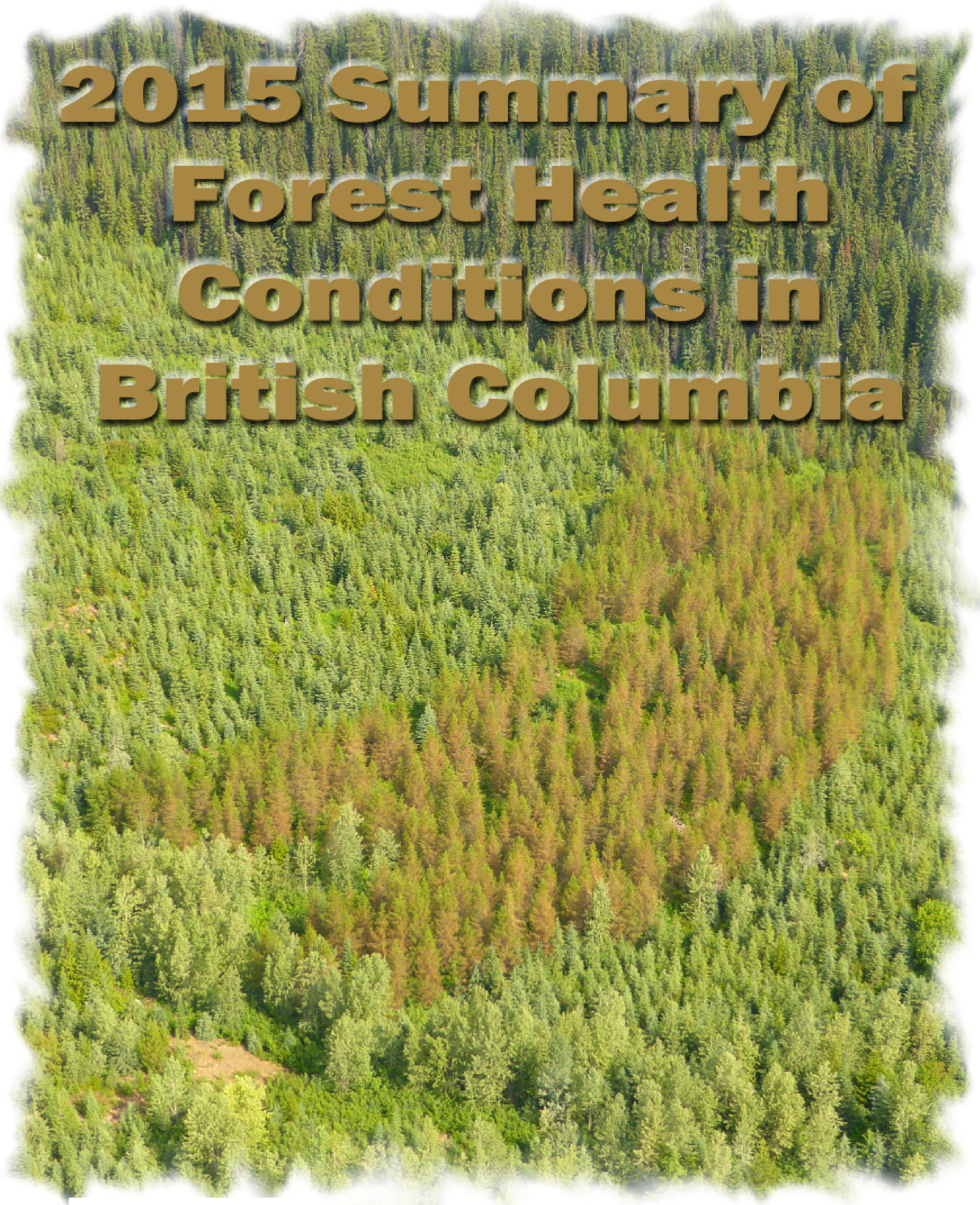
2015 Summary of Forest Health Conditions in British Columbia



BRITISH COLUMBIA

Ministry of Forests, Lands and Natural Resource Operations

Resource Practices Branch

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

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

Annual.
Vols. for 2015- issued in Pest management report series.
Also issued on the Internet.
ISSN 1715-0167 = Summary of forest health conditions in British Columbia.

