2014 Summary of Forest Health Conditions in British Columbia

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Front cover photo by Rick Reynolds: Yellow-cedar decline on Haida Gwaii

2014 Summary of Forest Health Conditions In British Columbia

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Summary

The *2014 Summary of Forest Health Conditions in British Columbia* (BC) contains forest health information gathered during the 2014 aerial overview surveys and other BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) sources. Overview material is supplemented for targeted forest health issues with lower flown helicopter surveys. Further specific damaging agent ground sources include insect population assessments, forest health surveys and ground observations by trained personnel. The final sections of the report consist of project summaries, meetings, presentations and publications conducted by MFLNRO entomologists, pathologists and their associates.

The aerial overview survey covered an estimated 89% of the province this year, with over 12.2 million hectares (ha) of damage mapped. These disturbances were caused by a wide variety of forest health agents affecting many different host tree species. By a narrow margin, bark beetle mortality continued to affect the largest area across the province. Western balsam bark beetle damage led with just under 3 million ha affected. Intensity of attack was noted to be higher as well, though 84% of the infestations were still just rated as trace. The mountain pine beetle outbreak which has dominated the landscape of BC for over a decade declined for the fifth consecutive year to 2.2 million ha. Intensity of mortality decreased as well and infestation expansions were minimal, primarily in the far north and south. Lodgepole pine mortality north of the delineated mountain pine beetle attack was attributed to lodgepole pine beetle with 73,079 ha mapped. Spruce beetle damage increased to 288,892 ha, primarily in the Omineca Region, and Douglas-fir beetle infestations grew to 39,481 ha mostly in Williams Lake TSA of the Cariboo Region.

Area affected by defoliators was very close to that of bark beetles this year and damage was dominated by deciduous pests. Aspen leaf miner continued to be the leading cause with a record 3.6 million ha of damage observed throughout the province, though ground observations noted intensity of attack at the tree level seemed to be on the decline. Large aspen tortrix infestations, mainly in the Northeast Region, rose to just under 1 million ha. The forest tent caterpillar outbreak also continued in the Omineca and Cariboo Region, with 711,297 ha delineated. An unexpected increase in gypsy moth populations in Surrey and Delta resulted in a proposed aerial spray treatment in May, 2015 to eradicate this infestation.

Two-year-cycle budworm led the conifer defoliation with 164,979 ha observed mid province. Western spruce budworm damage (mainly in the southern interior) decreased to 44,608 ha, the lowest level recorded since 2000. Part of this reduction can be attributed to treatment of 56,737 ha of high value stands with the biological insecticide *Bacillus thuringiensis* var. *kurstaki* (Btk) in the Cariboo and Thompson/Okanagan Regions.

Damage caused by diseases that were visible from the aerial overview surveys continued to be dominated by Venturia blight with 559,583 ha affected, mainly in the Northeast and Skeena Regions. Foliage diseases detected were Lophodermella needle cast (2,979 ha) Dothistroma needle blight (1,842 ha), cottonwood leaf rust (1,242 ha) and larch needle blight (1,072 ha). White pine blister rust damage was observed at spot or trace intensity on 1,694 ha in the South Coast Region.

The most damaging abiotic agent was wildfire, with 405,426 ha burnt, mainly in six large northern fires. Flooding damage, primarily in the northeast, rose to 42,298 ha. Coastal BC yellow-cedar decline mortality also increased to 38,752 ha. Weather damage specifically related to drought conditions affected 25,810 ha of mainly deciduous trees in the Northeast Region while a further 35,509 ha of predominately western redcedar throughout the central to southern interior of the province was also affected by undetermined climatic conditions. Post wildfire related damage decreased to 10,381 ha.

Observable animal damage increased this year, in particular 18,172 ha of porcupine damage in Fort Nelson TSA of the Northeast Region. Black bear damage affected mainly managed lodgepole pine stands with 4,173 ha delineated. A complex of porcupine, black bear and/or lodgepole pine beetle mortality was suspected in several areas.

Other damaging agents including western blackheaded budworm, birch leaf miner, pine needle sheathminer, windthrow, slides and aspen decline affected localized stands throughout the province.

2014 Summary of Forest Health Conditions in British Columbia

Introduction

The forests of British Columbia (BC) are very diverse, with a wide variety of tree species. Many agents including insects, diseases, animals and abiotic factors can damage these trees. Forest disturbances resulting from these agents often vary substantially in size, intensity and location over a short period of time. Hence, an annual aerial overview survey is conducted across the forested landscape of BC to capture current damage in a cost effective and timely manner. All visible damage is recorded by agent, extent and severity of damage for all commercial tree species.

These surveys have been the responsibility of the provincial government for the past eighteen years and have been conducted by the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO). As Timber Supply Area (TSA) boundaries are relatively stable in the province, the data collected is summarized by these units (Figure 1). The exception is reporting for the Pacific and Cascadia TSAs which were recently created and consist of small fragmented units within several larger TSAs.

Many interest groups including government agencies, industry, academia and the public use the data collected from the annual overview surveys for a wide range of purposes. These include input into government strategic objectives, guidance for management and control efforts related to forest health, usage of disturbance data for research projects, providing national indicators for sustainable forest management, input for timber supply analyses and contributions to the National Forest Pest Strategy database.

Once the surveys are completed the data is digitized, reviewed and collated. In this report, individual damaging agent results are grouped by host tree species. Area damaged data is obtained directly from the aerial overview survey data. Information collected by other methods such as helicopter and ground assessments may also be presented but since data collection methods differ they are not added to the overview database. The supplemental information includes damage that is not visible at the height the overview survey is flown (primarily damage caused by diseases) and specific insect population information (collected by pheromone trapping, egg surveys and tree beatings).

Pertinent forest health activities undertaken by MFLNRO entomologists, pathologists and their associates over the past year are included after the individual damaging agent reporting section. This includes projects, presentations, workshops and publications conducted by the aforementioned participants, which does not necessarily capture forest health activities conducted by other agencies. For more detailed forest health information in the Southern Interior, refer to the 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

Small fixed wing aircrafts are used to conduct the aerial overview surveys. Two trained observers sitting on opposite sides of the plane map the disturbances. An additional trainee occasionally maps from the seat behind the most experienced surveyor. A minimum of two observers and a pilot cover each MFLNRO region.

Aerial observers recording forest health damage

Current damage is sketched on customized 1:100,000 scale maps (colour Landsat 5 satellite images with additional digital features such as contours, site names, water features and roads). On flight completion, the individual working maps are collated onto a mylar which is then digitized to obtain the spatial data. Survey methodology and digitizing standards are available at http://www.for.gov.bc.ca/hfp/health/overiew/methods.htm.

Surveys in each region are conducted when damage from the primary forest health factor(s) of present concern is most visible, flight conditions permitting. Operations began July 7th in 2014 (a common start date for some regions) but were not completed until November 11th, more than a month later than is typical (Table 1). Spring weather was generally cool and wet, which delayed some damage expression. Summer however was warm and overall very dry. This resulted in a few very large fires in central and northeast BC resulting in very poor visibility for extended periods, particularly in the northeast, and lead to significant survey delays. Flight time to complete the surveys was 732.6 hours, conducted by 23 surveyors and eleven aircraft companies.

Table 1. Flying hours and survey dates by region for the 2014 provincial aerial overview survey.

Regions	Flight hours	Survey Dates
Cariboo	125.3	July 22nd – Aug 9th
Thompson/Okanagan	44.2	July 18th – July 28th
Kootenay/Boundary	104.5	July 26th – Aug 24th
Omineca & Northeast	242.8	July 7th – Nov 11th
Skeena	122.6	July 17th – Sept 17th
West & South Coast	93.2	July 9th – Sept 16th
Total	**732.6**	**July 7th – Nov 11th**

Flight lines were recorded with recreational quality Global Positioning Satellite (GPS) receiver units. This data was collated weekly so coverage intensity and survey progress could be easily monitored as the surveys progressed. Lines were flown between 700m to 1400m above ground level, depending on terrain and visibility. In relatively flat terrain parallel lines were flown 7km to 14km apart, depending on the intensity of mapping activity and visibility. For mountainous terrain, valley corridors were flown. Intensity of coverage in the mountains depended on visibility up side drainages from main drainages. Aircraft speed ranged from 130 to 180 kph depending on mapping intensity and wind speed. All commercial tree species were surveyed for visible current damage, regardless of land ownership or tenure.

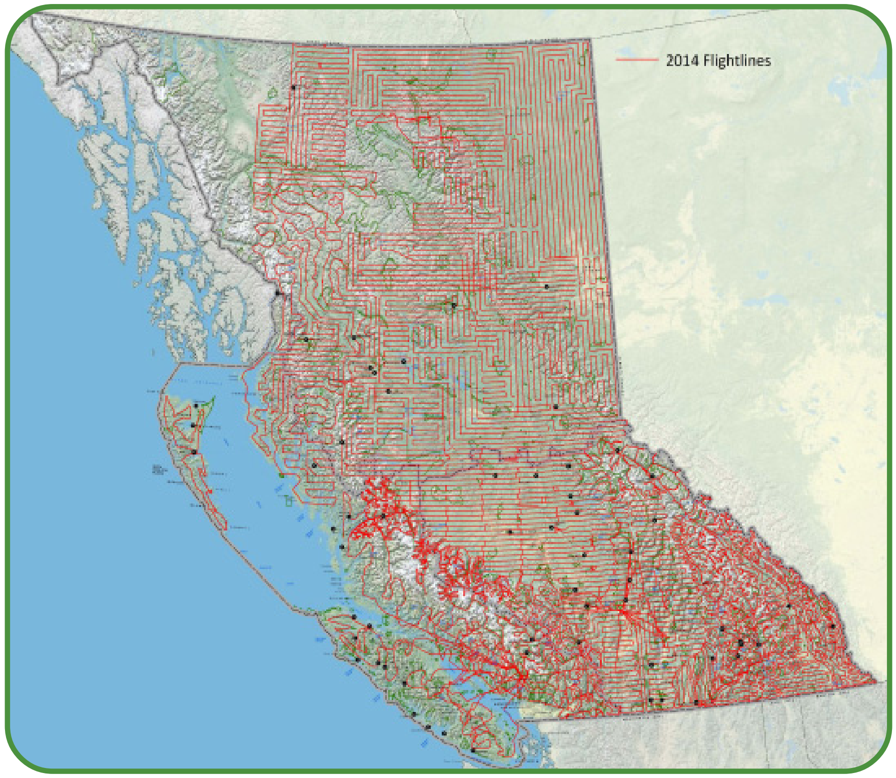


Figure 2. Flight paths flown while conducting the 2014 aerial overview surveys. Approximately 89% of the province was surveyed in 2014.

The goal is to survey all forested land across the province annually, weather and funding permitting. This goal is difficult to obtain within the survey timing window, therefore high priority areas and major drainages in lower priority areas are targeted first. All priority areas were adequately covered this year, with the exception of the northern half of the Mackenzie TSA (Figure 2). Surveyors worked hard to fill this hole, but visibility in this area was very poor due to smoke until late in the fall, when poor weather conditions required a halt to the project. In total 89% of the province was flown, which was still very good coverage. The estimated percentage flown was calculated using a digital planimeter. The estimate did not factor in whether areas contained non-forested types such as lakes, grasslands or alpine.

Tree mortality (caused by bark beetles, animal feeding, root diseases and some abiotic factors) was identified by the colour of the foliage. Only trees killed within the past year were mapped. Clumps of up to 50 dead or dying trees were mapped as points referred to 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 of mortality were drawn as polygons with five mortality intensity classes (Table 2).

Trees with foliar damage (caused by insect feeding, foliage diseases and some abiotic factors) usually cover reasonably large areas, often with all age classes of host trees affected. Therefore, only polygons were mapped for this type of damage and intensity was based on the amount of foliage damaged during the past year on all host trees in the polygon. Three current damage intensity classes were used for foliar damage, with any cumulative damage that results in mortality recorded as grey once an agent has run its course in a given area (Table 2).

Some exceptions were made to the "polygon only" rule for foliar damage. Venturia blight damage in the northern interior 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 spot damage. Occasionally needle diseases (particularly in the Kootenay/Boundary Region) severely affect host trees which are a very low component of the stand composition. This damage was sometimes recorded as spot damage.

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.

Aspen leaf miner damage that is visible from the air tends to have an "all or nothing" signature that has very little discernible tree-to-tree variation in damage. However, in many areas of the province, aspen occurs in mixed rather than pure stands. To most accurately map this damage, procedures were modified in 2012 to record these disturbances in a manner similar to mortality with severity ratings based on the percentage of the stand affected, rather than the intensity of the defoliation to the trees.

There are known limitations with the data collected during the aerial overview surveys. Not all damage is visible, either due to the height flown or the timing of the surveys. For example, spruce beetle mortality can be under-reported because foliage changes on dying trees can happen very quickly or occur outside the survey period (Figure 3). Also many diseases cause significant growth loss and tree defects that aren't visible by aerial assessments, such as mistletoe infections and gall rust.

Figure 3. Same spruce tree fully attacked in 2013. Left photo taken July 20, 2014, right photo taken Sept. 17, 2014.

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 as new damage may be recorded in all or a portion of the same stands that were previously disturbed. Also the relatively broad intensity classes and known errors of omission must be considered. For example, calculating accurate mortality volume estimates is not possible since the actual number of trees killed (and consequently volume) is not precise.

Stem breakage of lodgepole pine due to western gall rust canker

Despite the survey limitations, 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, since the data is the most complete record of the outbreak's progress across the province. The annual survey data is also being used by districts to estimate non-recoverable pest-caused losses for incorporation into timber supply reviews.

For the past six years the composite mylar 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 needing immediate access to the information. The final provincial summaries of the spatial and tabular data were available by January 23rd, 2015.

General Conditions

Total damage mapped across the province in 2014 from the aerial overview surveys was 12,243,065 ha (Table 3). Following four consecutive years of decline, combined disturbances primarily due to fire, deciduous defoliators, western balsam bark beetle and spruce beetle, accounted for an overall increase of thirty percent over 2013.

By an increasingly smaller margin, bark beetles continued to cause the most damage. Western balsam bark beetle mortality increased for the third consecutive year to 2,977,629 ha, which was a record for area affected as well as the highest level of attack intensity since 2006. Conversely, the mountain pine beetle outbreak declined for the fifth consecutive year to 2,208,687 ha with a corresponding decrease in intensity. Minor expansions continued to occur in the northeast and in Boundary TSA of the Kootenay/Boundary Region. At the northern-most reaches of the mountain pine beetle attack, trace to light lodgepole pine mortality was attributed to lodgepole pine beetle with some porcupine damage (73,079 ha), mostly in the Fort Nelson TSA of the Northeast Region. Spruce beetle damage increased dramatically to 288,892 ha, though intensity of mortality was lower than last year. Most of the infestations occurred in the Prince George and Mackenzie TSAs of the Omineca Region. Douglas-fir beetle attack increased to 39,481 ha, the majority of which was observed in Williams Lake TSA of the Cariboo Region, where populations have built-up in old wildfires.

Table 3. Summary of hectares affected by forest damaging agents as detected in 2014 aerial overview surveys in British Columbia.

Damaging Agent	Hectares Affected	Damaging Agent	Hectares Affected
Bark Beetles:		*Diseases:*	
Western balsam bark beetle	2,977,629	Venturia blight	559,583
Mountain pine beetle	2,208,687	Unknown disease**	6,316
Spruce beetle	288,892	Lophodermella needle cast	2,797
Douglas-fir beetle	39,481	Dothistroma needle blight	1,842
Secondary beetles	28	White pine blister rust	1,807
Lodgepole pine beetle	73,258	Cottonwood leaf rust	1,242
Total Bark Beetles:	5,587,975	Larch needle blight	1,072
Defoliators:		Root diseases***	426
Aspen leafminer	3,616,055	*Total Diseases:*	575,084
Large aspen tortrix	937,962	*Abiotics:*	
Forest tent caterpillar	711,297	Unknown	1,613
Two-year-cycle budworm	164,979	Fire	405,426
Western spruce budworm	44,608	Flooding	42,298
Unknown defoliators**	7,102	Yellow cedar decline	38,752
Western blackheaded budworm*	4,238	Weather related****	35,509
Birch leaf miner	1,984	Drought	25,810
Pine needle sheathminer	1,684	Post fire	10,381
Satin moth	445	Windthrow	2,691
Balsam woolly adelgid	92	Slides	2,572
Lodgepole pine needle miner	464	Aspen decline	1,548
Total Defoliators:	5,490,909	Hail	111
Animals:		*Total Abiotics:*	595,044
Porcupine	18,172		
Bear	4,173	*Provincial Total Damage:*	12,243,065
Unknown animal damage**	38		
Total Animals:	22,383		

* 3,129 ha are current, remaining damage is cumulative mortality.
** Unknown refers to damage that could not be confirmed with ground checks.
*** Root disease damage is greatly underestimated from aerial overview surveys.
**** Includes unusual redcedar damage (see pg. 32)

Defoliator damage increased to 5,490,909 ha across BC in 2014. Aspen leaf miner continued to be the leading cause of defoliator damage (and was responsible for more hectares affected than any other single damaging agent) with a record peak of 3,616,055 ha mapped. Intensity of attack for this defoliator is rated as a percentage of trees affected in a stand but ground observations this year, particularly in the Skeena Region, reported that intensity of attack on an individual tree basis was considerably lighter than the last few years. Large aspen tortrix infestations were active on 937,962 ha this year, with the majority of the disturbances contained in the Northeast Region. Damage at the southernmost

Aspen leaf miner damage

extent of the outbreak (ground confirmed) overlapped with defoliation identified as the northernmost reaches of the forest tent caterpillar last year. Forest tent caterpillar defoliation continued to rise as well with 711,297 ha affected, primarily in Prince George TSA of the Omineca Region and Quesnel TSA of the Cariboo Region. Two-year-cycle budworm damage doubled since last year to 164,979 ha, mostly in the Cariboo Region, Kamloops TSA of the Thompson/Okanagan Region and Robson Valley TSA of the Omineca Region, where this budworm was in the second year of the cycle. Western spruce budworm defoliation declined for the third consecutive year to 43,248 ha, which is the lowest level reported since 2000.

The leading cause of observable disease damage continued to be by Venturia blight with 559,583 ha affected. This is lower, however, than the record peak of 837,586 ha last year and intensity decreased as well, most likely due to the last two relatively dry summers. Most of the disturbances were mapped in the Northeast and Skeena Regions. Detected lodgepole pine needle diseases were Lophodermella needle cast with 2,979 ha (in Fort Nelson TSA of the Northeast Region and the Thompson/Okanagan Region) and Dothistroma needle blight with 1,842 ha (Omineca, Skeena and Thompson/Okanagan Regions) delineated. White pine blister rust damage rose to 1,694 ha in the South Coast Region, though almost all was rated as trace. Other identifiable disease damage visible from the height of the aerial overview survey was less than 1,300 ha per disease, which is known to be far less than the estimated level of disease damage in the province.

Wildfire continued to cause the most abiotic damage with 405,426 ha burnt, primarily due to six large fires in the northern half of the province. Flooding damage increased in area and intensity with 42,298 ha affected. The majority of the flooding occurred in Fort Nelson TSA of the Northeast Region, though the most potentially environmentally damaging event was the result of the Polley Mine tailing pond breach in Williams Lake TSA of the Cariboo Region. Yellow-cedar decline damage along the coast of BC doubled for the second consecutive year to 38,752 ha. Climate related damage (winter desiccation, low snowpack melt timing, change in soil moisture regime/timing or drought) was identified on 35,509 ha this year. Western redcedar was the most commonly affected species in the northern reaches of Thompson/Okanagan and Kootenay/Boundary Regions as well as the eastern portion of the Cariboo Region. Climate related damage specific to drought was delineated on 25,810 ha, almost all of which occurred in the Northeast Region on deciduous trees. Mortality occurring in wildfire areas in succeeding years decreased to 10,381 ha this year, mainly in the Cariboo and Skeena Regions.

Animal damage is often not detected from the height the aerial overview survey is flown but this year was an exception. Porcupine in Fort Nelson TSA of the Northeast Region was assessed as the main damaging agent on 18,172 ha. Black bear damage remained relatively stable at 4,173 ha in primarily young to intermediate age lodgepole pine stands.

A variety of other damaging agents caused localized damage throughout the province. Locations, extent and intensity of damage by all forest health factors are described in the following section by host tree species.

Damaging Agents of Pines

Mountain pine beetle, *Dendroctonus ponderosae*

Provincial

After a record peak of just over 10 million hectares of damage in 2007, the current mountain pine beetle outbreak has declined for the fifth consecutive year to 2,208,687 ha in 2014 (Figure 4). Intensity of mortality has also decreased to 1,497,920 ha (68%) trace, 632,932 ha (29%) light, 70,500 ha (3%) moderate and 7,335 ha (<1%) severe.

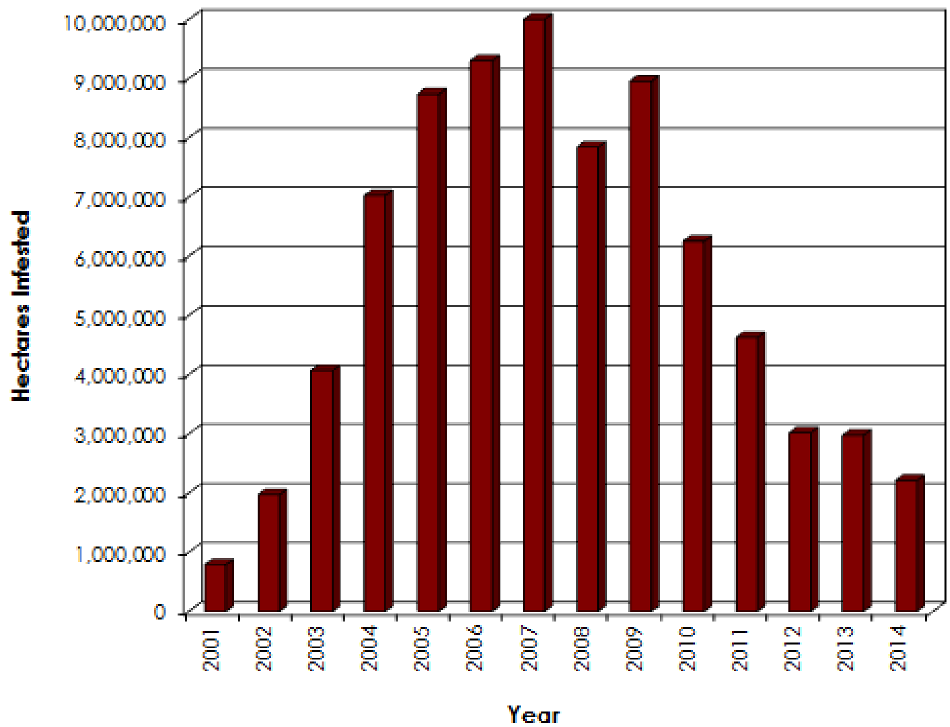


Figure 4. Hectares infested (all severity classes) by mountain pine beetle from 2001 – 2014 in British Columbia.

