both the north and south sides of the Fraser River.
  - Affected plantations ranged in age from 15 to 30 years.

Stand Development Monitoring: how are coastal stands performing post-free growing?

Stefan Zeglen, Regional Pathologist, Coast Area
Dave Weaver, Silviculture Surveys Specialist, Forest Stewardship Branch

Venue:
Coastal Silviculture Committee Winter Workshop, Nanaimo, BC, February 28, 2013.

Abstract:
Stand development monitoring (SDM) is intended to collect mid-rotation data to provide an additional point of reference to determine if a stand is growing according to expectations and will meet intended management objectives. The method provides silviculture, inventory and forest health information that can be used to update stand attributes and provides a point of comparison of stand performance against both conventional and modelled projections. This talk provides an overview of SDM implementation on the coast and a brief explanation of the survey protocol and field procedures. Some preliminary results of survey data collected from coastal TSAs is provided as well as plans for future data capture, analysis and reporting.

Test of Aerial Application of Bacillus thuringiensis var kurstaki against 2-Year Cycle Budworm at Mt. Tom in 2012

Robert Hodgkinson, Forest Entomologist, Omineca & Northeast Regions

Venues:
Mt. Tom Research & Forest Health Meeting, Quesnel District Office, May 7, 2013.
Quesnel Timber Supply Area Steering Committee Meeting, Quesnel District Office, Oct. 29, 2013.

Abstract:
The 2012 operational research trial of Bacillus thuringiensis (Btk) against two-year cycle budworm at Mt. Tom in Quesnel District was outlined. The presentation included the main objectives, plot location, phenology, larval development, weather, site challenges, results, discussion, conclusions and recommendations. On subalpine fir Btk significantly reduced: 1) larval populations by 75 - 95%, 2) defoliation by 32-74% and 3) moth egg mass depositions by 85-88%.

The least you should know about rust management in the Omineca Region

Richard Reich, *Forest Pathologist, Omineca and Northeast Regions*

Venue:
Winter Northern Silviculture Committee Meeting, Prince George, February 19th, 2013.

Abstract:
Topics covered during the presentation were:
- District Rust Working Groups
- Surveyor Training for Rusts/FH
- Pine Stem Rust Hazard Rating
- Provincial Silv Database ("RESULTS") Rust Map
- Progeny Trials & Rust Screening Trials Assessments
- Climate Change & Rust Monitoring

Using an inoculum reduction treatment to reduce root disease: stand development 20 years later

Dean Stewart, *Compliance & Enforcement Officer, South Island District*
Stefan Zeglen, *Regional Pathologist, South and West Coast Regions*

Venue:
Coastal Silviculture Committee Summer Field Tour, Nanaimo, BC, June 19-20, 2013.

Abstract:
What happens to stands that have been identified as having high levels of root disease and are logged and treated in order to "bring the site back to maximum productivity?" Searching the ancient scrolls, we examined the sordid history behind one such block and using stand monitoring and root disease survey data tried to determine how well various treatments worked and where the stand is today in its search for maximum productivity. Discussion involved treatment options, quality control, prescriptive forestry and the optimism of the times.

Warmer and wetter might not be better

Alex Woods, *Regional Pathologist, Skeena Region*

Venue:
IUFRO Foliage Shoot and Stem Disease Conference, Cerna Hora/Brno, Czech Republic, May 19 – 24th, 2013.

Abstract:
A link between warmer wetter conditions and the declining health of lodgepole pine plantations and natural stands in northwest British Columbia, Canada has been established. Dothistroma needle blight has caused extensive defoliation and mortality in plantations of lodgepole pine in that area. The severity of the disease is such that mature lodgepole pine trees in the area have

succumbed, and this is an unprecedented occurrence. After more than a decade of investigation, directional climate change towards warmer wetter conditions remains the most plausible explanation for the epidemic. Despite this established link, projections of improved tree growth have been made for lodgepole pine in BC provided seed sources are optimized, but these projections overlook the role of insects and disease. Climatic trends of increasing summer precipitation and warmer overnight summer minimum temperatures, are clearly influencing the health of managed stands across the northern half of the province. A foliar pathogen of spruce, *Rhizosphaera kaukhoffii*, has caused increasing levels of defoliation in plantations, leading to suppressed growth and in some cases mortality. Other foliar pathogens of lodgepole pine appear to be more common than in the past. More significantly, the landscape level incidence of hard pine rusts in the central interior including *Endocronartium harknessii, Cronartium comandrae* and *Cronartium coleosporoides*, have increased dramatically over the same time period that the Dothistroma needle blight epidemic developed further to the west. Both foliar diseases and hard pine rusts appear to be benefitting from more rain and warmer summer minimum temperatures but a recent widespread occurrence of top-die back in lodgepole pine is likely linked to another forecast trend associated with climate change, that of increasingly erratic weather. An abrupt (40^{o}C) drop in temperature in the fall of 2010, following a drier than average summer, is believed to have triggered an outbreak of *Cenangium ferruginosum*. Evidence of the combined impacts of abiotic and biotic damage agents on managed stand productivity is accumulating but just as forest genetics forecasts of potential for improved growth under a changing climate appear optimistic, so too do growth and yield model projections that similarly overlook damage agents.

Yellow-cedar decline

Stefan Zeglen, Regional Pathologist, South and West Coast Regions
Paul Hennon, Research Pathologist, USDA Forest Service, Juneau, AK

Venue:
Climate Change Adaptation Workshop, Richmond, BC, October 17, 2013.

Abstract:
The case of yellow-cedar decline was presented as a natural phenomenon occurring as a result of long-term changes to climate patterns on the west coast. Decades of research from SE Alaska has provided a wealth of information on the occurrence, dynamics and likely cause of the decline. A summary of this research and the current model of decline is provided. The concurrent story of yellow-cedar decline in BC is presented and the implications for future research of the decline and management of the species is explored.

Forest Health Publications

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Reich, R.W., K.J. Lewis, and A.M. Wiensczyk. 2013. Tomentosus root rot forest health stand establishment decision aid. Journal of Ecosystems and Management 14(1):1–8. FORREX Forum for Research and Extension in Natural Resources. http://jem.forrex.org/index.php/jem/article/viewFile/562/489

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Western blackheaded budworm defoliation in Kingcome TSA

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Babin Air
Blackcomb Aviation
Cariboo Air Ltd.
Glacier Air
Guardian Aerospace Holdings Inc.
Inland Air Charters Ltd.
Lakes District Air Services
Lawrence Aviation Ltd.
Trek Aerial Services
Westair Aviation Inc.

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