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

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

Front cover photo by Kevin Buxton: Larch needle blight near Birk Creek, Kamloops TSA

2015 Summary of Forest Health Conditions in British Columbia

Joan Westfall[1] and Tim Ebata[2]

Contact Information

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

2 Forest Health Officer, Ministry of Forests, Lands and Natural Resource Operations, PO Box 9513 Stn Prov Govt, Victoria, BC, V8W 9C2. Email: Tim.Ebata@gov.bc.ca

Table of Contents

Summary

The *2015 Summary of Forest Health Conditions in British Columbia* (BC) is a compilation of forest health information collected from the 2015 provincial aerial overview surveys (AOS) and other BC Ministry of Forests, Lands and Natural Resource Operations (FLNRO) sources. The AOS data is the primary source for reporting damaging agents, but this material is augmented by some detailed helicopter surveys, insect population assessments, forest health surveys and ground observations by trained personnel. Summaries of special projects, meetings, presentations and publications conducted by FLNRO entomologists, pathologists and their associates in 2015 are also included in the final sections.

An estimated 89% of the province was flown during the AOS this year, resulting in 5.1 million hectares (ha) of damage being mapped. These disturbances were caused by a wide variety of forest health factors affecting many different host tree species on forested lands in BC. Of damage visible during the surveys, bark beetle mortality continued to affect the most hectares provincially. Western balsam bark beetle infestations led this category with 2.3 million hectares of damage, though intensity of attack continued to be low (98% trace to light). The mountain pine beetle outbreak continued to wane for the sixth consecutive year to 326,477 ha. Spruce beetle damage declined after a sharp increase in 2014 to 194,050 ha. This reduction was however mainly an artefact of large, lightly infested disturbances delineated in central BC last year being replaced with smaller, more accurately drawn areas of damage with higher intensities. For the third consecutive year Douglas-fir beetle attack increased to 47,628 ha, primarily in the Cariboo Region.

Damage by defoliators was a third of last year with 1.6 million hectares affected provincially. Pests of deciduous trees (in particular trembling aspen) continued to dominate. However, the greatest decrease occurred in aspen leaf miner infestations, which dropped to 942,085 ha. The forest tent caterpillar outbreak peaked at 711,297 ha last year with a decline to 609,999 ha mapped in 2015, primarily in the Prince George TSA (Omineca Region). Bruce spanworm affected 22,452 ha in Dawson Creek TSA (Northeast Region).

Defoliation of conifers generally declined this year. Two-year-cycle budworm damage dropped to 46,420 ha though intensity of damage increased substantially, with most of the damage reported in areas of the Skeena and Omineca Regions where defoliation has not been observed since 2011. Western spruce budworm defoliation dropped for the fourth consecutive year to 9,135 ha with damage mainly mapped in the Cariboo Region. Part of this reduction can be attributed to treatment of 15,867 ha of high value stands with the biological insecticide *Bacillus thuringiensis* var. *kurstaki* (*Btk*). Conversely, pine needle sheathminer damage more than tripled to 5,508 ha with most of the infestations delineated in the Cariboo Region.

A 4,780 ha aerial spray program to eradicate a significant gypsy moth population was conducted in spring 2015 in South Delta and Surrey. Trap catches in the summer indicated the treatment was successful. CFIA/FLNRO trapping caught 31 moths in south coastal BC. All moths were North American strain of European gypsy moth except for a single Asian gypsy moth caught in Vancouver.

Abiotic agents caused similar levels of damage to last year with 547,951 ha mapped in 2015. The most damaging agent continued to be wildfire with 265,788 ha burnt, the bulk of which occurred in Fort Nelson TSA of the Northeast Region. Post wildfire damage, primarily in forests where fires burnt last year, accounted for 147,638 ha. With the warm dry summer conditions experienced in most of BC in recent years, drought damage tripled to 72,053 ha mapped across the province. Drought damage was most prevalent in deciduous stands in the Northeast Region. Yellow-cedar decline along the coastline continued to affect 37,540 ha.

Damage attributed to diseases decreased overall, probably also due to dry summers that resulted in fewer disease infections. A total of 25,144 ha of disease disturbances were recorded, with Venturia blight causing 13,636 ha of the damage, primarily in Skeena Region. Larch needle blight affected 4,768 ha, mainly in Kootenay/Boundary Region. Dothistroma needle blight disturbances almost tripled since last year to 4,441 ha, with most of the damage occurring in young stands in Prince George TSA of the Omineca Region.