Infestation expansions continued to occur in a few TSAs in the northeastern portion of the province, but only at light to trace intensities. The extent of the northern most spread in Fort Nelson TSA was uncertain as lodgepole pine mortality was delineated right to the Yukon border, but ground checks were not possible this year. Helicopter reconnaissance combined with local knowledge and a few ground checks last year resulted in the furthest northern disturbances being tentatively identified as caused by lodgepole pine beetle with some porcupine damage. Damage in the remainder of the province tended to occur in the same general areas as last year, but with overall reductions in size and intensity (Figure 5). The only notable exception was some small new disturbances in Boundary TSA of the Kootenay/Boundary Region. Beetle population growth continues to be slowed by host depletion in central BC, cold weather in the north and mixed stands/topographical barriers in the south.

Where the mountain pine beetle was active early fading of current attack was noted in several areas, possibly accelerated by drought conditions. With very little current attack in accessible areas and few mountain pine beetle treatment zones left in the province, tracking of beetle biology in 2014 was minimal.

Mountain pine beetle attack in young lodgepole pine stands steadily declined from a peak of 357,017 ha in 2008 to only 183 ha scattered throughout the province this year. Young pine mortality thought to be caused by secondary beetles also declined to only 28 ha, primarily located in Robson Valley TSA of the Omineca Region.

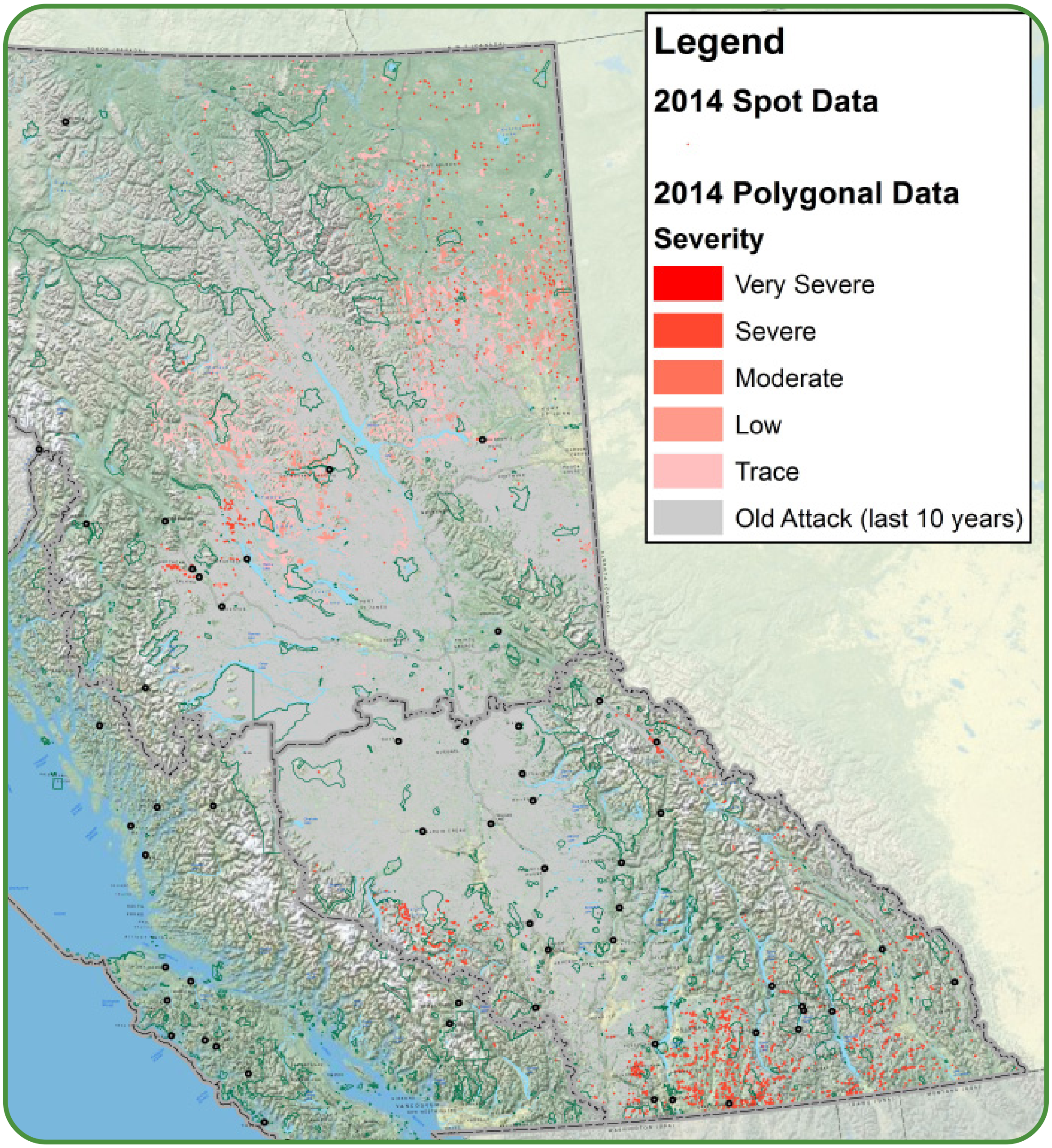


Figure 5. Current mountain pine beetle infestations recorded in British Columbia in 2014 with old attack in grey.

The majority of the mountain pine beetle mortality continued to occur in lodgepole pine with a few exceptions. Whitebark pine mortality increased marginally since last year to 5,323 ha affected scattered throughout the Kootenay Region and the western half of Lillooet TSA in the Thompson/ Okanagan Region. Ponderosa pine attack declined to 15 ha of mostly spot infestations scattered predominantly throughout the southeastern portion of the province. Only six spots of widely scattered western white pine mortality was observed.

Northern Interior Damage

The Northeast and Omineca Regions continued to sustain the majority of mountain pine beetle damage with 1,116,030 ha and 959,545 ha affected, respectively (Figure 6). This represents 94% of the infestations mapped across the province. However, 97% of the mortality was observed to be trace to light severity.

In the Northeast Region, attack in Fort St. John TSA declined 20% since 2013 to 803,307 ha. Mortality intensity also generally declined, with the exception of several moderate polygons being delineated along the Alberta border. Attack rates in Fort Nelson TSA rose 9% to 244,888 ha as infestations moved slowly northward. Attack in Dawson TSA was a third of last year at 67,835 ha. The majority of the decline occurred mid TSA with the most intense activity now located along the Alberta border east of Redwillow River.

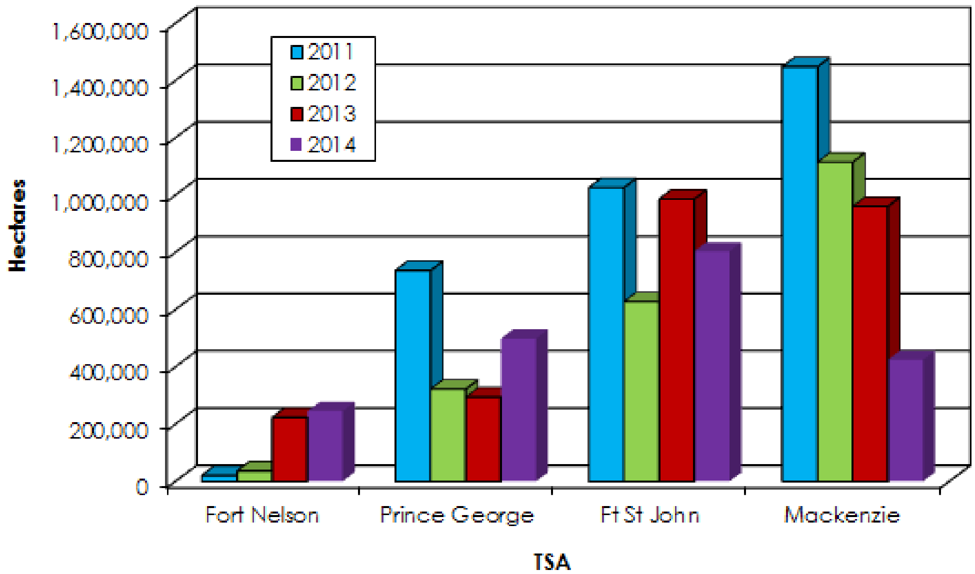


Figure 6. Hectares infested by mountain pine beetle from 2011 – 2014 in the Omineca and Northeast Regions (TSAs with more than 200,000 ha affected in 2014).

In the Omineca Region, area affected in Prince George TSA almost doubled since 2013 to 498,790 ha. This increase was a reflection of different mapping styles by new surveyors in the TSA this year who were mapping larger, less intensely damaged polygons. Thus, the increase may not indicate an overall increase in beetle activity. The most active infestations in this TSA occurred in Fort St. James District from Bear Lake northward. Conversely, disturbances decreased by more than half in Mackenzie TSA to 423,991 ha. This may in part have been because the northern quarter of the TSA could not be surveyed this year. Attack in Robson Valley TSA increased to 36,764 ha, with active infestations near Lucerne Lake and Hugh Allan Creek accounting for 40% of the severe mortality mapped in the province.

Mountain pine beetle caused mortality in Robson Valley TSA

Skeena Region mountain pine beetle damage was a third of that mapped last year, with 80,540 ha delineated. Kispiox TSA experienced an increase however to 24,402 ha, though 94% of the disturbances were rated at trace intensity in the northeast portion of the TSA. The only active infestation (with light to moderate mortality) was noted in the south around Lorne Creek. Damage declined more than four-fold in Morice TSA to 24,166 ha, located mostly in the north tip. Infestations in Bulkley TSA were only 20% of that recorded last year with 19,065 ha mapped. Most of the attack was noted south of Hudson Bay Range and in the north tip of the TSA. Lakes TSA damage increased somewhat to 12,242 ha, all of which was located along the northern edge. Cassiar, Kalum and Nass TSAs had minor infestations totalling 263 ha, 216 ha and 185 ha, respectively.

Southern Interior Damage

Mountain pine beetle damage in Kootenay/Boundary Region TSAs has generally been in decline for four consecutive years with the exception of Boundary TSA, where infestations have steadily increased (Figure 7). Overall, this resulted in total hectares affected in the region remaining static at 41,528 ha. Ground checks in the southeastern portion of the region indicated that mapped red attack was somewhat misleading as some mortality was due to late fading old strip attacks (perhaps induced by drought conditions), secondary beetles, Armillaria root disease and blister rust. Boundary TSA contained 25,717 ha of the attack that was quite active (higher intensities than many TSAs) and widely scattered. A total of 6,635 ha were mapped in Invermere TSA, primarily in the western half. Kootenay Lake TSA sustained 3,195 ha of scattered damage. In suppression areas, initial beetle surveys for this TSA reported an average ratio of 0.2 green attack to red attack, which indicated a declining population. Scattered mountain pine beetle mortality delineated in Golden TSA totalled 2,423 ha with concentrations along Valenciennes River and north of Moberly. Cranbrook TSA contained 1,932 ha of attack, principally located in the northwest. Ground surveys conducted in this TSA in suppression areas reported an average of 0.57 green attack to red attack. Areas in suppression units where beetle populations were found to be quite active were the Upper Prudhomme area, southwest side of Moyie Lake, 41 km on the Bull River FSR and Thunder Creek. Widely scattered infestations in Arrow and Revelstoke TSAs accounted for 1,500 ha and 126 ha, respectively.

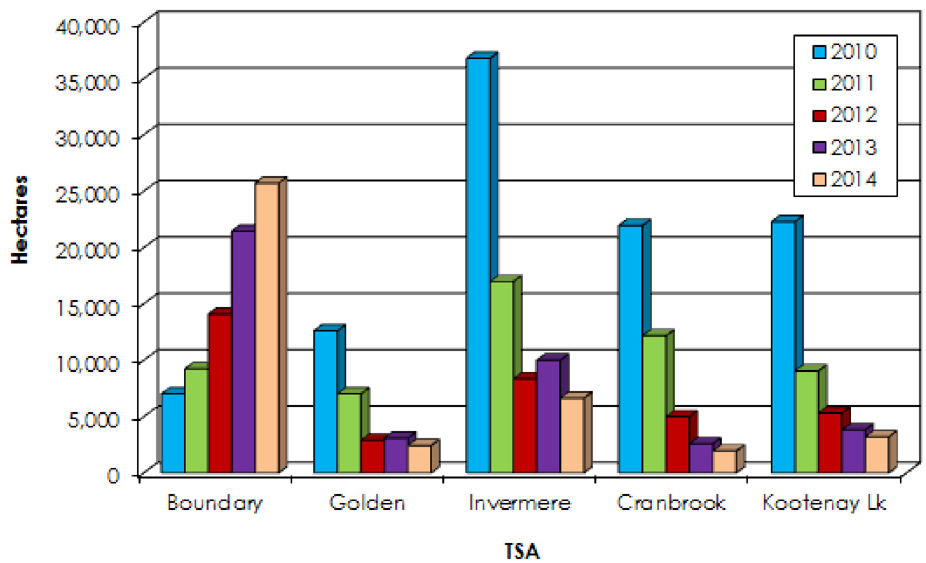


Figure 7. Hectares infested by mountain pine beetle from 2010 – 2014 in the Kootenay/Boundary Region (TSAs with more than 1,900 ha affected in 2014).

Attack in the Thompson/Okanagan Region decreased by half since 2013 to 9,272 ha. Infestations in Lillooet TSA remained relatively static at 4,462 ha scattered throughout the TSA with concentrations south of Bralorne and around Bridge River. Damage in Okanagan TSA continued to sharply decline to 3,516 ha, primarily mapped in the southern half with small concentrations along the eastern boundary. Merritt TSA disturbances totalled 1,284 ha of very small scattered infestations with the exception of higher attack levels continuing in the McNulty Creek area. Only one 10 ha infestation was mapped in Kamloops TSA on the east side of Adams Lake.

Mortality observed in the Cariboo Region continued to drop to 1,527 ha which was all mapped in Williams Lake TSA, mostly in the south along the Lillooet TSA boundary.

Coastal Damage

Mountain pine beetle attack in the South Coast Region declined for the ninth consecutive year with 277 ha affected. Infestations mapped in Soo TSA were small and widely scattered for a total of 195 ha. Area affected in Fraser TSA dropped from 4,091 ha in 2013 to only 82 ha, though almost all the attack noted last year was at the trace level. Remaining infestations are polygons and two spots east of Boothroyd and Chilliwack Lake.

Mountain pine beetle attack in Williams Lake TSA along the Lillooet TSA boundary.

West Coast Region infestations actually increased marginally from 1 ha last year to 45 ha. All damage except for one spot in Kingcome TSA was mapped in Mid Coast TSA, located east of Kwatna Inlet.

Lodgepole pine beetle, *Dendroctonus murrayanae*

Lodgepole pine beetle damage was delineated on a record 73,258 ha this year. However, almost all of the damage (73,079 ha) was assessed at trace intensity. Three polygons of light intensity totalled 165 ha and the remaining 14 ha of severe was all identified in spot infestations. All of the attack occurred in the northeastern portion of the province and it is important to note that ground confirmations could not be made this year. The damaging agent call was made by helicopter reconnaissance, local knowledge and a few ground checks last year. More detailed inspections are planned for in 2015. Although the primary damaging agent was assessed as lodgepole pine beetle, it was also noted in the database comments that attack by porcupine was also present in these stands.

Almost all (73,015 ha) of the mortality was observed in the Fort Nelson TSA of the Northeast Region along the northern border with the Yukon. Attack was particularly prevalent south of Scarecrow Mountain and Maxhamish Lake. The remaining disturbances of 243 ha were mapped in Cassiar TSA of the Skeena Region. This damage was recorded in two polygons west of Hluey Lakes and in spots widely scattered throughout the western portion of the TSA.

Lophodermella needle cast, *Lophodermella concolor*

Lophodermella (pine) needle cast damage has been low throughout the province for several years. Disturbances did increase in a few specific areas in 2014 however with a total of 2,797 ha mapped. Intensity of needle damage was assessed as 2,783 ha (99%) light and 49 ha (1%) moderate.

The majority of the damage occurred in Fort Nelson TSA of the Northeast Region, where 2,356 ha were delineated. The disturbances were confined to two large polygons south of Fishing Lake. Ground checks were not conducted this year but have in previous years confirmed Lophodermella needle cast damage in these stands.

The remaining 440 ha were mapped in the Thompson/Okanagan Region. Damage due to Lophodermella needle cast infections identified last year in the southern tip of Merritt TSA grew to 391 ha in young stands around Stemwinder Mtn. and east of Friday Mtn. Samples were collected at some of these sites and sent to the Skeena Region pathologist for confirmation. Both Lophodermella needle cast (most prevalent) and Dothistroma needle blight infections were found in the samples. The remaining 49 ha of moderate damage were located in one young stand south of Tsuius Mtn. in Okanagan TSA.

Dothistroma needle blight, *Dothistroma septospora*

Dothistroma needle blight damage is difficult to detect from the height of the aerial overview survey unless considerable amounts of red foliage is present in damaged stands at the time of the flight. This disease has been recognized as an ongoing problem in the Skeena Region since the early 2000's as documented from ground and helicopter observations but was not detected during the overview surveys until 2005. Mapped damage since that date has varied from a few thousand hectares to a peak of 27,255 ha in 2008, primarily in the Skeena Region with minor disturbances in Prince George TSA of the Omineca Region and individual young stands in the Thompson/ Okanagan Region.

In 2014 both northern BC pathologists noted that Dothistroma needle blight damage was extensive. Generally, overnight temperatures in August were unusually warm in the north and Welsh *et al* (2014) have found overnight minimum temperatures in August to be one of the most influential climatic drivers of Dothistroma needle blight. Dothistroma needle blight damage observed during the aerial overview flights in 2014 though remained relatively low at 1,842 ha recorded in small polygons. Severity increased though with 647 ha (35%) light, 1,016 ha (55%) moderate and 179 ha (10%) severe.

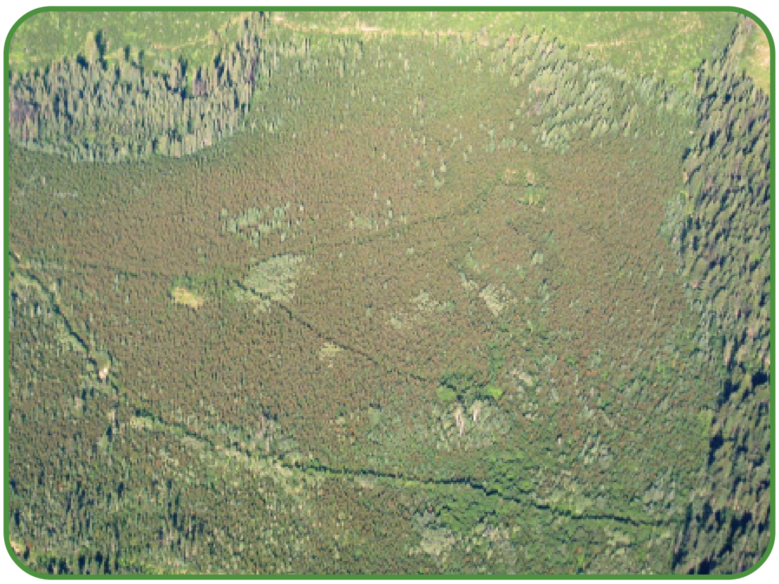
The Omineca Region sustained 670 ha of damage, all located in the southeast corner of the Prince George TSA around McGregor River and Pinkerton Peak.

The Skeena Region, where no damage was observed last year, contained 638 ha of Dothistroma needle blight damage. In Kalum TSA three disturbances clumped north of Kitsumkalum Lake accounted for 369 ha. One moderately damaged polygon of 203 ha near Bulkley Canyon in the Kispiox TSA was observed. The remaining 66 ha in the region were mapped along the western edge of the Bulkley TSA near Kitseguecla Lake and Red Canyon Creek.

A total of 534 ha of damage was noted in the Thompson/Okanagan Region. Infected stands were widely scattered in the eastern half of the Okanagan TSA, where 394 ha were delineated. Kamloops TSA contained 140 ha of damage near Vavenby, Groundhog Mountain and Blue River.

Dothistroma needle damage in Kalum TSA

Pine needle sheathminer, *Zellaria haimbachi*



Pine needle sheathminer defoliation in 100 Mile House TSA

Pine needle sheathminer defoliation was recorded provincially for the fourth consecutive year with a peak of 1,684 ha of damage. Intensity was assessed as 960 ha (57%) light and 724 ha (43%) moderate in scattered young lodgepole pine stands.

Defoliation was not observed in the Cariboo Region in 2013 but in 2014 864 ha of attack were mapped. 100 Mile House TSA contained 509 ha of damage in the north between Forbes Creek to Canim Lake. Stands totalling 311 ha were affected in Quesnel TSA on Deserters Creek and around Alexandria in the south and near Blackwater Mountain and Bowron Lake in the north. The remaining 44 ha in the region were observed in one polygon east of Skelton Lake in Williams Lake TSA near the Quesnel TSA infestations.

All of the pine needle sheathminer defoliation in the Thompson/Okanagan Region this year occurred in Kamloops TSA, with 758 ha affected. Polygons were scattered mid TSA from Niskonlith Lake north to Raft Mountain.

Pine needle sheathminer larva

For the first time during the present outbreak other regions also sustained minor damage. In the Omineca Region 51 ha were mapped in one stand on the southern edge of Prince George TSA near Cariboo Mountain. A further 12 ha were delineated in a polygon north of Trail in Arrow TSA of the Kootenay/Boundary Region.

Shore pine damage

Shore pine damage of 6,242 ha was observed on the south tip of Moresby Island in Haida Gwaii TSA of the West Coast Region. Damage was assessed as 1,271 ha (20%) light, 2,404 ha (39%) moderate and 2,567 ha (41%) severe. These stands were slow growing on thin soils adjacent to or in bogs. The aerial signature of the damage was a grey cast with a tinge of red. This damage was possibly caused by a defoliator but more likely thought to be a needle disease and hence was recorded in the database as unknown disease damage. These stands are difficult to investigate due to access restrictions imposed by BC Parks but efforts will be made to do a ground check next year if the damage is still visible.

White pine blister rust, *Cronartium ribicola*

White pine blister rust damage is only visible during aerial overview surveys when mortality occurs. The majority of the recorded disturbances have been mapped as spots or small polygons in the Coast and Kootenay/Boundary Regions at less than 200 ha annually.

For the third consecutive year however damage over 1,200 ha per year has been recorded, but almost all of the polygon disturbances have been trace intensity. In 2014 total area affected rose slightly to 1,788 ha, of which 1,788 ha (99%) was trace with 19 ha (1%) severe spots.

The South Coast Region sustained 1,694 ha of visible white pine blister rust damage, up substantially from 2013. Sunshine Coast TSA contained most (1,694 ha) of the disturbances in scattered spots and a concentration of polygons on Texada Island. Five spots of damage were also delineated in the eastern half of Fraser TSA.

In the West Coast Region observed damage declined to only 113 ha. Arrowsmith TSA had most of the disturbances, with 110 ha mapped as scattered spots and one polygon west of Nanoose Bay. Strathcona TSA had an additional 10 scattered spot infection centers, and two spots of damage were observed in Kingcome TSA south of Fort Rupert.

Lodgepole needle miner, *Coleotechnites milleri*

Lodgepole needle miner defoliation was observed in Kootenay National Park, adjacent to the Golden TSA in the Kootenay/Boundary Region. The disturbance was confined to one moderately affected polygon of 464 ha. Trees affected were 20 to 30 year old lodgepole pine in a wildfire regenerated stand. Samples were collected and the damaging agent was confirmed by the Kootenay/Boundary Regional Entomologist.

Discussion with a local traveller revealed that this damage had been ongoing for the past several years but noted that this year seemed particularly bad. The defoliation was observed to stretch well into Alberta from the Continental divide.

This moth has a two-year life cycle, with adults emerging to fly usually on even years in BC. Defoliation by the lodgepole needle miner has only been observed historically in the Banff and Kootenay National Parks in BC, with the most frequent occurrence noted in Banff National Park. It was first recorded in 1942 with a peak outbreak in 1947 of 78,000 ha. Since then, noted damage has been low with the last recorded defoliation occurring on 50 ha in 1992.

Lodgepole needle miner defoliation in Kootenay National Park

Damaging Agents of Douglas-fir

Western spruce budworm, *Choristoneura occidentalis*

Recorded Defoliation
For the third consecutive year western spruce budworm defoliation declined provincially to 44,608 ha (Figure 7). Intensity of damage decreased as well to 43,248 ha (97%) light and 1,360 ha (3%) moderate. A record 847,344 ha of defoliation was recorded in 2007, and since 2001 until now at least 123,000 ha have been delineated annually. Disturbances have not been this low since 2000, when 22,851 ha were reported.

The Cariboo Region contained 39,536 ha of western spruce budworm defoliation in 2014. Light defoliation was more widespread than what was mapped, but extensive smoke from wildfires made detection of subtle damage very difficult from the height flown for the aerial overview surveys. Williams Lake TSA had 29,462 ha delineated, primarily along the Fraser River and around Williams Lake. A total of 9,809 ha of defoliation were mapped in 100 Mile House TSA, particularly around Clinton, west of Meadow Lake and south of 108 Mile Lake. The remaining 265 ha noted in the region occurred at the south edge of Quesnel TSA along the Fraser River.

Defoliation in the Thompson/Okanagan Region fell to 4,689 ha. Kamloops TSA contained the bulk of the damage with 3,789 ha mapped in the southern half, mainly around the Lac Du Bois area. Damage in Okanagan TSA was 662 ha with small polygons around Summerland and one near Malakwa. Merritt TSA had 186 ha of damage recorded near Agate Mountain, Kingsvale and north of Mamit Lake. Only one 53 ha polygon was observed in the Lillooet TSA south of Seton Portage.

In Soo TSA of the South Coast Region a small 3 ha polygon was delineated by Boulder Creek near Mt. Athelstan. A ground check was conducted to confirm causal agent and it was noted that the primary species being damaged was amabilis fir with a minor component of western hemlock. In the Fraser TSA small polygons of very light damage were observed from the ground but were not visible from the height of the surveys.

No defoliation was mapped during the survey in the Kootenay/Boundary Region, though a few small, dispersed light infestations were visible from the ground at lower elevations in the Boundary and Arrow TSAs.

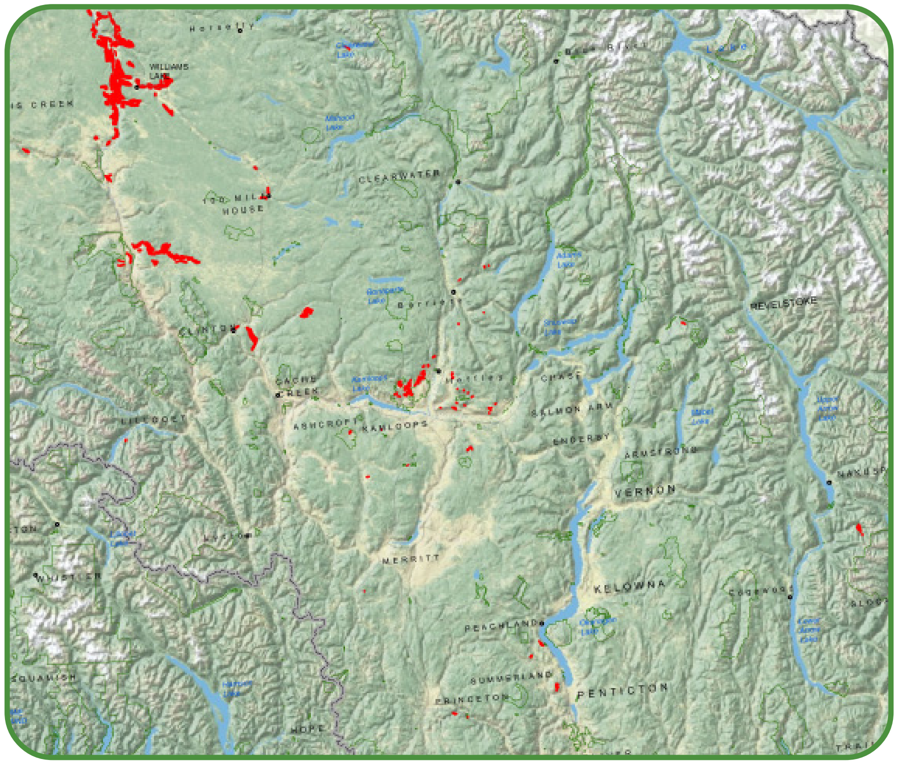


Figure 7. Areas defoliated by western spruce budworm in BC in 2014.

2014 Treatment Program

High value Douglas-fir stands that were predicted to sustain moderate to severe defoliation were designated for treatment in the spring of 2014. Foray 48B® (active ingredient *Bacillus thuringiensis* var. *kurstaki* (Btk)) was applied aerially in a single application at a rate of 2.4 litres/ha. Across the southern interior a total of 56,737 ha were treated. Bud flush and larval development were carefully monitored to determine optimal treatment timing. Pre and post spray larval sampling was conducted to determine treatment success.

Treatment in the Cariboo Region covered 35,387 ha from June 23rd to July 2nd on seventeen blocks ranging from 380 ha to 6,359 ha in size. The spray was conducted with two fixed wing AT 802 Air Tractors from the Provincial Air Tanker Center. Treatments in 100 Mile House TSA covered 17,393 ha mainly west of 100 Mile House and around the Jesmond area. Williams Lake TSA blocks were concentrated around Williams Lake, near Fletcher Lake and around Gaspard Creek with a total of 17,994 ha sprayed.


AT 802 Air Tractors treating a Cariboo Region site

The Thompson/Okanagan Region spray program was conducted over 23,623 ha from June 18th to 25th on twelve areas ranging from 348 ha to 5,694 ha. Treatment was conducted with two AS315B Lama and two UH12ET Hiller helicopters from Western Aerial Applications Ltd. Operations were almost entirely in Kamloops TSA around Kamloops and east of Logan Lake.

Population Monitoring 2014 and Proposed Treatments 2015

Egg mass surveys were conducted in the fall of 2014 to predict expected western spruce budworm defoliation in the spring of 2015 (Table 4). On sites where moderate to severe defoliation is predicted other factors such as values at risk, stand recovery capability and previous damage levels are considered to prioritize treatment areas.

Table 4. Summary of western spruce budworm defoliation predictions for 2015 based on 2014 egg mass survey results.

Region	TSA	Number of Sites by Defoliation Category				Total Sites
		Nil	Light	Moderate	Severe	
Cariboo	100 Mile House	6	57	10	0	73
	Williams Lake	11	71	11	0	93
	Quesnel	3	5	0	0	8
Thompson/ Okanagan	Kamloops	60	48	3	0	111
	Merritt	34	19	0	0	53
	Okanagan	19	13	0	0	32
Kootenay/ Boundary	Boundary	14	1	1	0	16
	Cranbrook	7	3	0	0	10
South Coast	Fraser	13	8	0	0	21
	Total	**167**	**225**	**25**	**0**	**417**

For the third consecutive year, average predicted severities fell. Total number of sites with moderate defoliation predicted decreased to 25 (6%) with no severe damage expected. Total number of sites with light defoliation predicted were 225 (54%) and those with nil were 167 (40%).

Sites in the Cariboo Region with moderate defoliation predicted decreased from 36 last year to 21. Half the areas were located in the Williams Lake TSA with the highest areas of concern located north and south of Meldrum Creek. The remaining sites are in 100 Mile House TSA and are spread over three main areas: south of Lac La Hache Lake, east of Loon Lake and south of 70 Mile House. Up to 16,600 ha are proposed for treatment in the Cariboo Region for the spring of 2015.

Sites in the Thompson/Okanagan Region with moderate defoliation predicted dropped sharply from 49 in 2013 to only 3 this year. All three sites were located in the Lac Du Bois area.

Results from the Kootenay/Boundary Region contained only one moderate site, between Rock Creek and Bridesville in the Boundary TSA.

Surveys in South Coast Region resulted in only light to nil predictions.

Low populations predicted for the Thompson/Okanagan and Kootenay/Boundary Regions by egg mass surveys were supported by three tree beatings (conducted at permanent sample sites in areas of historical outbreaks) that resulted in low to nil larval counts.

Douglas-fir beetle, *Dendroctonus pseudotsugae*

Douglas-fir beetle damage across BC totalled 39,481 ha in 2014 (Figure 9), the highest level recorded since a peak of 100,726 ha in 2009. Intensity of mortality was assessed as 4,653 ha (12%) trace, 27,991 ha (71%) light, 4,916 ha (12%) moderate, 1,794 ha (5%) severe and 127 ha (<1%) very severe.

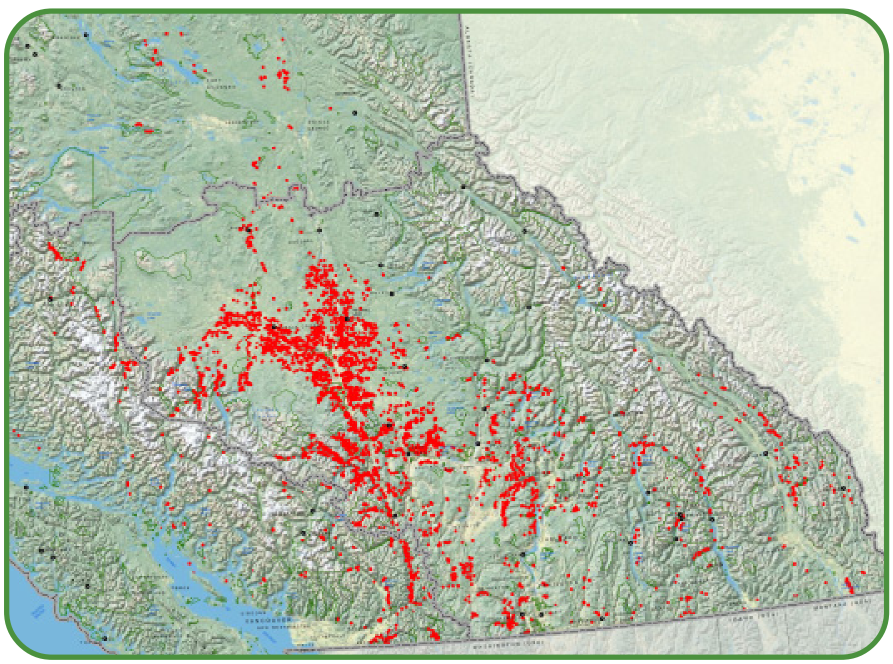


Figure 9. Douglas-fir beetle mortality recorded in BC in 2014.

The increase in Douglas-fir beetle infestations was largely driven by damage in the Cariboo Region, which increased ten-fold from 2013 to 26,892 ha. Infestations expanded in the same general areas as 2013 into most of the mature Douglas-fir stands in the region. The large fires of 2009 and 2010 combined with favourable winter conditions in 2012 and 2013 have resulted in population build-ups. Overwinter mortality survey sampling in spring 2014 showed an average

R-value (ratio of surviving brood to initial attack) of 4.0 for the region (Table 5). Values over 1.3 indicate increasing populations. Compared to 2013 results though, R-values are generally lower and adult mortality is higher, indicating that the outbreak may be slowing.

Table 5. Summary of Douglas-fir bark beetle winter mortality 2014 results in the Cariboo Region.

District or Area	Number of Sites	Number of Samples	R-value 2013	R-value 2014	Adult Mortality (%)
Chilcotin	14	280	6.78	3.03	30.8
Central Cariboo	13	260	5.7	5.11	25.4
Quesnel	3	60	NA	5.12	26.5
Sum or Mean	**30**	**600**	**9.6**	**4.0**	**27.8**

Douglas-fir beetle infestation in Williams Lake TSA

Detailed (rotary wing) aerial surveys based on the results of the aerial overview survey were also conducted in the Cariboo Region this fall. Mortality within old wildfires was not assessed and still 177 polygons totalling 16,559 ha and a further 2,998 spots with 16,959 current attack were recorded. The ratio of green attack to red attack in the spot infestations was 1.5:1, which also indicated a growing population.

The majority of the Cariboo Region damage continued to be noted in Williams Lake TSA where 26,892 ha were mapped, primarily mid TSA. 100 Mile House TSA sustained 3,686 ha of attack, mainly in the western half. A total of 548 ha were located in Quesnel TSA in the south around the Fraser River, in the north along the Blackwater River and near Nazko in the east.

The Omineca Region had 3,916 ha of Douglas-fir beetle mortality identified. With the exception of four spot infestations in Robson TSA, all of the damage occurred in Prince George TSA. Disturbances were relatively dispersed in the western quarter of Prince George District and the southern quarter of Fort St. James District. One infestation near Bobtail Lake in Prince George District was harvested with plans to follow-up this spring with deployment of MCH (3-methylcyclohex-2-en-1-one, a pheromone beetle repellent). The infestation in Vanderhoof District was primarily along Francois Lake, which extended into Lakes TSA of the Skeena Region, where 733 ha of damage was recorded. An aggressive trap tree/fall and burn program in Vanderhoof District last year contributed to the declining populations in that district.

Douglas-fir beetle was active in 3,493 ha of the Thompson/Okanagan Region. Lillooet TSA sustained 1,945 ha of this damage, dispersed along all major drainages (the majority of this beetle mortality is inaccessible). Noted infestations were widely scattered in the Okanagan and Merritt

TSAs, where 897 ha and 274 ha were mapped, respectively. Ground surveys conducted in the Salmon River area of the Okanagan TSA indicated population expansions with ratios of 7 green attack to 1 red attack. The remaining disturbances in the region occurred over 377 ha in small areas throughout the southern half of the Kamloops TSA. Ground observations at trap tree sites north of Kamloops reported that populations were not strong as trap trees were not at capacity and a healthy component of parasites were present.

Mortality caused by Douglas-fir beetle

Kootenay/Boundary Region had a total of 2,654 ha of Douglas-fir beetle damage delineated. Disturbances were generally small and widely scattered. Arrow TSA sustained 994 ha of attack, while Invermere and Kootenay TSAs reported 722 and 690 ha, respectively. Wildfires in Arrow TSA have been noted to be causing beetle population build-ups. The remaining TSAs had minor infestations under 102 ha per TSA.

Area affected in the South Coast Region was 1,594 ha. Fraser TSA had 949 ha of damage mapped, primarily along the Fraser River and the east side of Harrison Lake. Sunshine Coast TSA had widely dispersed attack totalling 405 ha. In Soo TSA a total of 240 ha were observed, mainly in the eastern half of the TSA.

West Coast Region contained 198 ha of Douglas-fir beetle attack. Most (186 ha) were noted in Mid Coast TSA, mainly along Knot Lakes, Talchako and Dean Rivers. Spot infestations totalling 11 ha occurred in Kingcome TSA in the northeast tip around Trophy Lake. Five spot infestations were mapped on the mainland of Strathcona TSA as well. No attack was noted in Arrowsmith TSA though 786 ha were denoted last year. However, many scattered spot root disease centers were mapped and it is very likely that this mortality is a complex of beetle and root disease.

Laminated root disease, *Phellinus sulphurascens*

Laminated root disease damage, present throughout southern BC, is rarely recorded during the aerial overview surveys. As changes in root disease disturbances are relatively slow, large changes in damage recorded annually during the overview surveys are likely due to differing visibility conditions and varying surveyor knowledge. Most identified infection centers have been in the South and West Coast Regions, due to local knowledge of the surveyors.

After a large increase in observed damage to 603 ha last year, only 79 ha were delineated in 2014. Intensity of mapped disturbances was 41 ha (52%) trace, 13 ha (17%) moderate and 25 ha (31%) severe. Damage was very scattered. The severe infection centers were all spots. South Coast Region contained 70 ha of laminated root disease damage. Sunshine TSA had 55 ha delineated in spots and one polygon near Narrows Inlet. Fraser TSA had a 13 ha polygon north of Hope plus spots and Soo TSA contained two spot disturbances. Damage in the West Coast Region was observed as spot infection centers totalling 9 ha. Disturbances were delineated on 5 ha in Arrowsmith TSA and 4 ha in Strathcona TSA.

Douglas-fir tussock moth, *Orgyia pseudotsugata*

A Douglas-fir tussock moth outbreak occurred in the Thompson/Okanagan Region from 2009 to 2011. Since then defoliation has been minimal to nil, with no current damage observed during the aerial overview surveys the past two years.

Since outbreaks by this defoliator develop rapidly and can result in extensive host mortality, populations are monitored annually with six-cluster pheromone moth traps at permanent monitoring sites in 100 Mile House, Boundary, Kamloops, Lillooet, Merritt and Okanagan TSAs. Since the last outbreak average trap catches per TSA have steadily declined in most areas (Table 6). All trap catches in 2014 were well below the threshold for outbreak concerns in 2015. The highest trap catches occurred in Kamloops TSA near Monte Creek and Heffley Creek with an average of 12 and 8 moths caught per trap at each site, respectively. After a slight rise in average trap catches in the 100 Mile House TSA last year, numbers subsided in 2014. Three tree beatings at permanent sample plots in historical Douglas-fir tussock moth outbreak areas also produced nil to very low numbers of larvae. Based on these results, no treatment program is required for 2015.

Table 6. Average number of Douglas-fir tussock male moths caught per trap, 2006 – 2015 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)
2014	1.6 (19)	0.1 (14)	1.6 (19))	0.2 (1)	0.5 (10)	0.3 (10)

Damaging Agents of Spruce

Spruce beetle, *Dendroctonus rufipennis*

Provincially, spruce beetle infestations have been relatively low since a peak of 315,953 ha in 2003. In 2014 damage across BC rose fifteen-fold over last year to 288,892 ha (Figure 10). Intensity of mortality was lower however, with 195,619 ha (67%) trace, 85,348 ha (30%) light, 6,014 ha (2%) moderate, 1,866 ha (1%) severe and 46 ha (<1%) very severe.

Damage in the Omineca Region was responsible for the majority of the increase with 217,252 ha mapped. Much of this area was surveyed late summer into fall due to a delay from wildfire smoke. The surveyors felt this delay allowed them to identify more spruce beetle attack than if they had flown earlier. Prince George TSA contained 108,472 ha of attack. The majority of the

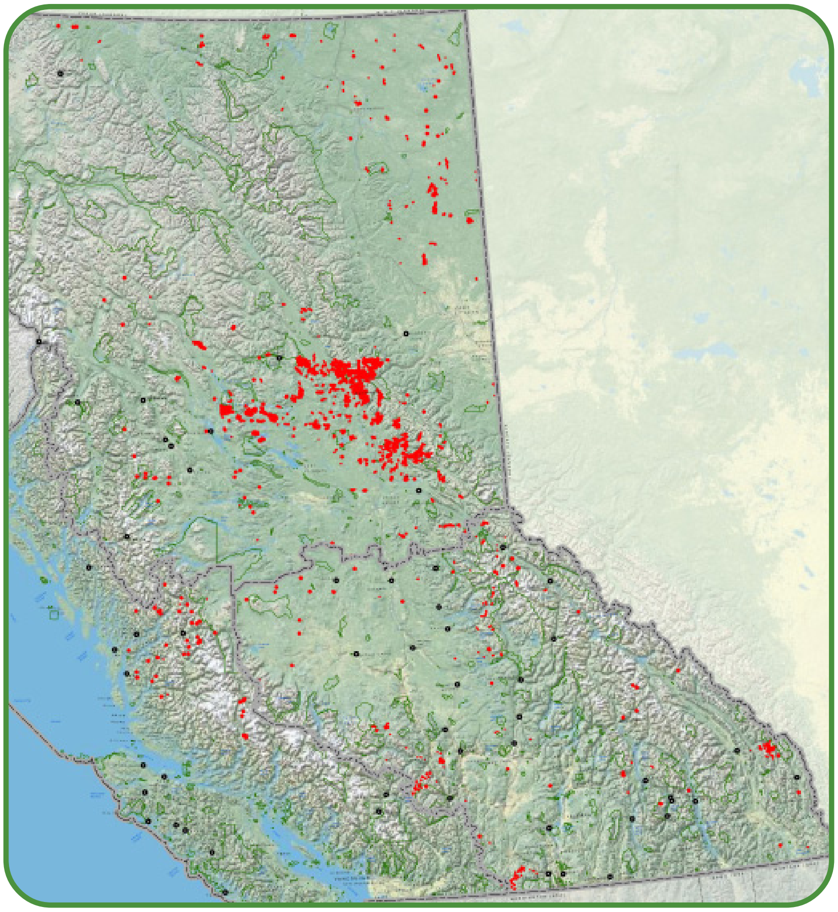


Figure 10. Spruce beetle infestations recorded in BC in 2014.

disturbances were in the northern half of Prince George District and in the lower third of Fort St. James District. Some of the northern Prince George District infestations have been confirmed with ground checks. Only one small polygon of 12 ha was observed in Vanderhoof District near Lucas Lake, but recent ground surveys and more detailed aerial surveys in this district have identified other infestations. A total of 105,900 ha of spruce beetle mortality were delineated in the Mackenzie TSA, the majority of which was located in the southern quarter. The northern quarter of the TSA could not be flown in 2014. Ground confirmations have also been made in some of the Mackenzie TSA infestations. Robson Valley TSA disturbances of 2,880 ha were recorded, mainly along Hellroaring Creek, Raush River and Canoe River.

In the Northeast Region spruce beetle attack totalled 57,891 ha. Dawson Creek TSA sustained the most damage in this region with 35,810 ha mapped along the western edge, mainly around Mt. Garbitt. Infestations in Fort St. John TSA were primarily noted in the eastern half north of Chinchaga River to Etthithun River and west of Prespatou, with 14,228 ha denoted. Disturbances in the Fort Nelson TSA were small and scattered with 7,852 ha sketched.

Spruce beetle mortality in the Skeena Region totalled 4,161 ha. Morice TSA sustained the most damage with 2,994 ha mapped mainly in the northeast tip around Natowite Lake. Aside from one spot infestation, all 998 ha of spruce beetle attack in the Bulkley TSA was observed in two polygons southwest of Mt. Horetzky. Small disturbances totalling 103 ha in the Cassiar TSA were all located in the northeast tip near Wheeler Lake. In the Lakes TSA two small polygons near Klaytahnkut and Uncha Lakes and a few scattered spots accounted for 57 ha. Kalum, Kispiox and Nass TSAs only had a few spot infestations.

Kootenay/Boundary Region sustained 4,311 ha of damage, of which almost all (4,150 ha) was contained in Invermere TSA, primarily around Franklin Peaks. Small infestations in Arrow TSA, mainly around Whatshan Peak and Fosthall Creek, accounted for 90 ha. Revelstoke TSA had two spot attacks and one polygon west of Halcyon Hot Springs that totalled 59 ha. All remaining damage in Cranbrook, Golden and Kootenay Lakes TSAs were less than 10 ha per TSA.