Other damaging agents including bears, flooding, windthrow, slides, root diseases, rusts and birch leaf miner caused small, scattered disturbances throughout the province in 2015.

2015 Summary of Forest Health Conditions in British Columbia

Introduction

Ecosystems in British Columbia (BC) are very diverse, with a wide variety of tree species. Additionally, forest stand management practices and natural disturbances have created a mosaic of tree ages, stand structures and stand compositions across the province. These forests are damaged by a wide range of agents including insects, diseases, animals and abiotic factors. Disturbances caused by these factors can vary substantially in location, intensity and size over a relatively short period of time. Therefore, annual aerial overview surveys (AOS) are conducted to record current damage in a timely, cost effective way. Visible damage observed for all commercial tree species across the forested landscape of BC is noted by agent, severity, extent and host.

The provincial government has been responsible for the AOS for the past nineteen years, currently under the BC Ministry of Forests, Lands and Natural Resource Operations (FLNRO). The collected data is summarized by Timber Supply Area (TSA), as these administrative units are relatively stable (Figure 1). The exceptions are the Pacific and Cascadia TSAs which consist of small fragmented units within several larger TSAs, and which are consequently reported within the larger TSAs.

Upon completion of the surveys the data is digitized, reviewed and collated. For this report, damaging agent results are organized by host tree species. Area and intensity of damage is derived only from the AOS data. Supplemental information regarding damage that is not visible at the height the overview survey is flown (particularly damage caused by diseases) and specific insect population information (from pheromone-baited traps, egg surveys and tree beatings) may also be included in this report. However, this information is not included in the AOS database since data collection by other methods such as helicopter and ground assessments differ.

The AOS data is used by many interest groups including government agencies, industry, academia and the public for a wide range of purposes. These include input into government strategic objectives, guidance for management and control efforts related to forest health, usage for research projects, providing national indicators for sustainable forest management, input for timber supply analyses and contributions to the National Forest Pest Strategy *Pest Strategy Information System* (www.ccfm.org/pdf/PestStrat_infosys_2012_en.pdf).

Relevant forest health activities conducted by FLNRO pathologists, entomologists and their associates over the past year are presented after the damaging agent reporting section. This includes projects, presentations, workshops and publications that the aforementioned participants were involved in, but does not necessarily capture all forest health activities conducted by the provincial staff or other agencies in the province. A more detailed annual report of forest health in the Southern Interior of BC and previous copies of this publication are also available at: http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/aerial-overview-surveys/summary-reports.

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

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

Methods

Aerial observer recording forest health damage

Aerial overview surveys are conducted in a small (minimum 4 seat) fixed wing aircraft. Two trained observers sit on opposite sides of the plane and map the forest health damage they see. An additional trainee may map from the seat behind the most experienced surveyor. To become a second seat surveyor an initial training course followed by a minimum of 15 hours of trainee mapping in varied forest types is required. To be considered an experienced primary surveyor one season of flying second seat (minimum 50 hours) is required. A minimum of two observers and a pilot survey each FLNRO region.

Visible current forest damage is sketched on customized 1:100,000 scale maps (Landsat 5 satellite images in colour with additional digital features such as contours, site names, water features and roads). On flight completion, the individual working maps are collated onto mylars which are then digitized to obtain the spatial data. Survey methodology and digitizing standards are available at http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/aerial-overview-surveys/methods.

Surveys are conducted when damage from the primary forest health factors of concern for a given area are most visible, flight conditions permitting. Operations in 2015 began July 1st and were completed October 14th (Table 1). Weather was generally the opposite of 2014: the spring was unusually hot and dry across the province but by around the third week of July rain events began to occur and temperatures moderated. Rain and fog were a particular problem throughout the survey period in the northwest. The northeast had problems with visibility due to large fires at the beginning of the survey period and rain/fog later on. Although the survey period in the northeast began earlier than in other

Regions	**Flight hours**	**Survey Dates**
Cariboo	143.6	July 20th – Aug 14th
Thompson/Okanagan	41.6	July 14th – July 19th
Kootenay/Boundary	118.6	July 18th – Sep 29th
Omineca & Northeast	216.4	July 1st – Oct 14th
Skeena	98.6	July 22nd – Oct 4th
West & South Coast	100.7	July 20th – Oct 4th
Total	**719.5**	**July 1st – Oct 14th**

Table 1. Flying hours and survey dates by region for the 2015 provincial aerial overview survey.

areas it was the last area to be completed. Despite best efforts, not all areas could be covered in the north within the survey timeframe this year. Though there were a few rain and wildfire smoke issues, all areas in the southern half of the province were surveyed. Flight time to complete the surveys was 719.5 hours, conducted by 29 surveyors and 11 aircraft companies.