In the Cariboo Region 2,527 ha of spruce beetle attack was mapped. Williams Lake TSA continued to contain most of the damage with 1,634 ha delineated along the eastern edge of the TSA (though the infestations there have declined since last year) and around Lone Valley Creek. Mortality from Boss Creek to Deception Mountain in 100 Mile House TSA was recorded as 653 ha. Small scattered infestations in Quesnel TSA accounted for the remaining 241 ha of damage in the region.

Total area affected in the Thompson/Okanagan TSA remained similar to 2013 at 2,446 ha. Lillooet TSA sustained 1,203 ha of spruce beetle attack, primarily from Gott Peak northeast to Riley Creek and around Tepee Mtn. Infestations in Merritt TSA totalled 1,043 ha, most notably in the southern tip from Pasayten River northeast to Stemwinder Mtn. Damage was down substantially in the Kamloops TSA to only 183 ha.

Spruce beetle attack in Prince George TSA

All of the spruce beetle mortality in the South Coast Region occurred in the southeast tip of the Fraser TSA, with 188 ha affected near Chuwanten Mtn.

The West Coast Region sustained 117 ha of attack. Mid Coast TSA contained 99 ha in small, widely dispersed infestations. The remaining 19 ha were mapped in Kingcome TSA, mainly in the Remote Mtn. area.

Damaging Agents of True Fir

Western balsam bark beetle, *Dryocoetes confusus*

For the third consecutive year western balsam bark beetle disturbances rose provincially to 2,977,629 ha, more than doubling the area delineated in 2013 (Figure 11). Intensity of mortality increased as well, with 2,500,230 ha (84%) trace, 469,209 ha (16%) light, 6,760 ha (<1%) moderate and 1,430 ha (<1%) severe. This was a record for area affected, and the highest level of intensity recorded since 2006. The increase may in part be due to the decline in mountain pine beetle mortality which tended to mask western balsam bark beetle attack in mixed stands.

Western balsam bark beetle infestations covered 1,277,729 ha in the Omineca Region, five-fold higher than in 2013. Prince George TSA had 667,570 ha of attack with highest concentrations in Fort St. James District. Damage in Mackenzie TSA rose similarly to 596,846 ha, with the largest disturbances located in the southern third of the TSA. Attack in Robson Valley TSA was scattered in smaller polygons with only a slight increase to 13,312 ha.

Disturbances in Skeena Region rose 40% since last year to 1,164,473 ha. Attack mapped in Kispiox, Morice and Bulkley TSAs were similar in area at 253,633 ha, 248,588 ha and 224,725 ha, respectively. Generally, infestations noted last year throughout Kispiox and Bulkley TSAs expanded, while new damage was observed in the western half of Morice TSA. Disturbances expanded southward and westward in Cassiar TSA, where 181,611 ha were mapped. All 143,194 ha of mortality in Nass TSA occurred in the northern half of the TSA. The majority of the 104,677 ha mapped in Lakes TSA occurred in the southwest tip. Almost all the 8,046 ha of attack noted in Kalum TSA was in the northern tip, particularly east of Mt. Hoadley.

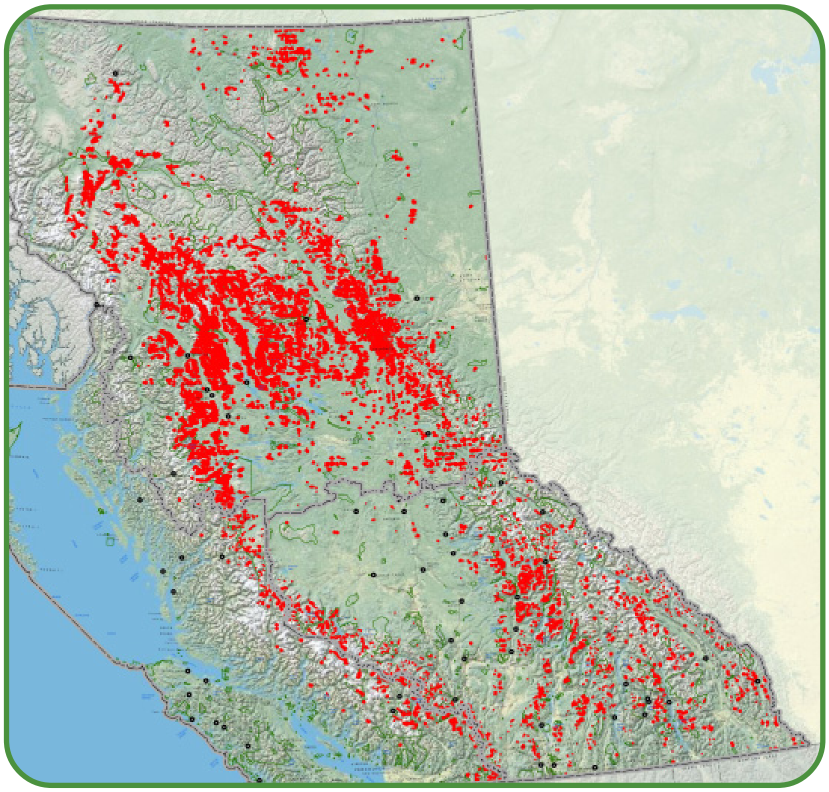


Figure 11. Western balsam bark beetle damage mapped in 2014 across BC.

Infestations by western balsam bark beetle in the Northeast Region grew more than six-fold over 2013 levels to 268,880 ha. Attack in Dawson Creek TSA rose to 115,011 ha with all disturbances located along the western edge of the TSA. Fort Nelson sustained 94,034 ha of attack scattered throughout the TSA but with concentrations from Mt. Halkett east to Nelson Forks. A total of 59,835 ha of damage was observed in Fort St. John TSA with most of the disturbances south of Halfway River and along Beaton River near La Prise Creek.

Attack mapped in the southern half of BC tended to be smaller, more scattered polygons and spot infestations when compared to the north. This was mainly due to smaller, more fragmented host species stands and partially due to differing survey styles (mapping of spot infestations as opposed to trace polygons).

In the Thompson/Okanagan Region area affected by western balsam bark beetle rose by a quarter to 184,836 ha. Kamloops TSA contained 101,529 ha, with concentrations in the northern half of the TSA. Infestations in the Okanagan TSA remained relatively static at 60,657 ha, with concentrations around Jubilee, Tahetkun, Mara and Pukeashun Mountains. Attack noted in Merritt and Lillooet TSAs rose to 11,409 ha and 11,240 ha respectively, with the largest increases occurring in Lillooet TSA.

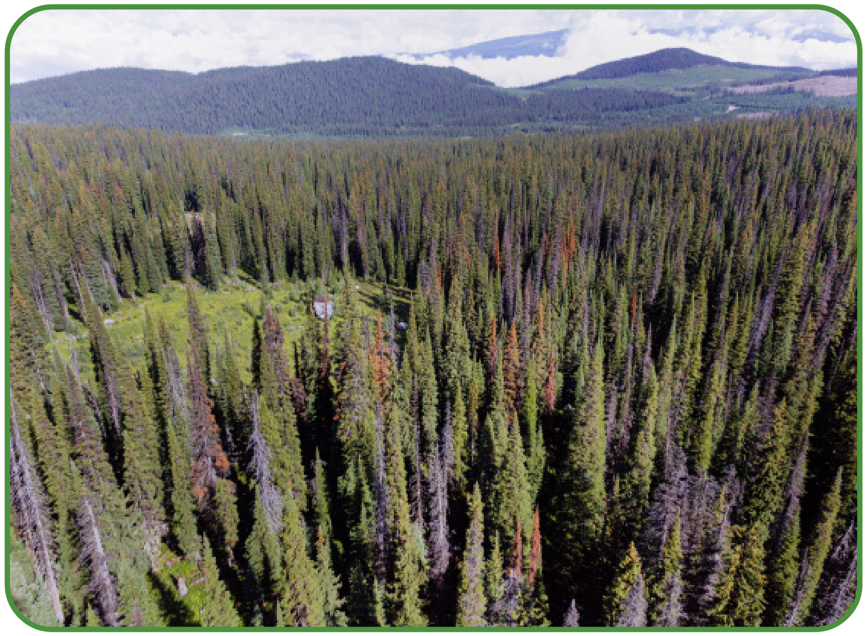
Damage in the Cariboo Region remained relatively static at 26,597 ha mapped. Most of the polygons mapped were in the same general area as last year but a large number of spot infestations were added mid region. Williams Lake disturbances totalled 20,029 ha with concentrations continuing along the southwest border and in the northeast tip. Infestations expanded in the northeast tip of

100 Mile House TSA for a total of 4,936 ha mapped. Conversely, Quesnel TSA disturbances declined substantially in the eastern portion to 1,632 ha. It is possible this decrease was at least partially due to attack being masked by extensive two-year-cycle budworm in this TSA.

Infestations rose by a third in the Kootenay/Boundary Region to 17,454 ha. All disturbances were small and widely scattered. Golden TSA sustained the most damage with 5,624 ha mapped. Invermere and Arrow TSA had similar levels of mortality, with 3,324 ha and 3,006 ha mapped, respectively. The remaining TSAs had less than 1,700 ha each in damage.

Western balsam bark beetle attack almost doubled in the South Coast Region with 24,563 ha delineated. A total of 17,826 ha were sketched in Fraser TSA with most of the disturbances occurring along the eastern edge. Mortality rose substantially in Soo TSA, particularly in the eastern half, with 6,220 ha mapped. Infestations totalling 516 ha in Sunshine Coast TSA were primarily scattered spots with the exception of polygons drawn along Bishop River.

Attack levels increased by two-thirds in the West Coast Region to 13,097 ha affected. Most (12,083 ha) occurred in Mid Coast TSA with highest concentrations in the north around Pattullo Range. With the exception of a few scattered spot infestations, all the 1,014 ha recorded in Kingcome TSA occurred in the northwest tip.



Western balsam bark beetle mortality in the Kamloops Region

Balsam Woolly Adelgid, *Adelges piceae*

Visible damage attributable to balsam woolly adelgid remained at low levels in 2014. A total of 92 ha of damage was recorded, all in Fraser TSA of the South Coast Region. Disturbance intensity was similar to last year as well with 86 ha (93%) light, 6 ha (7%) moderate and two spot infestations rated as severe. Damage locations were north of Yarrow, east side of Harrison Lake near Silver River and north of Needle Peak.

Two-year-cycle budworm, *Choristoneura biennis*

Two-year-cycle budworm damage is most severe in the second year of their two-year life cycle, when the larvae are largest. In BC this generally occurs north of Prince George during odd years and south of Prince George during even years. Provincially, mapped defoliation almost doubled since 2013 to 164,979 ha (Figure 12). Damage intensity increased slightly as well, with 159,174 ha (96%) light, 5,785 ha (4%) moderate and 20 ha (<1%) severe.

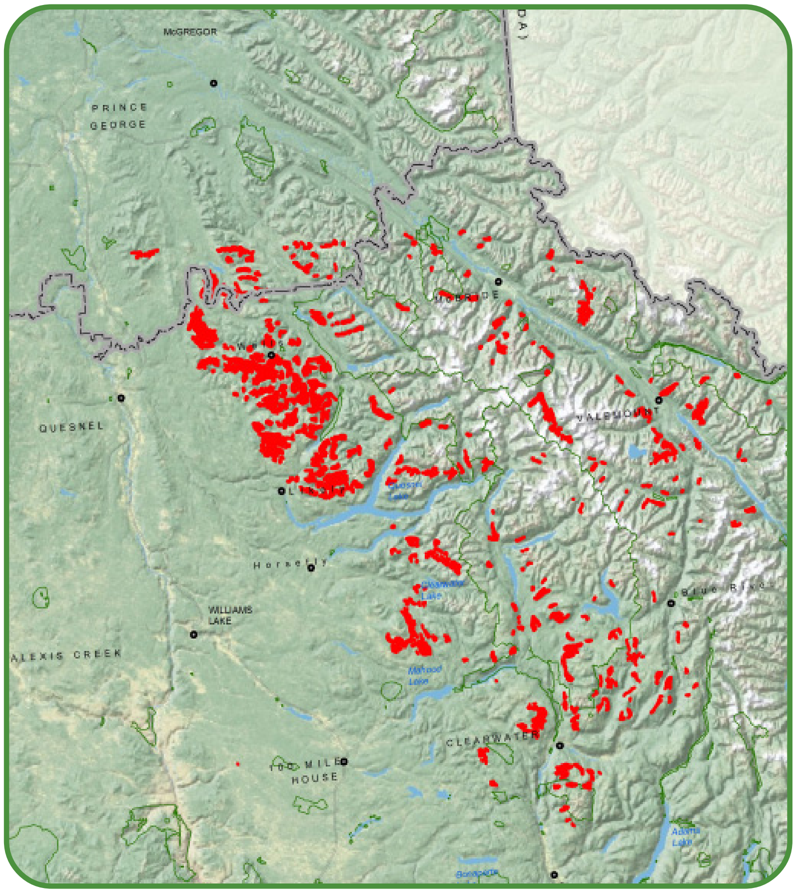


Figure 12. Two-year-cycle budworm defoliation mapped in 2014 in BC.

Even though 2013 was the first year in the cycle for the Cariboo Region, substantial damage (71,823 ha) was noted. As anticipated, more defoliation was observed this year with 100,245 ha mapped. Infestations in the eastern half of Quesnel TSA accounted for 56,611 ha, primarily in the same areas as last year. Damage expanded in the eastern tip of Williams Lake TSA east of Polley Lake to 35,945 ha. A further 7,689 ha were detected in the 100 Mile House TSA, mostly around Boss Creek in the northeast corner of the TSA.

Two-year-cycle budworm pupa

Two-year-cycle budworm defoliation in the Thompson/Okanagan Region rose sharply to 30,074 ha, all located in Kamloops TSA. Infestations were scattered throughout the northern half of the TSA.

The Omineca Region sustained 34,586 ha of damage. Infestations scattered throughout Robson Valley TSA in 2013 grew this year, accounting for 22,546 ha. The remaining 12,041 ha in the region were mapped south of Narrow Lake in the southern portion of Prince George TSA.

Only 74 ha of defoliation were mapped in the Skeena Region. One 54 ha polygon was delineated east of Burns Lake in Lakes TSA and one 20 ha polygon was recorded east of Mt. Seaton in Bulkley TSA.

Damaging Agents of Hemlock

Western blackheaded budworm, *Acleris gloverana*

The current western blackheaded budworm outbreak began in Haida Gwaii TSA in 2009 with a peak of 87,497 ha in 2010. As the outbreak in Haida Gwaii declined, damage began to occur on northern Vancouver Island in 2011, where defoliation has been mapped at just under 30,000 ha for the last two years, primarily in Kingcome TSA. In 2014 infestations decreased dramatically with only 3,129 ha of current attack recorded provincially. Intensity levels were rated as 1,056 ha (34%) light, 1,171 ha (37%) moderate and 902 ha (29%) severe.

The West Coast Region contained 3,094 ha of the observed defoliation. Most of this (2,789 ha) continued to be in Kingcome TSA where the most heavily impacted polygons shifted from Holberg Inlet to the southeast around the Mahatta River and the Raging River east of Benson. A few small polygons were identified inland along the eastern edge of the TSA in the Trophy Lake area as well. Only two polygons totaling 194 ha were mapped in Strathcona TSA near Nasparti Inlet. Only grey trees killed in the latest outbreak were mapped on Haida Gwaii. This damage amounted to 1,109 ha, recorded at 10 to 50% mortality per polygon.

The remaining 60 ha of damage by the western blackheaded budworm were observed in Williams Lake TSA of the Cariboo Region. The polygons were located on the western edge of the TSA near Three Sisters, and were close to the inland infestations mapped in Kingcome TSA.

Defoliation attribued to western blackheaded budworm in Williams Lake TSA

Western hemlock looper, *Lambdina fiscellaria lugubrosa*

A western hemlock looper outbreak in the southern interior peaked in 2012 with 8,103 ha of defoliation mapped. Last year saw a rapid decline in damage to 841 ha of current defoliation with a further 1,094 ha of cumulative damage resulting in mortality. In 2014, no new disturbances were visible.

Pheromone traps at permanent sampling sites have been used in three TSAs to monitor western hemlock looper populations since 2003. Moth trap catches were low until 2008 when counts rose sharply to high levels for four years. In 2012 catches began to decline and this trend has continued for three years (Table 7). Average trap catches at all individual sites were down this year with less than 45 moths per trap, with the exception of Noisy Creek in Okanagan TSA, where the average was 106. Traps deployed in the Rainy River area in Sunshine Coast TSA also showed low population levels. Larval three tree beatings were also conducted at permanent sample sites throughout the Kootenay/Boundary and Thompson/Okanagan Regions and very few western hemlock looper larvae were found. With very low 2015 population levels anticipated, no treatment program is planned for next spring.

Table 7. Average number of western hemlock looper male moths caught per trap at various MFLNRO monitoring sites (6-trap clusters per site), 2008 - 2014.

Year	**TSA (# sites)**		
	Kamloops (6)	Okanagan (10)	Revelstoke (11)
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
2014	3.6	35.3	14.5

Damaging Agents of Larch

Larch needle blight, *Hypodermella laricis*

Larch needle blight damage rose sharply to just over 30,000 ha in 2011 and 2012 respectively but subsided again in 2013 to 6,043 ha. This year the downward trend continued, with only 1,072 ha of foliage damage noted in the southern interior. Intensity was assessed as 694 ha (65%) light, 194 ha (18%) moderate and 185 ha (17%) severe, which was higher than last year. Host species were an even mix of alpine and western larch in 2013, but this year most (903 ha) of the damage occurred in western larch stands. The majority of the disturbances continued to be small and scattered. As was common last year it was noted that damage was often confined to the lower half of the trees, which made it difficult to see from the air.

Kootenay/Boundary Region continued to sustain the majority of larch needle blight damage, with 1,065 ha mapped. Kootenay Lake TSA had 315 ha of damage delineated in the northern half of the TSA. In Invermere TSA 298 ha were observed, mainly along the south border near Premier Lake. Scattered damage in Cranbrook TSA accounted for 225 ha and in the south tip of Golden TSA near Mt. Drysdale, 142 ha were mapped. The remaining 86 ha were detected in Arrow TSA.

In the Thompson/Okanagan Region, only one 6 ha polygon of light damage was recorded in Okanagan TSA in the northwest tip near Mt. Mobley.

Damaging Agents of Cedar

Yellow-cedar decline

Observed current yellow-cedar decline damage in the coastal areas of BC doubled for the second consecutive year to 38,752 ha (Figure 13). All disturbances were mapped as small polygons or spots with intensity rated as 23,217 ha (60%) trace, 11,596 ha (30%) light, 2,178 ha (6%) moderate and 1,762 ha (4%) severe.

The West Coast Region sustained 27,965 ha of the damage. Yellow-cedar decline mortality throughout Haida Gwaii TSA was mapped at a record 27,965 ha. The large increase may have been due to a lower than normal flying height (due to a relatively low cloud ceiling) combined with local knowledge from a surveyor who was very familiar with yellow-cedar decline. Noted damage in Mid Coast TSA increased to 11,674 ha. Disturbances were scattered along the coast, on islands and inlets from Moses Inlet north to the TSA boundary. Damage totalling 2,227 ha in the Kingcome TSA was more concentrated around Devereux Lake and north of Wakeman Sound.

Yellow-cedar decline damage in Skeena Region remained constant at 10,787 ha. Most of the damage (10,163 ha) occurred in North Coast TSA scattered along the entire coastline, but concentrations were noted from Surf Inlet to Tolmie Channel and around Work Channel. The remaining 624 ha were delineated in Kalum TSA south of Maitland Island and along Kildala and Kowesas Rivers.

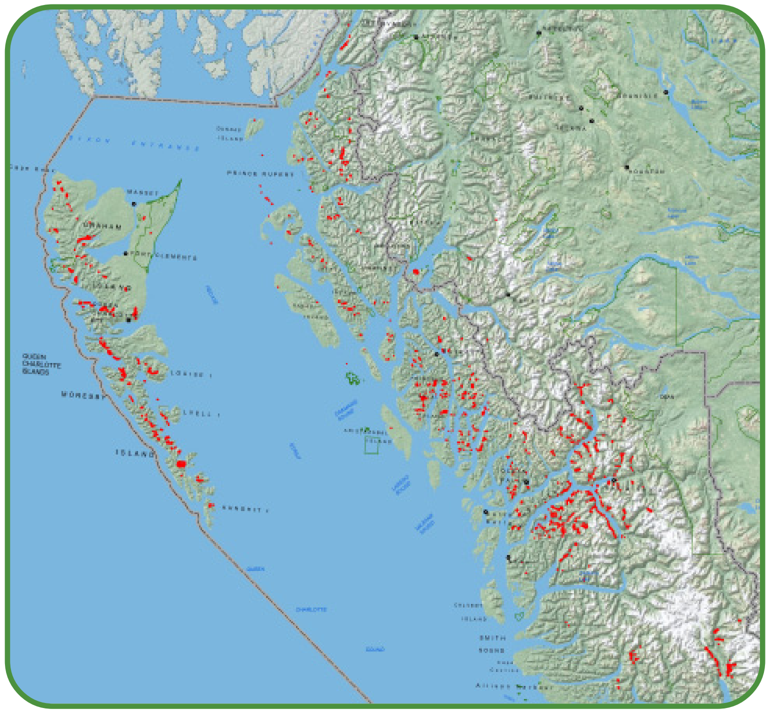


Figure 13. Yellow-cedar decline damage mapped in 2014.

New and old yellow cedar decline in Haida Gwaii TSA

Western redcedar weather damage

Unusual damage to western redcedar occurred this year on 32,870 ha (Figure 14), with severity noted as 13 ha (<1%) trace, 24,125 ha (73%) light, 8,065 ha (25%) moderate and 667 ha (2%) severe. Although it is highly suspected to be weather related damage, no adjacent shrubs or tree species were affected. The damage could not be attributed to a specific weather pattern or event; it could have been winter desiccation, low snowpack melt timing, changes in soil moisture regime/timing or drought.

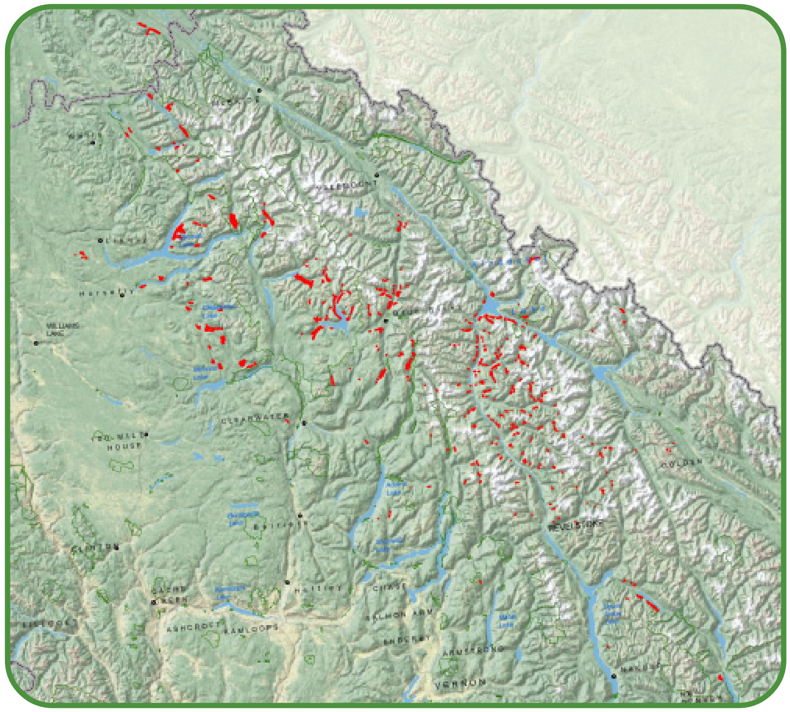


Figure 14. Western redcedar weather related damage mapped in 2014.

Western redcedar of all age classes (though mature was most prevalent) on all aspects and slope positions were damaged. Damage was from the top down with the upper crown most affected and from the outside in (as opposed to regular cedar flagging, where the oldest leaves on the inside of the tree are shed first from the bottom up). The heaviest damage occurred in sparsely treed, open canopy stands. Some of the affected trees also exhibited heavy cone crops. Mortality is anticipated to occur in some of the most heavily impacted stands.

Western redcedar weather damage in Williams Lake TSA

Disturbances mapped in the Thompson/Okanagan TSA totalled 10,776 ha. The majority (10,133 ha) was observed in the northern third of Kamloops TSA. Small areas of damage in the northern tip of Okanagan TSA accounted for 643 ha.

The Cariboo Region sustained 10,491 ha of damage. Polygons totalling 6,075 ha were sketched from Quesnel Lake to Crooked Lake in Williams Lake TSA. A further 2,732 ha were delineated in the northeast tip of 100 Mile House TSA and 1,684 ha along the eastern edge of Quesnel TSA.

Kootenay/Boundary Region contained 10,000 ha of damage with 7,650 ha scattered throughout Revelstoke TSA. The 1,518 ha mapped in Golden TSA was primarily along the western edge. Arrow and Kootenay Lake TSA had minor disturbances of 560 ha and 272 ha, respectively.

Omineca Region sustained 992 ha of damage, mainly in Prince George TSA around Dome Mountain where 892 ha were sketched. Small disturbances along Betty Wendle Creek in Robson TSA accounted for the remaining 100 ha.

Weather damaged western redcedar

Damaging Agents of Deciduous Trees

Aspen (serpentine) leaf miner, *Phyllocnistis populiella*

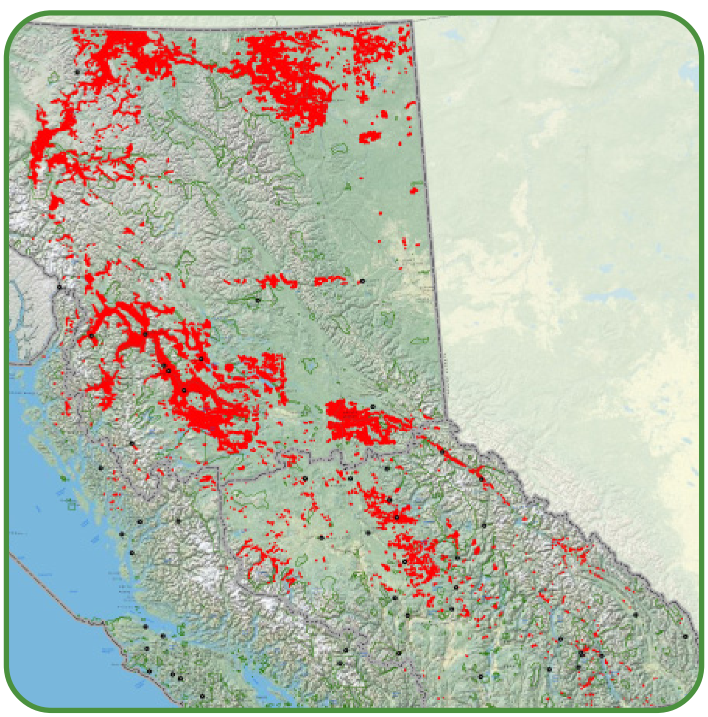


Figure 15. Aspen leaf miner defoliation in 2014.

Aspen leaf miner damage has been noted throughout the interior of BC at a large scale since 2009 when 109,609 ha were impacted. Since then infestations have increased every year to a record peak of 3,616,055 ha in 2014 (Figure 15). For the past three years aspen leaf miner has affected more hectares than any other damaging agent except the mountain pine beetle, and this year it even outpaced beetle damage. It was in fact exceedingly rare to find any aspen in BC that didn't have at least some defoliation.

Trembling aspen was the primary host but 17,019 ha of cottonwood leading stands were also damaged and a further 516,699 ha of attacked aspen stands contained a minor affected cottonwood component.

Intensity of attack (mapped as percentage of trees affected in a delineated polygon) was classified as 1,657,542 ha (46%) light, 1,437,113 ha (40% moderate) and 521,400 ha (14%) severe, which was similar to last year. Ground observers however, particularly in the Skeena Region, reported that the intensity of attack on a tree by tree basis was considerably lighter than the last few years, as was evidenced by much more fall colour this year (leaves on heavily attacked trees do not turn yellow in the fall, and they often drop up to a month earlier). As well, fewer moths were noted in the spring.

A decrease in aspen leaf miner populations would be very welcome, as anecdotal evidence suggests that mortality is being observed in some stands that have been severely defoliated for consecutive years. Stand damage has also been compounded in various areas by aspen leaf miner infestations mixed with other damaging agents, in particular Venturia leaf blight, forest tent caterpillar and satin moth. This type of mixed damage was sometimes difficult to differentiate from the air.

Aspen leaf miner infestations continued to spread in the Skeena Region with 1,818,118 ha of attack. Area affected in Cassiar TSA continued to grow, particularly in the south with a total 684,888 ha delineated (not all of the TSA was flown but the same area was surveyed as in 2013). Infestations in Lakes TSA almost doubled to 305,322 ha: the same general area mid TSA around Francois Lake was affected but damage expanded. Damage in Kispiox TSA expanded at a slower rate, with 262,603 ha mapped along major river corridors primarily in the southern half of the TSA. Attack in Morice TSA dropped by a third since 2013 to 242,323 ha. Most of the reductions occurred in the northern third of the TSA, with infestations in the middle third remaining relatively the same. Damage in Bulkley TSA also fell by a third to 138,015 ha. Decreases were mainly in the northern portion of the TSA, with the majority of the defoliation mapped along the Bulkley River. Conversely, infestations grew by about a third since last year in Kalum TSA to 108,495 ha, with expansions along the main river corridors plus new defoliation in the northern quarter of the TSA. Damage observed in Nass TSA more than doubled to 66,384 ha, particularly around Meziadin and Bowser Lakes. Infestations also increased to 10,088 ha in North Coast TSA around Hastings Arm and Alice Arm of Observatory Inlet.

Aspen leaf miner defoliation in Bulkley TSA

Damage grew by 60% over last year in the Northeast Region, with 1,014,707 ha affected. Almost all (990,941 ha) occurred in Fort Nelson TSA. Most of the infestations mapped last year increased in size, particularly in the northeast and northwest corners of the TSA. Fort St. John TSA had a slight reduction in defoliation, with 19,724 ha mapped, primarily north of Chincaga Lakes and on the northern boundary along Fontas River. Infestations in Dawson TSA decreased eight-fold to 4,042 ha all noted in the northwest corner but this reduction was likely a result of the remaining portion of the TSA being flown in October when the damage was less apparent.

Defoliation by aspen leaf miner rose 15% in the Omineca Region since 2013 to 544,712 ha. Prince George TSA continued to sustain the majority of the damage, with 477,725 ha affected, an increase of almost a quarter since last year. Infestations were scattered through mid TSA, with larger concentrations around Prince George east to the Fraser River. Conversely damage in Mackenzie TSA dropped by almost half to 38,283 ha, almost all concentrated from Peace Reach to Omineca Arm of Williston Lake. However, not all of the TSA could be surveyed this year and portions were flown too late to observe deciduous damage. Infestations in Robson Valley TSA tripled to 28,705 ha with most of the damage situated along the Fraser River.

Damage in the Thompson/Okanagan Region decreased by a quarter to 37,051 ha. Most of the damage continued to occur in Kamloops TSA with 31,949 ha mapped, primarily mid TSA. Small scattered infestations in the northern half of Okanagan TSA totalled 4,471 ha. Merritt TSA sustained 631 ha of damage along Maka Creek, north of Coalmont and east of Brookmere.

Aspen leaf miner defoliation in Williams Lake TSA

Infestations in the Cariboo Region more than tripled since last year to 174,156 ha. Williams Lake TSA defoliation grew to 74,454 ha, primarily mid TSA south of Quesnel Lake. The largest increases occurred in 100 Mile House TSA with damage scattered throughout the TSA, particularly in the eastern half, totalling 67,243 ha. A total of 32,459 ha were observed to be infested with aspen leaf miner in Quesnel TSA, with the largest concentrations occurring along the Quesnel River and near Mt. Milburn.

Aspen leaf miner defoliation in the Kootenay/Boundary Region almost doubled over 2013 to 18,647 ha. Disturbances were small and scattered, with Golden TSA continuing to sustain the most damage at 7,194 ha affected, primarily still mid TSA along the Columbia River. Kootenay Lake and Arrow TSAs had 4,501 ha and 4,117 ha of damage, respectively. Damage recorded in the remaining TSAs ranged from 1,651 ha to 234 ha.

Infestations quadrupled in the West Coast Region to 8,382 ha. The majority of this attack continued to occur along the northern edge of Mid Coast TSA where 8,174 ha of damage was recorded. The remaining 208 ha of damage in this region was mapped north of Trophy Lake.

The South Coast Region sustained 283 ha of damage, all of which was located in Fraser TSA. Small infestations were located along Silverhope and Chipmunk Creeks in the southeast, and one polygon in the northeast near Boothroyd.

Large aspen tortrix, Choristoneura conflictana

After three years of relatively low levels of defoliation, damage caused by the large aspen tortrix increased dramatically to 937,962 ha this year. This was substantially higher than the peak of the last outbreak in 2003 of 794,303 ha. Intensity of 2014 damage was rated as 595,398 ha (64%) light, 339,587 ha (36%) moderate and 2,977 ha (<1%) severe. Damage most likely was even higher in portions of the Mackenzie, Fort St. John and Dawson Creek TSAs that had to be flown in October when deciduous defoliation was not visible.

The majority of the disturbances (891,154 ha) were contained in the Northeast Region. Of this, 822,864 ha were mapped in Fort Nelson TSA where damage was extensive. A further 47,349 ha were delineated in Fort St. John TSA and 20,942 ha in Dawson TSA. District staff confirmed that the damage was large aspen tortrix in these TSAs this year, and some of the damage in these TSAs last year identified as forest tent caterpillar may have been large aspen tortrix or a mix. Often, as one aspen defoliator outbreak declines in the northeast, another one increases.

In the Omineca Region, all large aspen tortrix damage was observed in the Mackenzie TSA, where 38,005 ha of primarily moderate defoliation was mapped mainly along the Omineca and Peace Reach arms of Williston Lake.

Large aspen tortrix disturbances in the Skeena Region totalled 8,802 ha. All of the damage occurred in the northeastern tip of Cassiar TSA near the confluence of Hyland and Liard Rivers.

Forest tent caterpillar, *Malacosoma disstria*

A forest tent caterpillar outbreak, primarily in central BC, began around 2008 with a peak of 453,139 ha in 2011. Damage levels in 2012 decreased to less than half of the 2011 level but in 2013 defoliation it expanded again to encompass 581,910 ha. This upward swing continued in 2014 with a peak of 711,297 ha of damage (Figure 16). Intensity of foliage damage was rated as 197,972 ha (28%) light, 281,197 ha (39%) moderate and 232,128 ha (33%) severe. The provincial total would probably have been even higher had substantial portions of the Prince George, Dawson Creek and Mackenzie TSAs (where defoliation occurred last year) been flown earlier instead of in October when damage was no longer visible.

Much of the damage was described as patchy in occurrence within a given polygon, at least partially due to the patchy nature of the host species. Primary host species affected within delineated polygons were 71% aspen and 29% cottonwood.

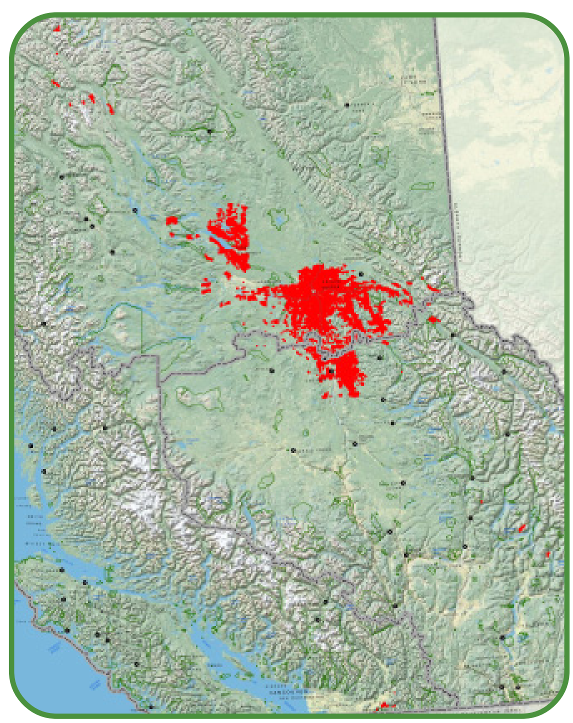


Figure 16. Forest tent caterpillar defoliation mapped in 2014.

The Omineca Region continued to sustain the most damage, with 575,875 ha mapped. The majority of the disturbances were delineated in Prince George TSA, primarily in the southern half of Prince George District with some infestations in the northern half of Vanderhoof District. Defoliation expanded into the northern tip of Robson TSA with 3,903 ha affected south of Goat River on the Fraser River and along Morkill River.

A total of 127,292 ha were affected in the Cariboo Region. Damage increased seven fold in Quesnel TSA, where 124,146 ha were recorded mid TSA, from Puntchesakut Lake east to the Sovereign Mountain area. The infestation continued south along the Fraser River into the north edge of Williams Lake TSA where 3,146 ha were defoliated.

After an absence of forest tent caterpillar damage for the past two years, 4,265 ha of defoliation was recorded in the Skeena Region. Most of the damage (3,937 ha) was observed in Lakes TSA, where one large polygon spilled out of the Prince George TSA on Fleming Creek in the northeast. The remaining 328 ha in the region occurred in Kispiox TSA on the Sicintine River east of Mt. Tommy Jack.

For the first time in recent history, 2,206 ha of defoliation was mapped in Fraser TSA of the South Coast Region. Most of the damage was observed around Cultus Lake. Ground checks confirmed the majority of the damage appeared to be caused by the forest tent caterpillar, but western tent caterpillar was also present. Further ground reports were made of defoliation along Harrison Lake on the east side near Big Silver River. This is the third year that tent caterpillar damage has been reported in the Fraser TSA but only the first time that it was visible during the aerial overview survey. Host species for all polygons in Fraser TSA was primarily cottonwood with a minor component of birch.

Defoliation by forest tent caterpillar in the Thompson/Okanagan Region decreased to 1,659 ha. Okanagan TSA contained a total of 1,564 ha of damage on Ross Creek north of Shuswap Lake and on Hunters Creek north of Mabel Lake. The remaining 95 ha was observed in Kamloops TSA on Harper Creek north of Barriere River.

Forest tent caterpillar defoliation in Fraser TSA

Venturia blight, *Venturia spp.*

Damage caused by Venturia blight (also known as aspen and poplar leaf and twig blight) has been commonly mapped in the northern interior for many years but until 2011 total area damaged annually remained below 82,000 ha. For the last three consecutive years, however, disturbances have increased substantially each year to a record peak of 837,586 ha in 2013. This year damage declined to 559,583 ha (Figure 17). Intensity also decreased with 421,686 ha (75%) light, 103,511 ha (19%) moderate and 34,386 ha (6%) severe. The relatively dry 2013 and 2014 summers may have resulted in fewer infections. The most common species affected continued to be trembling aspen but a total of 178,689 ha of cottonwood leading stands were also mapped. A further 170,541 ha of damaged aspen leading stands contained a minor cottonwood component.

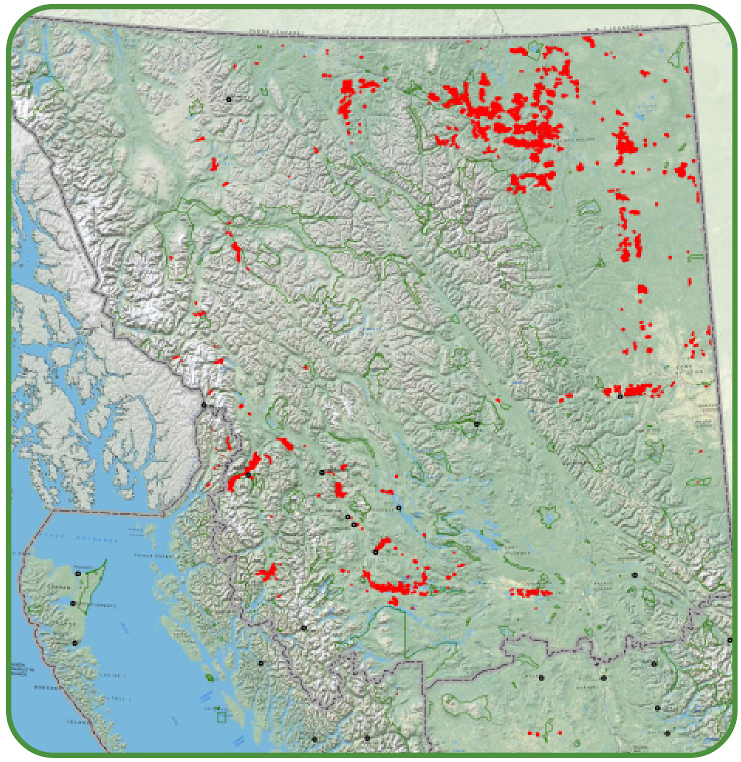


Figure 17. Venturia blight damage mapped in 2014.

Disturbances continued to be most prevalent in the Northeast Region, where 429,269 ha were mapped. Damage in Fort Nelson TSA increased by a third compared to 2013 with 355,467 ha affected. In general damage was recorded in larger, more concentrated polygons than last year, particularly from Fort Nelson west to Mt. Prudence, along the Kechika River and southwest of Kotcho Lake. Total hectares impacted in Fort St. John TSA continued to remain stable at 54,858 ha, though damage was less scattered with most polygons sketched along Chief River, Conroy Creek, north end of Beaton River and along the Alberta border in the south. After a large spike to 149,787 ha last year, recorded damage subsided in Dawson TSA to only 18,936 ha. It is suspected that this may be an artefact of survey timing however; all of the 2014 damage was mapped along the Peace River corridor which was flown in July, whereas the rest of the TSA had to be surveyed in October when most of the leaves had already been shed.

Venturia blight damage in the Skeena Region dropped to a third of that recorded last year to 119,555 ha. The decrease was not consistent however, with some TSAs experiencing substantial increases. Disturbances in Kalum TSA dropped by almost half, but still accounted for 32,620 ha of damage. Most of these continued to be observed along the Nass River, with one large new area north of Kitamaat Village. After a large decrease to only 6,058 ha last year, damage rebounded in the Morice TSA to 26,461 ha, primarily north of Houston and along Francois Lake. The Francois Lake damage extended into Lakes TSA which was responsible for the majority of the 19,454 ha recorded in that TSA, which was also a large increase in Venturia blight damage over 2013. Observed damage rose slightly in Cassiar TSA to 13,861 ha, primarily along Dease Lake and Klappan River. The largest decrease occurred in Kispiox TSA, where only 11,203 ha were mapped compared to 197,589 ha last year. This trend continued into Bulkley TSA where 8,255 ha were delineated compared to 105,442 ha in 2013. Most of the damage in these two TSAs occurred along the Bulkley River near Moricetown. Small scattered infestations accounted for the remaining 5,078 ha in Nass TSA and 2,624 ha in the north tip of North Coast TSA.

Venturia blight damage in Bulkley TSA

Omineca Region Venturia blight damage rose almost a quarter to 10,752 ha. Most of this (8,295 ha) occurred along the Nechako River east of Vanderhoof in Prince George TSA where disturbances increased three fold since 2013. Conversely, damage decreased to less than half that observed last year in Mackenzie TSA where 2,457 ha were delineated, still situated along Williston Lake.

For the second consecutive year, small pockets of Venturia blight damage were recorded in the southern portion of the province. In the Thompson/Okanagan Region one 8 ha polygon was mapped south of Mt. Morrisey in Kamloops TSA. All the damage in the Cariboo Region occurred in Williams Lake TSA, where five spot infection centers were recorded around Temapho Lake in the northeast portion of the TSA.

Gypsy moth, *Lymantria dispar*

Gypsy moth egg masses

The Canadian Food Inspection Agency placed over 5,000 traps in areas at risk to the moth's introduction across BC in 2014. After three years of low numbers of male moth captures, 2014's trapping results were alarmingly high (Figure 18). A total of 214 moths were caught with the majority (199) being collected from one area in Surrey near the Cloverdale border. Within the centre of the area with high trap catches, Surrey municipal workers discovered egg masses at the base of trees planted in the median of 64th Avenue – a very busy commuter route. Dozens of egg masses were later collected within the immediate vicinity of the original egg mass finds and further inspection of the median trees discovered pupal cases and live caterpillars. A cluster of moths (7) were also trapped in a small area near the Delta Municipal Golf Course. Both the Surrey and Delta infestations (an area of about 4,600 ha) have been identified for aerial application treatments using Btk in the spring of 2015. Other locations where low numbers of moths were caught were in reoccurring areas in the Lower Mainland and Southern Vancouver Island plus one outlier in Trail in the Southern Interior. All positive finds will be surrounded by a higher density trapping grid to determine if the populations persist and if they do, attempt to locate them with enough certainty to establish treatment boundaries. All moths were identified as European gypsy moth likely brought into BC from infested areas in Ontario or Quebec.