Flight lines were recorded with recreational quality Global Positioning Satellite (GPS) receiver units. This data was collated and disseminated weekly to involved parties so coverage intensity and survey progress could be monitored. 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 and the intensity of coverage depended on visibility up side drainages from main drainages to the tree line. Aircraft speed ranged from 130 to 180 kph depending on mapping intensity and wind speed. All commercial tree species on the flight lines were surveyed for visible current damage, regardless of land ownership or tenure.

The annual goal is to survey all forested land across the province, weather and funding permitting. This goal is difficult to obtain within the survey window, which is dependent on the timing for damage visibility (e.g. damaged needles may drop off or snow may cover damage). Therefore, high priority areas are targeted first, followed by major drainages in lower priority areas. All priority areas were adequately covered this year, with the exception of the northeastern portion of the Mackenzie TSA (Figure 2). In total 86% of the province was flown, which was a little lower than the previous few years but reasonable, considering the weather challenges in the north. 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 or x's and referred to as "spots" with an estimated number of dead trees. 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, to capture the area affected. Larger areas of mortality were drawn as polygons with five mortality intensity classes (Table 2).

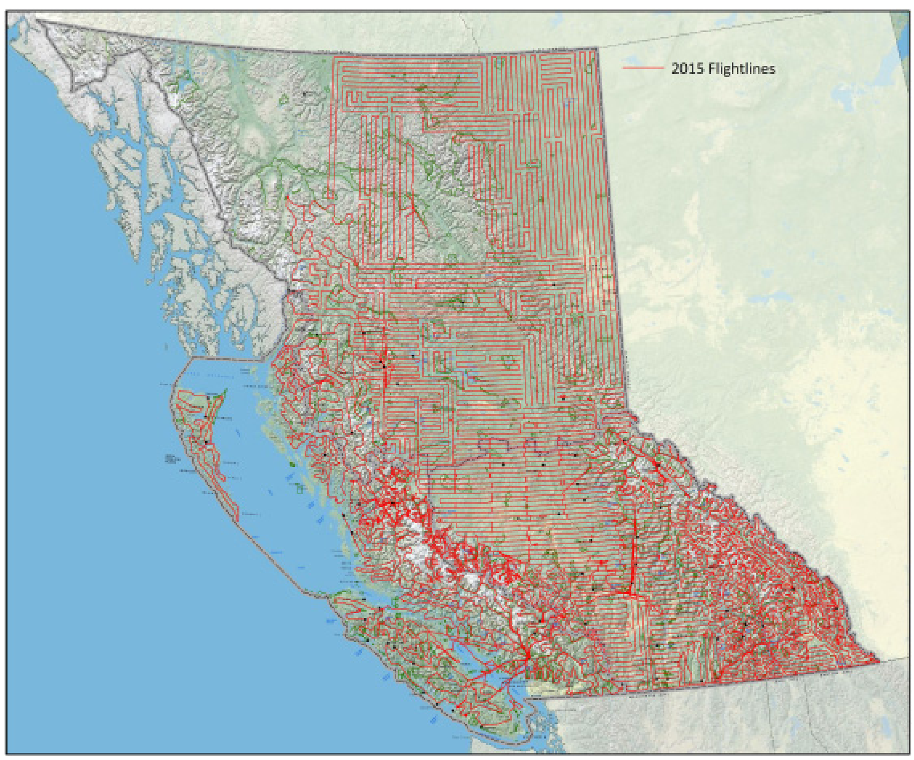


Figure 2. Flight paths flown while conducting the 2015 aerial overview surveys. Approximately 86% of the province was surveyed this year.

Trees with foliar damage (caused by insect feeding, foliage diseases and some abiotic factors) usually cover fairly large areas, often (but not always) with all age classes of host trees affected. Therefore, only polygons were mapped for this type of damage; 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).