Gypsy moth caught in pheromone trap

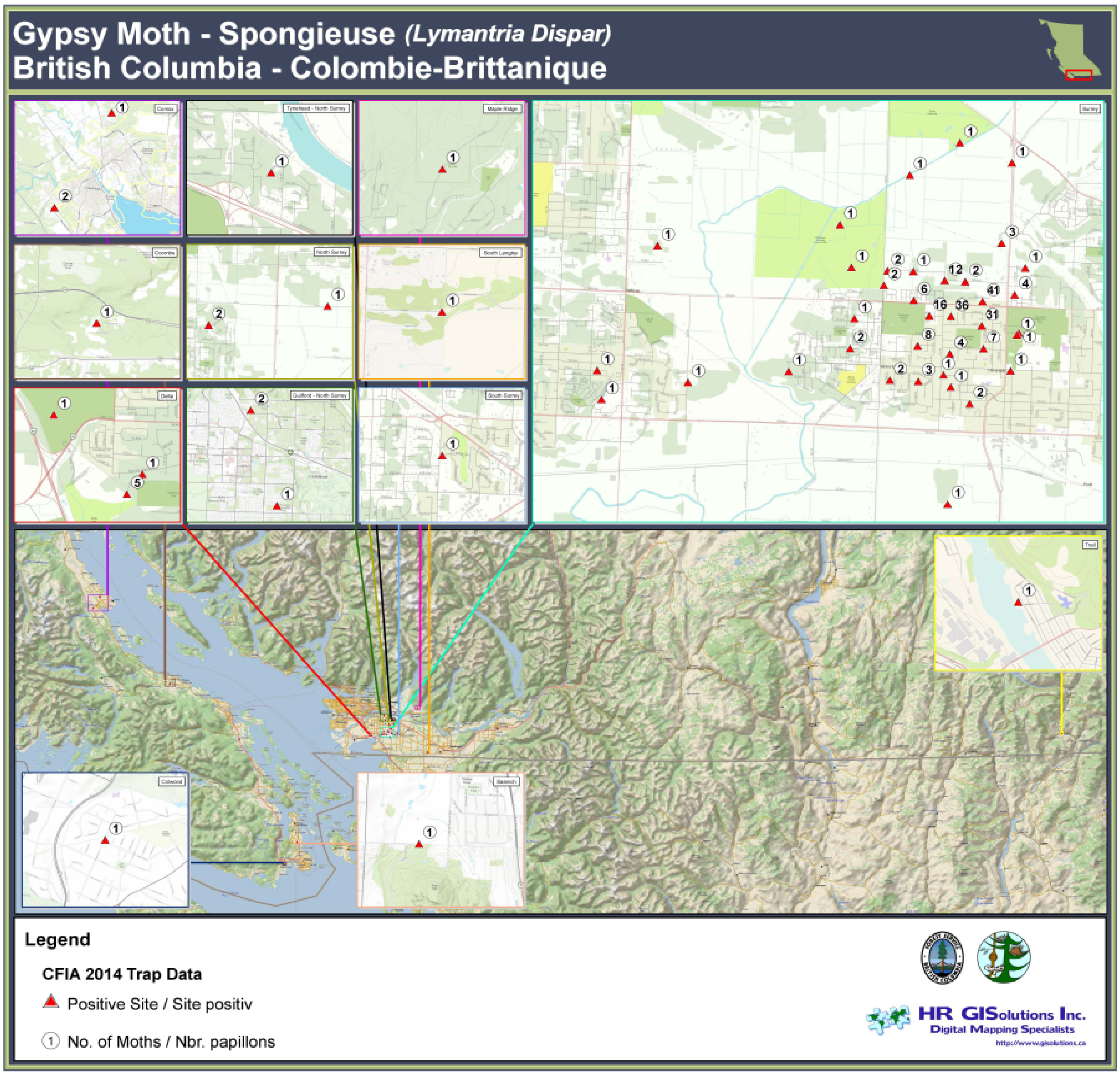


Figure 18. British Columbia gypsy moth trap catch locations in 2014.

Birch leaf miner, *Fenusa pusilla*

Birch leaf miner defoliation increased slightly over last year to 1,984 ha delineated as small polygons across the southern interior. Intensity of damage increased as well, with 730 ha (37%) light, 1,179 ha (59%) moderate and 75 ha (4%) severe.

Birch leaf miner defoliation, Kamloops TSA

The Thompson/Okanagan Region sustained 1,307 ha of attack, a threefold increase over 2013. Most (1,092 ha) were mapped in Kamloops TSA, primarily north of Mt. Tod. The remaining 215 ha of defoliation in the region were observed in Okanagan TSA west of Tappen.

Conversely, infestations in the Kootenay/Boundary Region decreased to almost half of that observed last year to 677 ha. Kootenay Lake TSA sustained 420 ha of defoliation, mostly in the north tip around Duncan River. Golden, Revelstoke and Arrow TSA had small areas of damage totalling 120 ha, 114 ha and 23 ha, respectively.

Cottonwood leaf rust, *Melampsora occidentalis*

Cottonwood leaf rust aeciospores on leaf

Observed cottonwood leaf rust damage increased for the second consecutive year to 1,242 ha, up from only 159 ha the first time it was recorded during the aerial overview surveys in 2012. Intensity of foliage damage increased as well, to 498 ha (40%) light, 484 ha (39%) moderate and 260 ha (21%) severe. All occurrences were small and scattered.

Most of the damage (1,096 ha) continued to occur in the Thompson/Okanagan Region. A total of 844 ha were delineated in the northern half of the Okanagan TSA. A further 252 ha were mapped in Kamloops TSA, predominantly mid TSA.

All 146 ha in the South Coast Region occurred in two polygons in Sunshine TSA along the Homathko River north of Waddington Harbour.

Aspen decline

Aspen decline in Merritt TSA

Deciduous declines are difficult to detect from the height of the aerial overview surveys, though some aspen decline has been delineated in the southern interior over the past three years. Damage identified in 2014 was half that recorded last year with 1,548 ha mapped. Intensity levels were very similar however with 1,043 ha (67%) light, 411 ha (27%) moderate and 94 ha (6%) severe. All disturbances were small and widely scattered.

The Thompson/Okanagan Region sustained 1,205 ha of the aspen decline damage. Merritt TSA was most affected with 803 ha delineated in the northern half of the TSA. In Kamloops TSA 324 ha were mapped in the west from McLean Lake to Oregon Jack Creek. Lillooet TSA contained one 54 ha polygon north of Pavilion Lake and two polygons near Vernon and Winfield in the Okanagan TSA totalled 24 ha.

Aspen decline in the Cariboo Region was 327 ha. 100 Mile House TSA sustained 218 ha of damage, while 109 ha were delineated in Williams Lake TSA.

The remaining 17 ha of damage was detected near McBride in Robson TSA of the Omineca Region.

No birch decline was observed aerially this year, but staff in Fort St. James District noted some damage from ground observations.

Satin moth, Leucoma salicis

Satin moth defoliation in Merritt TSA

Satin moth defoliation doubled since last year to 445 ha. Damage intensity was assessed as 216 ha (48%) light, 70 ha (16%) moderate and 160 ha (36%) severe. All the disturbances were small, with infestations confined to the Thompson/ Okanagan Region. Defoliation was scattered throughout Okanagan TSA with 321 ha mapped. Infestations in Merritt TSA totalled 60 ha and ranged from Red Creek north to Swakum Mountain. Kamloops TSA damage of 55 ha was confined to the south tip of Adams Lake. The remaining 9 ha were identified in one polygon in Lillooet TSA west of Spences Bridge.

Damaging Agents of Multiple Host Species

Abiotic injury and associated forest health factors

2014 wildfires Lakes TSA

Wildfire damage in 2014 was almost fifteen-fold that recorded last year with 405,426 ha affected, primarily due to six large fires (over 29,000 ha each) in the northern half of the province. Severity was rated as 33 ha (<1%) light, 1,620 ha (<1%) moderate, 403,542 ha (99%) severe and 231 ha (<1%) very severe.

The Omineca Region contained 189,779 ha of fire damage. Mackenzie TSA was the most affected with 121,486 ha, mainly in two large fires at Forres Mtn. and south of Carina Lake. One wildfire at Entiako Lake accounted for most of the 68,211 ha mapped in Prince George TSA. This fire extended into Lakes TSA of the Skeena Region where two large polygons on either side of Tetachuck Lake were responsible for most (97,287 ha) of the damage in the Skeena Region, where a total of 98,577 ha were burned. The Northeast Region sustained 80,917 ha of damage, mainly in the Dawson TSA (62,110 ha), where two fires near Mt. McAllister and Huguenot Creek were chiefly responsible. Of the 18,788 ha burnt in the Cariboo Region, 16,225 ha were located in Quesnel TSA, primarily in a fire east of Kluskus Lakes. Kootenay/Boundary Region had 8,134 ha of damage, mainly in four moderate sized wildfires in Invermere TSA where 6,174 ha were burnt. In the rest of the province, small dispersed fires accounted for less than 2,700 ha of damage per TSA.

Flooding caused by Polley Mine tailing pond breach

Flooding resulted in 42,298 ha of mortality across BC, an increase of almost five-fold since 2013. Intensity of damage also increased, with 29 ha (1%) trace, 12,513 ha (30%) light, 24,878 ha (59%) moderate and 4,878 ha (11%) severe. A variety of conifers were affected. Lodgepole pine and Douglas-fir were the most commonly affected tree species across most of the province, however, trembling aspen was the species most often damaged in Fort Nelson TSA. Most disturbances were small and scattered and damage remained at levels similar to last year except in the Northeast Region where it rose to 39,161 ha. Fort Nelson TSA contained most (32,457 ha) of this damage, mainly in the eastern half of the TSA and one large disturbance north of the Grand Canyon of the Liard River. A further 5,525 ha were delineated along the northern boundary of Dawson TSA and 1,179 ha were mapped in Fort St. John TSA. The Cariboo Region had 1,278 ha of flood damage primarily in Williams Lake TSA (803 ha) where many small disturbances were scattered across the western half and one large disturbance (500 ha) was identified in the east. This polygon was actually the result of the Polley Mine tailing pond breach. The remaining flood-caused mortality was scattered throughout the province at less than 350 ha per TSA.

Drought damage was up significantly this year, most likely as a result of two consecutive dry, warm summers over much of the province. A total of 25,810 ha were mapped at intensities of 3,191 ha (12%) light, 21,832 ha (85%) moderate and 787 ha (3%) severe.

The Northeast Region sustained the bulk of the damage with 25,536 ha delineated, primarily on trembling aspen stands with a minor component of cottonwood. Disturbances in the southeast corner of Fort St. John TSA accounted for 13,550 ha of the damage, which spilled into the northeast corner of Dawson Creek TSA where 1,752 ha were recorded. Stands north of Mt. Halkett and around Snake River were damaged in Fort Nelson TSA with 10,233 ha mapped.

Drought damage in Williams Lake TSA

Four polygons near Little Sapeye Lake in Williams Lake TSA of the Cariboo Region totalled 89 ha of damage. The affected stands were young lodgepole pine with a minor Douglas-fir component, which were ground checked due to an unusual aerial signature. Regional experts confirmed it was drought damage, based on the site details: the damage was concentrated on rocky outcrops with thin soils and steep aspects. Also, symptoms disappeared in depressions and at the toe of affected slopes. Ground observations in this TSA also noted drought damage on lodgepole pine infected with dwarf mistletoe, particularly where infections were heavy. By mid-summer (after the aerial overview surveys were complete) ground observations in the Cariboo Region noted drought symptoms in aspen stands. It tended to be very clonal in nature like Venturia blight but symptoms seemed to develop from the bottom up (unlike conifer drought or Venturia damage) and the leaves tended to be intact and larger unlike the small or missing leaves created by Venturia infections.

Similarly, the only polygon of 76 ha mapped north of Lava Lake in Kalum TSA of the Skeena Region was ground checked. Though the stand was composed of several species, only subalpine fir (all ages) were affected on south facing slopes with shallow, rocky soils. In the South Coast

Region 79 ha of drought was mapped in Fraser TSA south of Bridal Falls in redcedar. It was also noted from ground observations in this TSA that maple trees were showing signs of drought by early July. Minor (29 ha) of damage was also mapped in the Kamloops/Lillooet TSAs of the Thompson/Okanagan Region, and one spot in Strathcona TSA of the West Coast Region.

Post-wildfire damage records mortality occurring in the survey year within areas previously damaged by wildfires. Damage across BC totalled 10,381 ha this year with mortality assessed as 2,212 ha (21%) light, 2,643 ha (26%) moderate and 5,526 ha (53%) severe.

Douglas-fir, lodgepole pine and some spruce were the species most affected in 2014. Post burn mortality is related to fire damage as well as a complex of other forest health agents invading the weakened trees. In the Cariboo Region in particular, Douglas-fir beetle populations have built up in these damaged stands and are now moving into the adjacent healthy forests.

Damage declined in the Cariboo Region to 4,757 ha. Williams Lake TSA sustained 2,984 ha, primarily west of the Fraser River, east of Baldy Mtn. and near Vert Lake. A total of 1,559 ha were delineated in 100 Mile House TSA, mainly northwest of Kelly Lake. Quesnel TSA had 214 ha of post-wildfire damage near Castle Rock.

Post-wildfire damage was observed on 3,780 ha in the Skeena Region. Most (2,952 ha) continued to occur in Cassiar TSA, most notably south of Telegraph Creek and in the northeast near Wheeler Lake. Almost all the 525 ha mapped in Lakes TSA was located between Eutsuk Peak and Tetachuck Lake. Disturbances in Morice TSA accounted for 229 ha north of Morice Lake. Two polygons of damage totalling 74 ha were mapped along the Kitlope River in Kalum TSA.

All the post-wildfire damage in Omineca Region occurred in Prince George TSA where 431 ha were detected north of Stony Lake and south of Tatuk Lake. Similarly, all the damage identified in the Northeast Region was contained in Fort Nelson TSA where 1,245 ha were affected near the Red River west of Aeroplane Lake.

Post-wildfire damage was minimal in the Thompson/Okanagan Region where 121 ha were delineated. Disturbances were small and scattered in Lillooet, Okanagan and Kamloops TSAs at 85 ha, 23 ha and 13 ha, respectively. The remaining damage in the province was noted in Mid Coast TSA of the West Coast Region where 46 ha were mapped.

Windthrow in Bulkley TSA

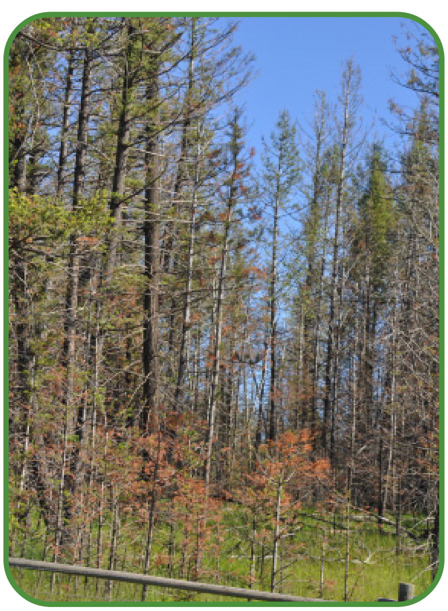
Windthrow affected 2,691 ha provincially, down for the second consecutive year. Severity was down as well, with 39 ha (1%) trace, 51 ha (2%) light, 614 ha (23%) moderate, 1,945 ha (72%) severe and 42 ha (2%) very severe. The majority of the disturbances (1,457 ha) continued to be mapped in the West Coast Region, mainly scattered around Haida Gwaii TSA where 1,439 ha were delineated. The Northeast Region sustained 684 ha of windthrow damage. Fort Nelson TSA had 647 ha of this damage, mainly northeast of Fort Nelson. A few scattered polygons in the Prince George TSA of the Omineca Region accounted for 116 ha. Of the 306 ha delineated in the Kootenay/Boundary TSA, half were observed in small, widely scattered disturbances in Cranbrook TSA. All remaining TSAs in the Province had less than 70 ha of windthrow damage per TSA.

Weather related damage was mapped over 2,639 ha in the far north this year. Most (2,498 ha) was assessed as moderate with the remaining 141 ha denoted as severe. Lodgepole pine and spruce were the species most often affected and the damage was thought to be caused by either drought or winter desiccation. In the Northeast Region 2,356 ha were recorded in two disturbances in the Fort Nelson TSA along Berg Creek near Campbell Peak. The remaining 893 ha were observed in Cassiar TSA of the Skeena Region along the Yukon border from Big Creek east to McKinney Lake.

Slides damaged a total of 2,572 ha in 2014, up a quarter since last year. A total of 1,141 ha (44%) were noted as being caused by snow avalanches. The bulk of the damage (95%) continued to be assessed as severe. All disturbances were small (most <20 ha, largest disturbance was 95 ha) and the majority were widely scattered. Spruce and subalpine fir were the species most affected, though a variety of other conifers and some deciduous trees were killed as well.

Slides in Strathcona TSA

West Coast Region continued to sustain the bulk of the damage with 1,126 ha mapped, primarily in Haida Gwaii (632 ha) and Strathcona (310 ha) TSAs. Unlike the scattered disturbances in the rest of the province, damage in Strathcona TSA was clumped south of Knight Inlet around Glendale Cove area. Damage noted in the Kootenay/Boundary Region rose to 882 ha. Cranbrook, Invermere and Arrow TSAs contained the majority of the disturbances with 387 ha, 163 ha, and 146 ha affected, respectively. Slides in Skeena Region totalled 190 ha with North Coast TSA most affected (102 ha). All 123 ha observed in the Northeast Region occurred in Fort Nelson TSA. The remaining Regions had less than 100 ha of damage delineated per region.



Hail damage in 100 Mile House TSA

Hail damaged 111 ha to a moderate extent in two polygons west of 100 Mile House. This damage occurred on September 2nd, 2013 and was mentioned in last year's report but it was not mapped until 2014. Douglas-fir and aspen of all ages were affected and at least some of the Douglas-fir were damaged to such an extent that mortality is occurring.

Abiotic factors caused moderate mortality in three polygons totalling 1,613 ha in Haida Gwaii TSA. It was mapped for the first time this year and added to the database as old (grey) since it hadn't been detected previously. The stands were located about 3 km inland north of Cape Ball on the plateau at the northeast corner of Graham Island. The damage was ground checked and was found to be affecting all the mature trees in the stand (western redcedar, western hemlock and Sitka spruce). Although the agent for the mortality was not confirmed, a rising water table may have been the cause.

Animal damage

Porcupine feeding damage

Most animal damage is underestimated in the aerial survey data as it is difficult to detect from the height the survey is flown. Visible damage usually results from substantial feeding that either kills the tree outright or kills large portions of the tops.

Porcupine (*Erethizon dorsatum*) damage was only mapped in Fort Nelson TSA of the Northeast Region this year. A total of 18,172 ha were delineated at 15 ha (<1%) trace, 10,370 ha (57%) light and 7,787 ha (43%) moderate intensity. Primarily lodgepole pine was affected, but a variety of other species were damaged as well. This is the highest level ever recorded but does not indicate a sharp increase in porcupine activity: damage is known to be ongoing in dispersed locations throughout much of the province but it often isn't identified during the overview surveys. The damage this year was noted to most likely also include bear damage and probably lodgepole pine beetle mortality as well. Conversely, disturbances that were identified as mainly lodgepole pine beetle in this TSA were thought to have a component of porcupine damage too. Only minimal confirmations were made regarding this complex of damaging factors; more are planned for next year.

Black bear (*Ursus americanus*) damage observed across the province remained relatively stable compared to 2013 with 4,173 ha noted. Mortality levels were classified at 412 ha (10%) trace, 3,038 ha (73%) light, 465 ha (11%) moderate and 258 ha (6%) severe. All noted damage was in small polygons scattered throughout young to intermediate age stands. All attacked trees were lodgepole pine, with the exception of a few Douglas-fir stands in Okanagan and Lillooet TSAs. Scattered mortality in young stands is marginally visible at survey height, hence the lower the survey is flown, the more disturbances are observed.

Damage rose slightly in the Kootenay/Boundary Region to a total of 1,959 ha. Most of the increase occurred in Kootenay TSA, where area affected doubled to 801 ha. Arrow and Cranbrook TSAs sustained similar levels of damage, with 324 ha and 301 ha, respectively. A total of 241 ha were mapped in Kootenay TSA, and 214 ha in Golden TSA. Remaining mortality by TSA was minor (under 70 ha). District staff noted that in general in the Selkirk District bear damage seemed to be on the rise in intermediate aged spaced stands, whereas higher density stands were experiencing less mortality.

Black bear damage in Kootenay TSA

Disturbances in the Cariboo Region declined to 1,934 ha. Almost all (1,733 ha) continued to occur in the eastern portion of Williams Lake TSA, particularly near Wartig Lake. The remaining 200 ha of mortality in the region was mapped in 100 Mile House TSA north of Pendleton Lakes in the northeast tip of the TSA.

Bear damage in the Thompson/Okanagan TSA remained constant with 233 ha delineated. Okanagan TSA sustained 177 ha of damage, while 45 ha were mapped in Merritt TSA. Remaining damage in the region was under 10 ha.

All the damage in Omineca Region occurred in Robson TSA, with 48 ha detected. District staff noted that most of the damage in this TSA occurs at mid-elevation in the Interior Cedar Hemlock (ICH) biogeoclimatic zone.

Snowshoe hare (*Lepus americanus*) damage is rarely visible from the aerial survey (last year was an exception) but ground observations of damage continue to be reported in the Prince George and Lakes TSAs. Hare damage in most areas continued to be endemic, however, some ground surveyors in the Cariboo Region noted a substantial increase in hare sightings in the spring.

Vole (*Microtus and Clethrionomys*) populations have been low for several years, with just a few exceptions. In 2014, the only reported damage was in new plantations approximately 25 km east of Golden.

Armillaria root disease, *Armillaria ostoyae*

Although Armillaria root disease is prevalent throughout the southern half of the province, the damage is rarely seen during the aerial overview surveys due to the height flown. The few infection centers that have been recorded are usually by surveyors with local ground knowledge of the areas, primarily in the South and West Coast Regions.

In 2014 visible Armillaria root disease damage decreased to 347 ha at intensities of 283 ha (82%) trace, 28 ha (8%) moderate and 36 ha (10%) severe. All the severe damage was of spot size. All disturbances were scattered and most were small, aside from a few larger trace intensity polygons. Damage identified in the West Coast Region totalled 222 ha, of which most (213 ha) was located in Arrowsmith TSA. Spot Armillaria root disease centers in Strathcona and Kingcome TSA affected 6 ha and 3 ha, respectively. In the South Coast Region, 125 ha were impacted. Sunshine Coast TSA contained 122 ha of damage, while spots totalled 3 ha in Fraser TSA.

Miscellaneous Damaging Agents

Unknown defoliator damage was recorded on 7,102 ha in the Skeena Region this year. The intensity of the disturbances was assessed as 54 ha (1%) light, 5,930 ha (83%) moderate and 1,117 ha (16%) severe. The agent(s) of this defoliation could not be confirmed due to stand inaccessibility. Spruce and lodgepole pine, with some minor component of subalpine fir, were the host tree species, and all of the damage occurred in mature stands. The majority (6,771 ha) occurred in the northeast quarter of the Cassiar TSA. Most of the mapped polygons were small and scattered but one large disturbance (4,887 ha) was delineated east of Hluey Lakes. In North Coast TSA 306 ha of defoliator damage was observed, primarily on Banks Island. The remaining 24 ha was mapped in one polygon along Legate Creek in Kalum TSA.

Aspen defoliated by fall webworm

Fall webworm (*Hyphantria cunea*) continued to defoliate small shrubs and some aspen of all ages at low elevations in the Thompson/Okanagan and Cariboo Regions. The infestation was observed to be causing the most damage between Kamloops and Barriere in Kamloops TSA, where affected hosts were often completely stripped.

Fall webworm larvae

Willow leaf blotch miner (*Micurapteryx salicifoliella*) defoliation was noticeable for the fifth consecutive year in Fort Nelson, Fort St. John and Dawson Creek TSAs. Defoliation was on the decline but when combined with drought damage later in the summer, willow did very poorly in 2014. In Alaska there are concerns regarding mortality caused by willow leaf blotch miner and its effects on moose carrying capacity (US Forest Service, 2008). This damage was not mapped since willow is not a commercial tree species.

Alder decline was noted by the Regional Pathologist to be widespread throughout the Skeena Region. It appeared that the primary agent involved in this decline was *Cytospora umbrina*. In the spring in the Bulkley Valley *Cytospora umbrina* was also noted to be infecting Saskatoon bushes, resulting in considerable stem mortality. Bright red flagging caused by rapid dieback (after the new foliage had emerged) was very visible.

Heavy cone crops in mature and intermediate age class western hemlock stands in portions of the Skeena Region were initially mistaken for significant defoliation until ground checks were conducted. It is hypothesized that the hot dry summers of the past few years in the region have stressed the hemlock, which have reacted with unusually heavy cone crops.

Alder sawfly defoliation was noted in a small patch of alder just south of Vavenby in the Kamloops TSA along a main road.

Alder sawfly defoliation in Kamloops TSA

Ornamental apple defoliation was noted to be severe in the City of Terrace in Kalum TSA this year. Photos of the larvae were sent to the Regional Entomologist for identification, who identified it as either the apple ermine moth or ugly-nest caterpillar: without physical specimens these damaging agents are difficult to tell apart.

***Enargia decolar*, an aspen defoliator**, was found in gypsy moth pheromone traps in the Cariboo Region this year. Three or four of these moths per trap were found at monitoring sites located in the dry ecosystems of the Cariboo. Samples were sent to the Canadian Forest Service for identification. Historical outbreaks by this defoliator have occurred in the Rocky Mountain area.

Forest Health Projects

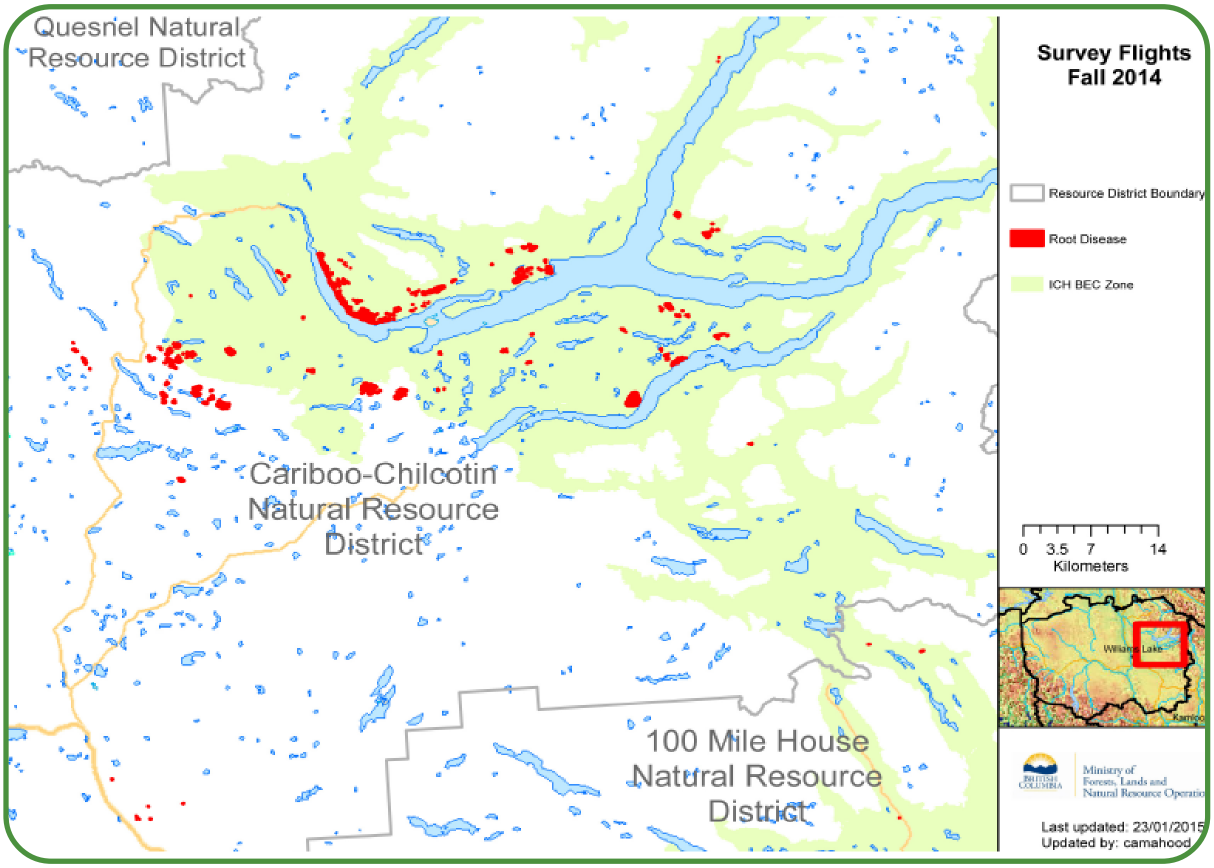
Aerial root rot detection in the Cariboo ICH

David Rusch Forest Pathologist, Cariboo & Thompson/Okanagan Regions
Richard Reich Forest Pathologist, Omineca and Northeast Regions

Young non pine leading stands aged 10-50 years were assessed for root rot in the Cariboo Interior Cedar Hemlock Zone (ICH) using a helicopter. This method was previously developed by Richard Reich in the Robson Valley and reported on in the 2009 Summary of Forest Health Conditions in BC. The majority of root disease encountered was in 1:50,000 map sheets 93A112 & 93A113 (Quesnel Lake/ Horsefly Lake area). In the eastern portion of the ICH bear damage was very prevalent. While the majority of the bear damage was on lodgepole pine, bear damage on spruce made it more difficult to detect root rot from the air. Despite this, ground checking showed that root rot was successfully identified from the air. It was not possible to distinguish laminated root rot from Armillaria in young stands during the aerial flights.

During the flights it was noted that laminated root rot centers could be detected in mature stands. The eastern shore of the western arm of Quesnel Lake had a number of large laminated root rot centers that were discernible from the air. Several of these were traversed on the ground. The location of the centers is strongly associated with timber types that are leading in both Douglas-fir and birch and in many cases the location of root rot boundaries could be fairly accurately predicted from good aerial imagery.

A half day follow-up flight of mature Douglas-fir leading types in Sub-Boreal Spruce (SBS) biogeoclimatic subzones (SBSdw1 and SBSdw2) was conducted in the fall. No root rot was detected in the SBSdw2. In the SBSdw1 fifteen root rot polygons were detected. Ground checks of five accessible polygons revealed that three were laminated root rot centers, one was an Armillaria center and one was an area with a high amounts of scattered Armillaria combined with Douglas-fir beetle. Because root rot distribution changes very little over time these maps should be a useful record of known root rot locations in the Cariboo SBSdw2 and ICH for many years to come.



Map of root rot detected during aerial surveys in the Cariboo ICH

A guide to managing Douglas-fir beetles on private property

Jodi Axelson, Forest Entomologist, Cariboo Region

Douglas-fir beetle populations have been on the rise in the Cariboo Region since the 2009/10 high wildfire years. A significant portion of the Douglas-fir stands in this region are on or adjacent to private property: therefore, Douglas-fir beetle infestations on private property have become a growing concern.

I worked with the communications department to develop a guide for private land owners to manage Douglas-fir beetle attack on their property. The brochure has descriptive photographs and details on identifying attack and how to deal with it.

Presently, the brochure is available in electronic format at:
http://www.for.gov.bc.ca/dqu/DouglasFirBeetles_factsheet_FLNRO_Web.pdf

Comandra blister rust trial results

Alex Woods, Forest Pathologist, Skeena Region

Preliminary results from a comandra blister rust trial established over 16 years ago in the Nadina District suggest that stem infections of the rust are very effective tree killers (>95% of 389 trees that were stem infected in 1997 at stand age 15 were dead by age 31). Approximately 40% of branch infected trees developed stem infections by age 30. The mean distance from the stem for all 717 branch cankers both live and dead at the two study site installations was about 10 cm. The mean distance for successful disease transfers for live branch infections was 6.5 cm for live cankers and 3.7 cm for branch cankers that appeared dead at age 15. At age 31 21.5% of total basal area on the two sites was affected by comandra and western gall rust combined. Of the total basal area 16.7% was affected by comandra alone and all of those trees were considered lethally infected as only stem infections were recorded.

Comandra blister rust responsible for creating gaps in 30 year old stands

Effect of silviculture treatments in a forty year old lodgepole pine stand severely impacted by Elytroderma needle cast and mountain pine beetle

David Rusch, Forest Pathologist, Cariboo & Thompson Okanagan Regions

Spacing, pruning, and fertilization were conducted in a 40 year old lodgepole pine stand in the IDFdk3. This stand was spaced in 1993 and is severely impacted by Elytroderma needle cast. Mountain pine beetle mortality of some of the larger and healthier trees in the stand have increased the percentage of trees severely impacted by Elytroderma. The stand where the trial was established is scheduled for underplanting with Douglas-fir in the spring of 2015. The purposes of the trial are 1) to see if fertilization will speed the recovery of some of the less impacted Elytroderma trees, 2) create more growing space for underplanting/natural regen by removing some of the most severely impacted layer 3 trees, 3) to see if pruning will speed the recovery and or improve the form of moderately impacted Elytroderma trees, and 4) quantify the effects of Elytroderma on branch form and growth by comparing branch size, height, and diameter in healthy and severely impacted trees. In addition, some of the control treatments that were laid out will be used as unplanted controls for the underplanting treatment scheduled in 2015.

Is western white pine more resistant to Armillaria root disease than other conifers?

Michael Murray, Forest Pathologist, Kootenay-Boundary Region

Western white pine has remarkable properties for promoting healthy forests and economies. It is fast-growing on a good variety of soil conditions and elevations. White pine provides large seeds for wildlife yet is resistant to deer browsing. Achieving heights over 200 feet, its straight-boled graceful stature is considered by many as the most attractive conifer in BC. White pine was historically a dominant tree in the Kootenays before over-harvesting and white pine blister rust invasion. By the late 1900s, very few old trees remained. Despite the availability of disease-resistant planting stock, relatively few are planted.

The loss of white pine has been accompanied by a shift to Douglas-fir and lodgepole pine domination. These species are prone to a greater variety of forest health agents than white pine. This shift has reduced productivity about 50% per acre (Fins and others 2001). In the Kootenays, a primary agent contributing to plantation tree mortality is Armillaria root disease where 30% or more cumulative infection occurs.

Is white pine more resistant to Armillaria than its competitors? This question was posed about 30 years ago leading to a handful of research trials being established to address this question. Three of these trials (Busk, Marl, and Smallwood) were installed by the Canadian Forest Service (CFS) in 1987 (Table 8). Results from an additional three trials (all unrelated) are also available (Table 9). Findings from the six trials indicate that white pine is typically less prone to Armillaria infection than Douglas-fir and lodgepole pine. Only a single trial indicated greater impacts to white pine. These new results suggest that planting white pine will usually yield better survival than Douglas-fir and lodgepole pine on sites prone to Armillaria.

Table 8. Percent (%) Armillaria Root Disease on DEAD trees (2014). Plantations established 1987 (27 yrs old).

Species	Busk	Marl	Smallwood
White Pine	2.5	13.9	18.4
Douglas-fir	-	5.0	25.0
Lodgepole Pine	5.0	-	-
Both Species	2.8	13.1	18.9

Table 9. Percent (%) *Armillaria* Root Disease on LIVING and DEAD (2013). Vlem Crk surveyed in 2003.

Species	Columbia West Planted 1987	McPhee Planted 2004	Vlem Creek Planted 1984
White Pine	4.0	5.4	2.0
Douglas-fir	4.3	5.6	10.3
Lodgepole Pine	6.7		
Cedar	0	1.8	
Larch	3.4		
Species Combined	3.4	3.8	5.6

Fins, L. and others. 2001. Return of the giants: restoring white pine ecosystems by breeding and aggressive planting of blister rust-resistant white pines. Station Bulletin 72. University of Idaho. 21 p.

Lodgepole pine dwarf mistletoe sanitation height trials in the Cariboo

<u>David Rusch,</u> *Forest Pathologist, Cariboo & Thompson Okanagan Regions*

Two trials were set up to test the effect of sanitation height on subsequent lodgepole pine dwarf mistletoe growth impacts. Sanitation treatments included removal of all advanced regen greater than 0.5m, 1m, and 2m and a no removal control treatment. One trial was established in the Cariboo IDFdk3 in cooperation with BC Timber Sales and the other in the Quesnel SBPSmc/dc transition in cooperation with West Fraser. Unfortunately the Quesnel site was burned in a wildfire prior to conducting sanitation treatments.

Lodgepole pine plantation monitoring

<u>Alex Woods</u>, *Forest Pathologist, Skeena Region*
<u>Erin Holtzman</u>, *Forest Health/Research Technician, Skeena Region*

Eighteen pine leading plantations that had been previously identified as covering a range of infection with Dothistroma needle blight in 2000 in the Kispiox Valley were surveyed using the SDM protocol. The preliminary results show a very large impact of Dothistroma on percent live crown. Stands with little Dothistroma damage clearly have significantly more crown retention than diseased stands despite all stands being close to the same age. Height growth is far less affected than diameter growth in infected trees.

New field trials established to screen blister rust resistance in whitebark pine

<u>Michael Murray</u>, *Forest Pathologist, Kootenay-Boundary Region*

As whitebark pine continues to decline in numbers, a new effort has begun to address an old forest health challenge….the non-native white pine blister rust disease. By identifying rare rust-resistant parent trees, we can protect them and collect seeds, thus promoting the planting of hardy offspring that are likely to survive the non-native pathogen. The development of disease resistance in western white pine has proven a successful model for whitebark pine in the US. Thus, the approach in BC is very similar.

Beginning in 2011, a search for healthy disease-free trees was conducted throughout the Kootenays. Forty trees were identified for seed collection. Progeny were reared at Kalamalka Research Centre's nursery (FLNRO) until this past summer when nearly 4,500 seedlings were planted in research trials (Table 10). The planted seedlings are tagged according to their respective parents. Survivorship will be monitored over the next five or more years. Those seedlings that thrive will indicate a natural resistance to disease. Thus, the original parent trees will be targeted for future seed collection.

Three field trial sites were chosen based on good accessibility and high blister rust hazard. Seedlings were planted along transects at 1 and 2 meter intervals based on available space. Idaho Peak is a maintained recreation area with interpretive signs, benches, and a decommissioned fire lookout. The Sale Mountain trial is adjacent to a BC Hydro communications facility. Puddingburn Mtn. supports a Nav Canada facility next to this trial. An additional two trials were established in Glacier National Park. Parks Canada oversaw planting of about 500 seedlings at two remote locations known locally as Grizzly and Prairie Hills. These semi-treed sites had experienced recent wildfire. Seedlings will be assessed annually during the following five years (2015-2019) for health and survivorship.

Table 10. Research field trials for blister rust resistance screening in whitebark pine.

Field Trial	General Location	Number of Seedlings
Grizzly Hills	Glacier National Park	250
Idaho Peak	New Denver – Silverton	1,000
Prairie Hills	Glacier National Park	250
Puddingburn Mtn.	Kimberley	2,000
Sale Mtn.	Revelstoke	1,000

Planting of Screening Trail Idaho Peak

Swiss needle cast update in the Chilliwack District

Lucy Stad, Stewardship Forester, Chilliwack District

Swiss Needle Cast (*Phaeocryptopus gaeumannii)* (SNC) was positively identified within the Chilliwack District with foliar analysis and surveys in 2012. Since then, occurrence of SNC has been confirmed throughout the western half of the district and as far east as the lower Fraser Canyon. Light infestations have also been recorded east of Hope along Highways 3 & 5 and in the Chilliwack River Valley.

Foliage damaged by Swiss needle cast

In an effort to determine the extent of defoliation and potential impacts on young trees, a multiyear monitoring project was started in 2014. Monitoring lines are being established in selected young Douglas-fir stands throughout the district where SNC presence has been confirmed. Trees between 6 to 14 years old are tagged and will be resurveyed every two years to determine the amount of needle loss over time. The goal is to determine the degree to which tree growth and survival are affected by the defoliation.

Healthy Douglas-fir will retain their needles for up to 4 years. Our surveys have shown that trees affected by SNC have from as low as one year to three years of needle retention. Although some mortality was identified in the surveyed stands, none could be positively attributed to Swiss Needle Cast. It will take further monitoring work to quantify potential impacts on the affected stands.

Young pine PSPs show effects of Elytroderma severity on lodgepole pine height and dbh growth

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

Three young pine permanent sample plots (PSPs) were re-measured in 2014 by EntoPath Management Ltd (Table 11). The trees were rated for Elytroderma foliage disease using a 6 point Hawksworth scale with stunting used in place of dwarf mistletoe brooms. Trees with ratings of 5 or 6 had significant reductions in height growth compared to healthy trees. PSP 8 also showed significant height reduction for trees with a severity rating of 4 (21% reduction compared to healthy trees). For the three sites, trees with severity ratings of 5 had 16-27% less height growth compared to healthy trees and trees with severity rating of 6 had 32-62% less height growth than healthy trees (Figure 19). Diameter at breast height (dbh) compared to healthy trees was only significantly lower for the most severely infected trees (tree class 6). The graph of dbh as a function of Elytroderma severity class (Figure 20) showed an increasing trend in dbh at lower severity ratings compared to healthy trees. However, the differences in dbh were only significantly higher than the healthy trees for PSP 8 severity rating 1, 2, & 3. One possible explanation for the higher dbhs is that stem swellings caused by Elytroderma stem infections may result in larger stem diameters compared to health for trees in the lower severity classes.

Table 11. Summary of Elytroderma PSPs

PSP	BEC	Age	Density (stems/ha)	% Infection	Mean severity of DFE infected trees	% of trees in severity class 5 &6
5	IDFdk4	30	6840	89	3.7	44
8	IDFdk3	30	2550	54	1.5	12
11	IDFdk3	39	5280	91	4.1	55

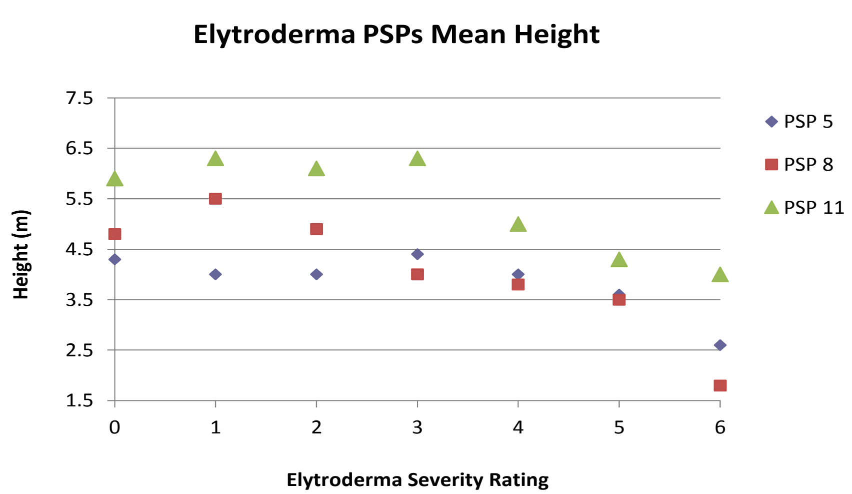


Figure. 19. Height as a function of Elytroderma Severity Rating for 3 PSPs.

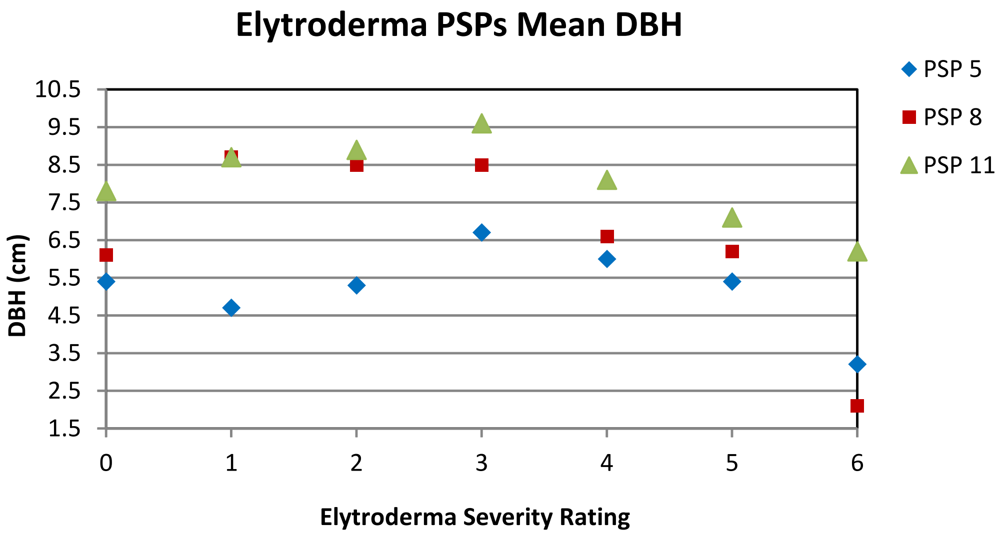


Figure 20. DBH as a function of Elytroderma Severity Class for 3 PSPs

Forest Health Meetings/Workshops/Presentations

After the mountain pine beetle: the dynamics of forest health in a changing environment

Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region

Venue:
Community Futures Development Corporation of Central Interior First Nations: Forestry Forum, Kamloops, BC.

Abstract:
BC has just witnessed the largest and most severe outbreak of mountain pine beetle recorded with over 53% of mature pine volume killed. Pine forests were conditioned over the past 100 years and presented a perfect landscape for mountain pine beetle: populations built; dispersed and colonized; and, left their imprint on the forests of BC. Now with the decline of mountain pine beetle salvage harvest and accompanying silviculture treatments, we are looking elsewhere for timber and silviculture opportunities. There has been a renewed interest in our low to mid-elevation Douglas-fir forests therefore it is critical we manage these dry fir forests in a thoughtful manner.

Dry fir forests are not without their forest health issues: western spruce budworm; Douglas-fir tussock moth; Douglas-fir beetle; *Armillaria* root disease; *Phellinus* and others. This talk focussed on the western spruce budworm and its impacts and management. I described the decision matrix for where and when *B.t.k.* spray should be prescribed and the resultant effects on budworm and non-target insects.

Application of *Bacillus thuringiensis* against 2-cycle budworm at Mt. Tom in 2012.

<u>Robert Hodgkinson</u>, *Forest Entomologist, Omineca & Northeast Regions.*

Venues:
Northern Silviculture Committee (NSC) *Winter Workshop* at UNBC on Feb. 18, 2014 and during the NSC Spring Field Trip in Quesnel District on June 17, 2014. Also presented at the *Natural Resources and Environmental Studies Institute Colloquium* at UNBC on Dec. 5, 2014 (*http://www.unbc.ca/nres/nresi_webcast.html*)

Abstract:
A total of 890 ha of 2-year budworm infested subalpine fir and Engelmann spruce in the higher elevation Mt. Tom research forest east of Quesnel were aerially treated with *Bacillus thuriengiensis (Btk)* at a rate of 2.4 litres per ha in early July 2012. Applications were made with a Hiller 12ET helicopter equipped with 4 Beecomist 361A ultra low volume hydraulic sprayers under good spray weather conditions. Efficacy sampling revealed significant population reductions due to treatment of 75-95% on subalpine fir but none on Engelmann spruce. Defoliation was significantly lower on all the treated subalpine fir, but not on the Engelmann spruce. The treatment also significantly reduced moth egg mass deposition by 85-88%. Discussion included the challenges of treating this insect given bud phenology and larval development issues, and possible alteration of strategy for future work.