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, a third of many trees severely damaged.
	Severe	Most trees sustaining more than 50% total foliage damage.
	Grey	Cumulative foliage damage resulting in mortality, recorded at end of damage agent cycle.

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

Some exceptions were made to the "polygon only" rule for foliar damage. Venturia blight damage sometimes affects only a small clump of trees (most likely a single clone) within a stand of undamaged suitable hosts, and was therefore recorded as spot damage in this case. Occasionally needle diseases (particularly in Kootenay/Boundary Region) severely affected host trees which were a very low component of the stand composition. This damage was sometimes recorded as spot damage.

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. In many areas 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, although the defoliator ranges of light, moderate and severe were used.

There are known limitations with the AOS data. Not all damage is visible, either due to the flight altitude or the timing of the surveys. For example, spruce beetle mortality can be under-reported because foliage changes on dying trees can happen very rapidly or occur outside the survey period. Also, many diseases cause significant growth loss and tree defects that are not detectable by the AOS, such as mistletoe infections and gall rust.

Care must also be taken when interpreting 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. In addition, 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. Spatial accuracy of the data, unless the damage is closely associated with clearly visible geographic references, can be low and thus unreliable for directing operational surveys and treatments.


Lodgepole pine dwarf mistletoe infections

Despite the survey limitations, FLNRO 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 draft information. The final provincial summaries of the spatial and tabular data were available by December 22nd, 2015.

General Conditions

Total forest damage observed across BC during the aerial overview surveys was less than half that recorded last year at 5,139,572 ha (Table 3). The decrease was primarily due to reductions in mountain pine beetle attack as well as deciduous defoliators and Venturia blight.

Bark beetles continued to cause the most damage. Western balsam bark beetle mortality decreased by almost a quarter to 2,349,470 ha, primarily due to areas not flown, though intensity remained similar to last year which was higher than average. Mountain pine beetle attack declined for the sixth consecutive year to 326,477 ha, though severity increased slightly. Area affected by spruce beetle rose sharply last year to 288,892 ha but declined to 194,050 ha this year. Intensity of mortality increased however as large, lightly infested polygons drawn in central BC last year were transitioned to smaller, higher mortality disturbances. The majority of the damage continued to occur in Omineca Region. Douglas-fir beetle attack increased for the second consecutive year to 47,628 ha; most of the attack continued to occur in Cariboo Region.


Western balsam bark beetle mortality in Omineca Region

Defoliator damage significantly declined in 2015 to 1,644,051 ha across the province. A large percentage of the decrease was

Damaging Agent	Hectares Affected	Damaging Agent	Hectares Affected
Bark Beetles:		*Diseases:*	
Western balsam bark beetle	2,349,	Venturia blight	13,636
Mountain pine beetle	326,47	Larch needle blight	4,768
Spruce beetle	194,05	Dothistroma needle blight	4,441
Douglas-fir beetle	47,628	Root diseases***	1,100
Secondary beetles	758	Comandra blister rust	425
Total Bark Beetles:	2,918,	White pine blister rust	417
Defoliators:		Cottonwood leaf rust	338
Aspen leaf miner	942,08	Delphinella needle cast	21
Forest tent caterpillar	609,99	*Total Diseases:*	25,144
Two-year-cycle budworm	46,420	*Abiotics:*	
Bruce spanworm	22,452	Fire	265,788
Western spruce budworm	9,135	Post fire	147,638
Pine needle sheathminer	5,531	Drought	72,053
Birch leaf miner	1,742	Yellow-cedar decline	37,541
Green spruce aphid	578	Flooding	13,158
Defoliators*	346	Windthrow	5,909
Western blackheaded budworm**	301	Slides	5,620
Balsam woolly adelgid	294	Aspen decline	174
Satin moth	131	Unknown	71
Larch casebearer	32	*Total Abiotics:*	547,951
Total Defoliators:	1,644,		
Animals:			
Bear	3,680		
Hare	364		
Total Animals:	4,044		
Provincial Total Damage:			**5,139,572**

* 17 ha are cumulative mortality.
** Unknown refers to damage that could not be confirmed with ground checks.
*** Root disease damage is greatly underestimated from aerial overview surveys.

Table 3. Summary of hectares affected by forest damaging agents as detected in 2015 aerial overview surveys in British Columbia.

attributed to aspen leaf miner damage which decreased 74% from last year to 942,107 ha. Ground observations concur that generally this insect is on the decline across the province. The bulk of the infestations were mapped in Prince George TSA (Omineca Region) and Lakes/Morice TSAs (Skeena Region). The current outbreak of forest tent caterpillar peaked at 711,297 ha last year with a decrease to 609,999 ha in 2015. Attack continued to be most prevalent in Prince George TSA (Omineca Region). The only other deciduous defoliator of note was Bruce spanworm with 22,452 ha of damage in Dawson Creek TSA (Northeast Region), which is the first time this insect has been noted during the aerial overview survey since 2011. Large aspen tortrix infestations covered 937,962 ha primarily in the Northeast Region last year, but in 2015 no defoliation was recorded.

Conifer defoliators were generally down in 2015. Two-year-cycle budworm damage was a quarter of that recorded last year at 46,420 ha, though intensity of damage was substantially higher. Location of damage changed to mainly Skeena and Omineca Regions, where this budworm is in the second year of its two-year life cycle. Defoliation has not been seen in these regions since 2011. Western spruce budworm defoliation, primarily located in Cariboo Region, declined for the fourth consecutive year to 9,135 ha. Only pine needle sheathminer infestations increased, with more than triple the area since last year which equated to 5,508 ha, with the majority of the attack occurring in the Cariboo Region.

Total area damaged by abiotic factors remained similar to last year at 547,951 ha, of which wildfire continued to cause the most impact with 265,788 ha burnt, primarily in scattered large fires in Fort Nelson TSA (Northeast Region). Post wildfire damage followed closely with 147,638 ha affected, with most of the disturbances located in Lakes TSA (Skeena Region) and Prince George TSA (Omineca Region). Drought damage almost tripled since last year to 72,053 ha, most likely the result of two consecutive warm, dry summers over most of the province. Deciduous stands in Northeast Region showed the most drought damage, though all regions were affected to some degree. Yellow-cedar decline damage in the coastal areas of BC remained relatively static at 37,540 ha. Flooding, windthrow and slides respectively damaged 13,158 ha, 5,909 ha and 5,620 ha respectively in small dispersed disturbances across the province.

Disease damage is greatly underestimated during the AOS as some disease symptoms are often not visible from the flight altitude. Of the damage that can be mapped, disturbances decreased dramatically in 2015 to 25,144 ha, from 575,084 ha last year. It is likely that the recent dry summers resulted in fewer disease infections. Most of this decrease was due to Venturia blight damage reductions to 13,636 ha, well below the peak of 837,586 ha recorded in 2013. The majority of the damage occurred in Skeena Region, which experienced a wetter summer than most of the province. Larch needle blight damage remained relatively low for the third consecutive year with 4,768 ha mapped, primarily in Kootenay/Boundary Region. Dothistroma needle blight damage almost tripled since last year to 4,441 ha but this was still far less than the 27,255 ha recorded in 2008. Most of the damage occurred in young stands in Prince George TSA of Omineca Region.

Animal damage is also underestimated from the height the AOS is flown, with the exception of feeding that results in large dead tops or mortality. Black bear damage affected 3,680 ha in 2015, primarily in small, scattered younger lodgepole pine stands with the bulk of the disturbances delineated in the Cariboo and Kootenay/Boundary Regions.

Other damaging agents caused local 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.

Aircraft used to survey Skeena Region

Damaging Agents of Pines

Mountain pine beetle, *Dendroctonus ponderosae*

Provincial

The current mountain pine beetle outbreak peaked in BC in 2007 with a record 10 million hectares of recent damage. Infestations have generally been in decline for six consecutive years with a large drop in 2015 to 326,477 ha (Figure 3). However, observed mortality intensity increased slightly since last year however to 166,061 ha (51%) trace, 119,813 ha (37%) light, 31,944 ha (10%) moderate, 7,704 ha (2%) severe and 955 ha (<1%) very severe.