BC report at the National Pest Forum

<u>Tim Ebata</u>, *Forest Health Officer, Resource Practices Branch*

Venue:
Shaw Conference Centre, Ottawa, ON, Dec. 2-4, 2014

Abstract:
A summary of the highlights from BC's 2014 aerial overview survey results and an overview of current priority forest health issues was provided to this annual gathering of Federal, provincial and territorial forest health specialists. The presentation included the update on the continuing collapse of the mountain pine beetle outbreak, a status report on major bark beetle, defoliators and pathogens affecting the province's timber supply, and a description of special projects and activities that highlight the province's unique forest health issues and approaches to managing them. One highlight was the announcement of the availability of the recently revised "Field Guide to Forest Damage in British Columbia" 3rd Edition.

Over 100 attendees representing provincial and federal forestry departments, the Canadian Food Inspection Agency, Pest Management Regulatory Agency, universities , non-government organizations (e.g., Tree Canada), and students participated in this year's National Pest Forum.

Dry-belt Douglas-fir and western spruce budworm management in the Cariboo Region

Jodi Axelson, *Forest Entomologist, Cariboo Region*

Venue:
Integrated Vegetation Management Association of British Columbia Bi-Annual Meeting, Richmond, BC, October 28-30, 2014

Abstract:
In the Cariboo Region insects and diseases are significant vectors impacting forest health. Forest health issues, including abiotic vectors such as snowpress, fire and flooding are highly integrated across the landscape and generate uncertainty in terms of timber supply, biodiversity, resilience and the impacts of ongoing climate change. Much of BCs interior sustained catastrophic mortality by the mountain pine beetle, and since the outbreak collapsed attention has turned to managing other tree species such as Douglas-fir. In the Cariboo Region 15% of forested land-base is dominated by Douglas-fir and 45% of the area is classified as part of the Interior Douglas-fir (IDF) biogeoclimatic zone. Douglas-fir is an example of a tree species that relies on habitat conditions associated with mature forests for successful regeneration, although mature forests are under increasing and unrelenting pressure due to insect outbreaks. An example is the western spruce budworm, a native defoliator of Douglas-fir and the most destructive defoliator in western North America. With the most recent western spruce budworm outbreak in its second decade management over the last 15 years has focused on biological control of this insect through the aerial application of *Bacillus thuringiensis* var. kurstaki (Btk). Treatment decisions are made based on: a decision-matrix approach at the landscape scale, past defoliation history (long-term and short-term), and predictive sampling to prioritize areas with the largest populations.

This talk focussed on the impact of western spruce budworm outbreaks in BC, the strategies employed when undertaking operational treatment, how treatment programs are executed in the southern interior of BC and the efficacy of such approaches.

Conference Link:
http://www.ivma.com/#!conference-2014-ivmabc/crh

Forest health and climate change: take a step back and see the future

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

Venue:
CEATI (Centre for Energy Advancement through Technological Innovation) Vegetation Management Workshop, Vancouver, BC, November 13, 2014.

Abstract:
In BC and the Pacific Northwest, numerous unprecedented outbreaks of forest insect pests have been recorded over the past 50 years. The most notable of these is the mountain pine beetle that infested and killed over 18 million hectares of pine forests throughout BC, Alberta and now, into the boreal forest. Given a susceptible landscape, insect or pathogen outbreaks are often incited by events that either decrease tree defenses or positively influence insect population growth or infection suitability for pathogens. Prolonged climate trends and periodic extreme weather events can have both direct and indirect effects on insect population success at multiple points throughout the course of an outbreak. Insects are highly sensitive to changes in weather that influence reproduction, host selection, dispersal and attack success, synchrony with host, growth rates, and mortality. The 1990's witnessed massive outbreaks of bark beetles and other forest insects across western North America, not only mountain pine beetle. Each successive outbreak event is pushing the extremities of historic ranges; covering larger areas; and, displaying more aggressive outbreak dynamics. For example, the area killed by the spruce beetle in Alaska between 1920 and 1990 was about 800,000 hectares compared to over 1.2 million hectares in the 1990's alone. In three outbreaks between 1962 and 1982, spruce beetle killed an estimated 18 million m^3 of spruce in Northeastern BC. The recent outbreaks of western spruce budworm and Douglas-fir tussock moth were the most expansive on record moving beyond known historic ranges. This presentation highlighted recent outbreak events, looked at the unique dynamics of forests and forest insects and provided insight into which insects will impact our forests in the future, and how.

Mountain pine beetle infestation in Boundary TSA

Forest health and Timber Supply Review: how do pests "move the needle"?

Stefan Zeglen, Forest Pathologist, South and West Coast Regions
Jim Brown, Senior Timber Supply Analyst, Forest Analysis and Inventory Branch

Venue:
Coastal Silviculture Committee Winter Workshop, Nanaimo, BC, February 27, 2014

Abstract:
On the coast, given the number of competing values constraining timber supply, losses from insects and diseases are believed to occur at levels that do not constitute a significant impact on projected timber supply. In other words, with a few notable exceptions and unlike the Interior of the province, pest damage here does not occur at incidence or severity levels that are sufficient enough to alter tree growth projections and markedly "move the needle" on the final AAC determination. Why does this assumption exist and is it accurate? We examined the three typical pathways that pest damage gets accounted for in timber supply reviews – as non-recoverable loss estimates, operational adjustment factors (OAF) and landscape-level or catastrophic loss estimates. Each pathway is derived differently and influences timber supply in its own unique fashion. We provided examples of how each method has been incorporated into the TSR process and how pest impact may be better accounted for in the future.

Forest health legislation in BC in 2014

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 17, 2014.

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 health training workshop-
the benefits of stumping for root disease control

Harry Kope, Forest Pathologist, Resource Practices Branch

Venue:
Skimikin Field Tour

Abstract:
Mechanical stump/inoculum removal is a practice that the Ministry insists licensees and contractors carry out when and where root disease has been identified. Recently however, there have been some instances where inoculum removal has not been done, or not done correctly and this has been a cause for alarm among district and regional forestry staff. The visit to the Skimikin stumping trial, as well as a tour of a recently stumped site were organized to address the issue of partial or incomplete stump removal.

Mike Cruickshank, Rona Sturrock and Elisa Becker of Natural Resources Canada (Pacific Forestry Centre), expertly guided a field tour through the Skimikin stumping trial on July 9th 2014. Licensees, contractors, and district, regional and branch forest ministry staff (20+ people) heard of the biological, ecological and economic benefits of stump and root removal for root disease control. The message that mechanical inoculum reduction, when done properly, is an effective and economical method for reducing potential losses incurred by root diseases. This message was reinforced through their presentations.

On July 10th Mike Cruickshank, and district, regional and branch forestry staff visited an opening where inoculum removal has not been done correctly. The message that inoculum removal must be done and done correctly to receive the immediate and long-term benefits made an impression on all in attendance, and now ministry staff in the south have a strong basis on which to instruct licensees and contractors that proper mechanical inoculum removal must be done.

The cooperation between forest pathologists at Pacific Forestry Centre and forestry staff of the province of British Columbia is a very good example of research converted to operating standards for root disease control.

IDF = Insects, Disease, Frustration - Insects and the IDF

Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region

Venue:
Forest health review committee meeting, Victoria, BC, February 19th, 2014.

Abstract:
Past harvest (1950-60s') is evident in most interior Douglas-fir stands and again, now that the harvest focus is moving away from pine salvage, these dry fir forests are the target of harvesting. There is no clear or single management regime for these forests but they are very complex and valuable on many levels. Many stands contain high densities in the understory and intermediate

size class largely as a result of past harvesting practices and little intermediate management (spacing, thinning). Western spruce budworm has adapted to these multi-layered, dense, and often drought stressed stands and as a result over the past 25 years we have seen the largest recorded outbreaks of budworm. Defoliation events cause radial growth suppression, top-kill and death of affected trees. Volume from these stands is below expectation and will continue to decline if more aggressive management is not implemented, and clearcut harvesting should not be the method of choice in the majority of these stands.

This presentation highlights results from numerous long-term studies on WSB, its impacts and outbreak dynamics. Dendrochonology data reveals at least one outbreak cycle in all of the 46 study sites, with 11 outbreaks that simultaneously affected multiple sites. Many reconstructed outbreaks were synchronous among sites and widespread. During the 20th century, outbreaks were detected at various sites in the 1930's, 1950's, 1980's or 1990's and 2000's (corresponding well to AOS data).

Refresh periods of past outbreaks are about 28 years long, with suppression events in tree rings lasting up to 20 years. The actual defoliation events are much shorter in duration and may peak numerous times over this 3 decade outbreak period, but the suppression in trees is continuous and lasts longer than the actual defoliation event. Select stands have been sprayed with *B.t.k.* over this recent outbreak episode (1985-2014) and have greatly reduced budworm populations and facilitated faster tree and stand recovery.

Lodgepole pine tour

Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region

Venue:
South Okanagan Field Tour

Abstract:
A tour of young and intermediate age pine in the south Okanagan was conducted to examine density and forest health issues. Participants included MFLNRO specialists, Weyerhaeuser Canada (Okanagan Falls) and consultants.

Stops included:
- thinning done in the late 1980's in suppressed, high density regenerated lodgepole pine. The remaining strips and control areas did not show drastic differences in total volume after ±30 years but there was some difference in individual tree volume with the edge trees along strips having larger diameters.
- Spacing trials installed in the early 1990'2 (Maclauchlan)
- Dense Douglas-fir, larch and pine regeneration in old wildfire and options to reduce density (herbicide strips)
- Permanent sample plots

Herbicide spacing of larch and pine

Dense Douglas-fir regeneration after wildfire

Managing forest health risk and mitigating stand losses, when the insect isn't there!

Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region

Venue:
SISCO (Southern Interior Silviculture Committee), Thompson Rivers University, Kamloops, BC, February 25th, 2014.

Abstract:
Results of the provincial aerial overview survey in 2013 showed significant decreases for all the major bark beetles and many of the defoliating insects. This trend was also observed in southern BC with some exceptions. The Boundary area saw a substantial increase in mountain pine beetle populations. Most insects display signature outbreak patterns and periodicity, and although we are now in a relatively calm period we need to be vigilant in both detection and forest health planning. Three issues were summarized in this presentation: using predictive tools and impact analysis for integrating into planning processes when the insects are not there; final results on mountain pine beetle impact to young pine stands; and the rationale for mitigating damage by western spruce budworm in IDF forests.

In 2013, 24 permanent sample plots established in 2005-2006 were revisited to quantify mortality due to MPB and other secondary bark beetles, and to evaluate the decline of the stands. Only two of the twenty four permanent sample plots have not sustained any mountain pine beetle mortality since plot establishment. Of the remaining twenty two plots, twelve plots are considered 'not satisfactorily restocked' based on levels of mortality from forest health factors. Another seven plots would be NSR based on the presence of non-lethal (currently) stem rusts. Out of twenty two mountain pine beetle-impacted plots, only three would be considered sufficiently stocked to meet mid-term rotation expectations, without intervention, provided the remaining trees were well spaced. There has been little new mountain pine beetle mortality since 2008 however, other forest health factors coupled with high mortality due to the beetles, have created significant gaps in satisfactorily restocked young stands over the long term.

Recognizing bark beetles: the signs & symptoms of attack

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

Venue:
SITCA 2014, Salmon Arm, BC, May 15th, 2014.

Abstract:
There are many tree killing bark beetles in BC but four in particular stand out because of their outbreak dynamics and impacts on BC forests. This talk focused on *Dendroctonus ponderosae, Dendroctonus rufipennis, Dendroctonus pseudotsugae* and *Dryocoetes confusus.* For each bark beetle I described five aspects of their biology, host recognition and attack dynamics and diagnostic signs and symptoms of attack:

1. Host tree and Life Cycle
2. Tree and stand symptoms
3. Gallery identification
4. Associated insects
5. Key diagnostics

Septoria musiva on poplar in the Fraser Valley of British Columbia

Harry Kope, *Forest Pathologist, Resource Practices Branch*
Stefan Zeglen, *Forest Pathologist, South and West Coast Regions*

Venue:
International Poplar Symposium VI – Vancouver, BC, July 21 – 23, 2014.

Abstract:
Septoria musiva Peck (*Mycosphaerella populorum* G. E. Thomps.) on *Populus* species causes leaf blight but more importantly, necrotic lesions that often result in stem breakage. *S. musiva* is indigenous to North America and is found throughout much of eastern and central Canada and the United States. Since 2007 *S. musiva* has been repeatedly detected in leaf spots and cankers on hybrid *Populus* in the Fraser River of British Columbia (B.C.). How *S. musiva* was introduced into BC has not been determined, though movement of infested plant material is suspected. Some hybrid poplar clones are known to be highly susceptible, and in the Fraser Valley of 21 hybrid plantations assessed, 16 (76%) were infested (187 trees sampled, 105 infested; ~56% incidence). Inoculum spread from plantations could infect native black cottonwood (*Populus trichocarpa* Torr. & A. Gray), and this has occurred. Since 2008 *S. musiva* has been repeatedly isolated from leaf spots and cankers of *P. trichocarpa* in riparian areas along the Fraser River; although cumulative incidence was very low (1.2% from over 1000 trees sampled). A survey of a provenance trial, in close proximity to an infested hybrid plantation, containing 183 families of *P. trichocarpa* from western North America, found that 44 families tested positive for *S. musiva*. These results indicate that *S. musiva* under favourable conditions can infect multiple families of *P. trichocarpa*. The impact that *S. musiva* could have on *P. trichocarpa* growth and ecology is currently unknown.

Spruce beetle ground survey training course

Robert Hodgkinson, Forest Entomologist, Omineca & Northeast Regions.

Venues:
Mackenzie Recreation Centre, Prince George's Aleza Rm., and a field site west of Mackenzie on Sept. 16-17 and Oct. 8-9, 2014.

Abstract:
The following topics were covered:

- Beetle biology, life cycle, and signs/symptoms of attack
- Causes of outbreaks and duration
- Stand susceptibility and risk rating
- Aerial and ground detection methods
- Walkthroughs and probes and data summarization
- Control tactics

The main course objectives were to have attendees: 1) accurately identify spruce beetle, 2) properly classify attacked trees, 3) record data on the *Spruce Beetle Probe Card* (FS 1111) and *Compass and Traverse Sheet* (FS 375), and 4) transpose data to the *Spruce Beetle Summary Sheet.*

Using western white pine to mitigate risk of stand losses in drier coastal subzones

Stefan Zeglen, Forest Pathologist, South and West Coast Regions

Venue:
Coastal Silviculture Committee Summer Workshop, Powell River, BC, June 11-12, 2014

Abstract:
In drier coastal forests, the risk of timber loss to root diseases, defoliation and, more recently, periodic drought can imperil projected stand yields, especially if too much reliance is placed on one species. High stand productivity can mask some of this loss but poor regeneration choices can increase stand vulnerability to any one of these or a new damaging agent. Mixed species plantings, while also potentially sacrificing potential volume, at least offer the trade of lowering risk to catastrophic failure of a single species. Historically, western white pine (*Pinus monticola*) was a stand component alongside the more predominant Douglas-fir in drier coastal subzones. Returning white pine, through the use of genetically resistant stock now available, to its historic role can help mitigate the risk of lowered stand volume due to mortality of Douglas-fir. White pine can be used in areas where western redcedar is not suitable and it is susceptible to a different range of pests than Douglas-fir. The stand we visited hosts a white pine resistance trial started by John King (BCFS, retired) that tests the survival of major gene resistant (MGR) white pine under coastal field conditions. Trial design and preliminary results were presented and tactics for deploying white pine were discussed.

Western spruce budworm and Douglas-fir bark beetle disturbances in the IDF

Jodi Axelson, Forest Entomologist, Cariboo Region

Venue:
2014 SISCO Fall Field Tour, Dealing with Complexity – Managing for Diversity, Gavin Lake BC, Spetember 9 – 11, 2014

Abstract:
In the Cariboo Region insects and diseases are significant vectors impacting forest health. Forest health issues, including abiotic vectors such as snowpress, fire and flooding are highly integrated across the landscape and generate uncertainty in terms of timber supply, biodiversity, resilience and the impacts of ongoing climate change. In the Cariboo Region 15% of forested land-base is dominated by Douglas-fir and 45% of the area is classified as part of the Interior Douglas-fir (IDF) biogeoclimatic zone. Douglas-fir is an example of a tree species that relies on habitat conditions associated with mature forests for successful regeneration, although mature forests are under increasing and sustained pressure due to insect outbreaks. Currently, the two most damaging insects in the region are the western spruce budworm and the Douglas-fir bark beetle. The western spruce budworm has been at outbreak levels across the region for nearly two decades, and Douglas-fir bark beetle populations have been on the rise since the 2009/10 high wildfire years. This talk focussed on the impacts of western spruce budworm and Douglas-fir beetle outbreaks and the resultant uncertainty this can generate for forest managers. We discussed tools and strategies to manage the risk and uncertainty these insects pose to forest management objectives. Figure 21 is an example of a figure from SISCO talk hand-out.

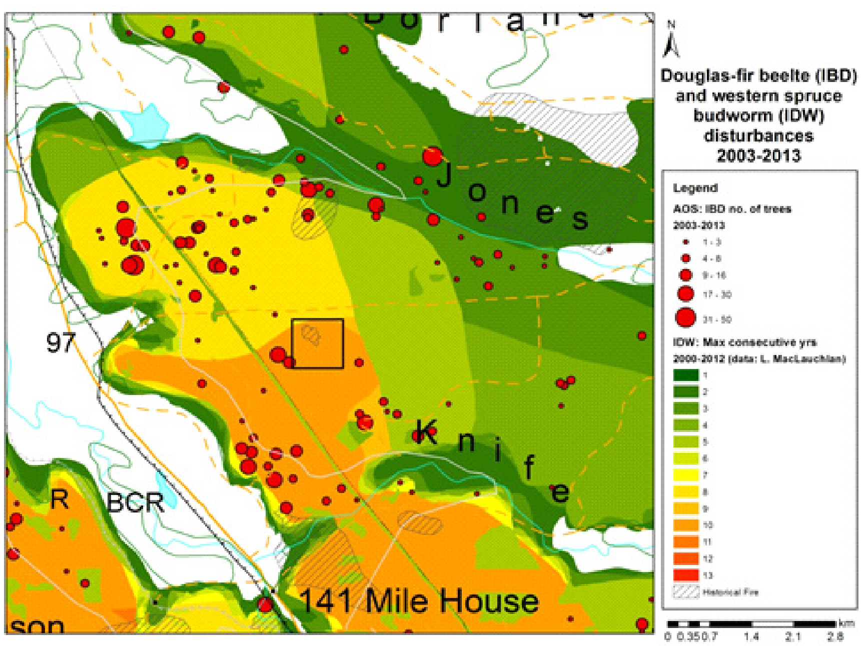


Figure 21. A portion of the Knife Creek UBC Research Forest (box shows approximate location of Station 11 on Day 2 agenda). Cumulative Douglas-fir bark (IBD) beetle impact (number of trees only) is shown from 2003 to 2013 (red circles). Cumulative western spruce budworm (IDW) shown as maximum consecutive years of defoliation from 2000 to 2012 (data: Lorraine Maclauchlan). Within the WLTSA 39% of western spruce defoliation occurs in the IDFdk3 and 47% in the IDFxm.

Western spruce budworm in British Columbia; using its historic footprint to plot future management

Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region

Venue:
SERG International, Pittsburgh, Pennsylvania, February 1st, 2014.

Abstract:
Douglas-fir dominated ecosystems in BC have changed in the past century as a result of harvest, fire suppression, lack of management and changing climate regimes. Western spruce budworm (WSB) periodically reaches outbreak proportions in these dry interior fir forests and can cause considerable impact. The outbreak dynamics, periodicity and management for WSB is different than for eastern spruce budworm and therefore more in depth understanding of these dynamics were necessary. This talk presented results from an entochronological study highlighted historic outbreak periodicity, duration and length of intervening "refresh" periods. The tree ring records were then compared to the past 100 years of defoliation.

Using these records and topographic and biogeoclimatic information, twelve distinct outbreak regions have been identified in southern BC with two outbreak regions in coastal BC. Both tree ring data and defoliation data show unique and outbreak region specific patterns which assists in applying better and more timely treatments. The presentation covered:

1. Background - budworm and forest management
2. Building a susceptibility system
   - outbreak (defoliation) history
   - historic outbreak events using dendrochronology (entochronology)
   - defining unique outbreak areas
   - management strategies
3. Integration - future management of interior BC fir forests and budworm

Forest Health Publications

Alfaro, R.I., Hawkes, B., **Axelson, J.** (2014) Using dendrochronology to characterize forest disturbance by mountain pine beetle. In: Di Filippo, A., Piovesan, G., Romagnoli, M., Helle, G., Gärtner, H. (2014), TRACE - Tree Rings in Archaeology, Climatology and Ecology, Volume 12 (pp.90-95). *Scientific Technical Report 14/05, GFZ German Research Centre for Geosciences*.

Alfaro, R.I., Berg, J., and **Axelson, J.** (2014). Periodicity of western spruce budworm in Southern British Columbia, Canada. *Forest Ecology and Management*, *315*, 72-79.

Axelson, J.N., Smith, D.J., Daniels, L.D. and Alfaro, R.I. 2014. Multicentury reconstruction of western spruce budworm outbreaks in central British Columbia, Canada. *Forest Ecology and Management* 335: 235-248.

Axelson, J.N., Bast, A., Alfaro, R., Smith, D.J., and Gärtner, H. (2014). Variation in wood anatomical structure of Douglas-fir defoliated by the western spruce budworm: a case study in the coastal-transitional zone of British Columbia, Canada. *Trees*, *28*(6), 1837-1846.

McKee, F.R., Dezene P.W., Huber, B., Staffan L., **Hodgkinson, R.S.** and Aukema, B.H**.** 2014. Effect of natal and colonised host species on female host acceptance and male joining behaviour of the mountain pine beetle (Coleoptera: Curculionidae) using pine and spruce. *Can. Ent*. available on *CJO2014.doi:10.4039/tce.2014.22.*

Murray, M.P. 2014. A Canadian-based blister rust inoculation trial for whitebark pine. In: Chadwick, K. Comp. *Proceedings of the 61st Annual Western International Forest Disease Work Conference*; 2013 October 6-11; Waterton Lakes National Park, Alberta. 35-38.

Welsh, C., Lewis, K.J. and **Woods, A.J.** 2014. Regional outbreak dynamics of *Dothistroma* needle blight linked to weather patterns in British Columbia, *Canada. Can. J. For*. Res. 44: 212-219.

Woods, A.J. 2014. BC's managed forests and those bothersome externalities: Climate change and forest pathogens. *BC Forest Professional*, November-December 2014: 19 (Viewpoints).

Woods, A.J. 2014. Warmer and wetter might not be better – Short review. *Journal of Forest Science*, 60(11): 484-486.

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