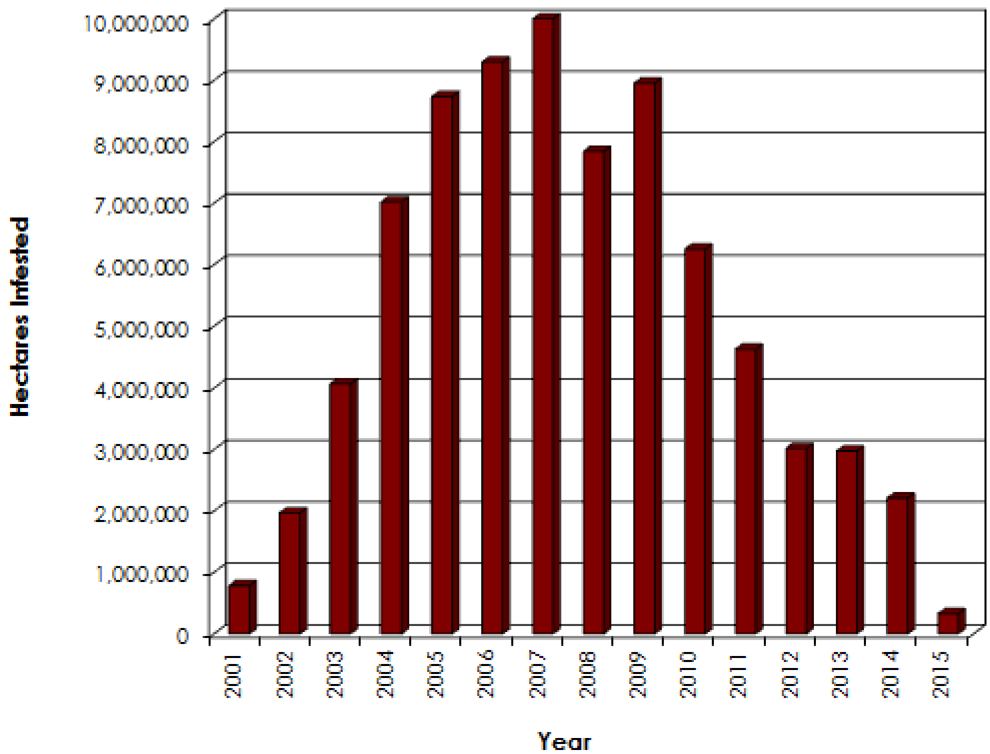


Figure 3. Infested area (hectares, combined severity classes) by mountain pine beetle from 2001 – 2015 in British Columbia.

A large percentage of the decline in affected area occurred in the northwest: large trace polygons (representing remnants of old infestations or in some areas population expansions) did not show current damage in 2015. The only widespread relatively active populations noted were in Fort St. John TSA, one southeast area in Dawson Creek TSA and some main drainages in Robson Valley TSA (Figure 4). Southern disturbances primarily continued to decline and were small and scattered, with the exception of a few areas in Lillooet TSA and some Beetle Management Units (BMUs) in the southern Kootenay/Boundary Region where some control measures are still being conducted.

Where the mountain pine beetle was still active early fading of current attack was noted, most likely accelerated by drought conditions. Very little of the current attack is in accessible areas so the biological activities of the beetle were not tracked this year.

Young lodgepole pine recently killed by mountain pine beetle peaked at 357,017 ha in 2008 but this unusual activity has steadily declined since then with only 50 ha noted in Fort St. John TSA this year. Young pine mortality most likely caused by secondary beetle increased slightly this year to 757 ha. Almost all this attack was observed at trace intensity in four disturbances south of Moose Lake in Prince George TSA, with the remaining 3 spot infestations mapped in Lakes TSA.

Most of the mountain pine beetle caused mortality continued to occur in lodgepole pine. The only other species noted as attacked this year was whitebark pine with 6,033 ha observed, up slightly

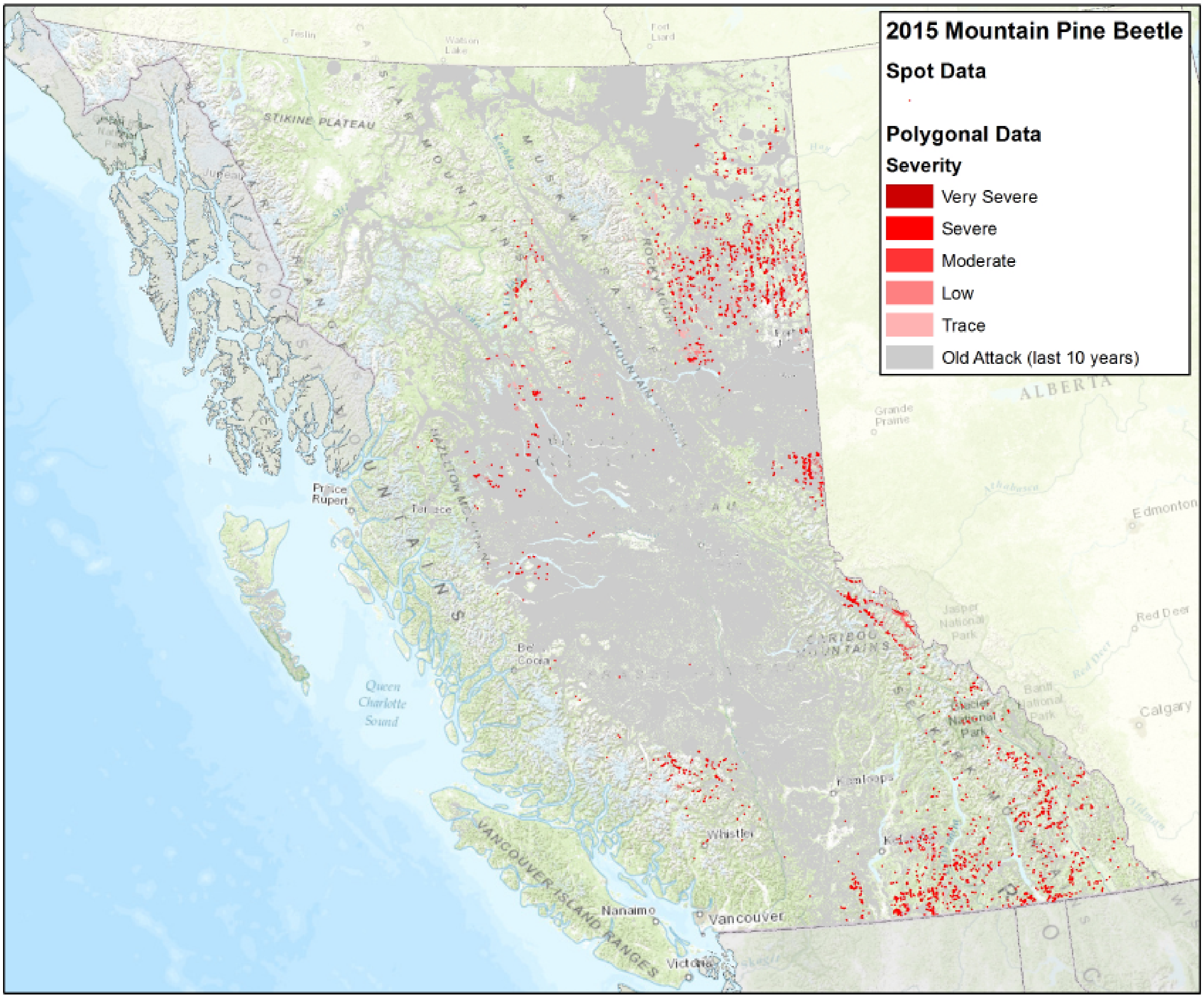


Figure 4. Current mountain pine beetle infestations recorded in British Columbia in 2015 with old attack in grey.

from last year. Stands with whitebark pine mortality were scattered throughout the interior of the province, but most affected were areas in Lillooet, Golden and Invermere TSAs.

Northern Interior Damage

Mountain pine beetle damage continued to be highest in the Northeast and Omineca Regions with 178,987 ha and 96,073 ha mapped, respectively. This represents 90% of the infestations noted provincially but most (90%) of this mortality was observed to be trace to light severity.

Attack in the Northeast Region continued to be most prevalent in Fort St. John TSA with 131,048 ha, though this is one-sixth the area affected last year (Figure 5). Damage continued to be scattered throughout the TSA but in much smaller disturbances. Infestations dropped eight fold since last year in Fort Nelson TSA with 29,740 ha mapped. In this TSA, disturbance sizes generally decreased but overall very little damage was mapped in the northern half of the TSA compared to last year. Infestations in Dawson Creek TSA decreased in size by three-quarters to 18,199 ha, primarily due to the absence of large light disturbances noted in the northwest as opposed to last year. However, the infestation observed last year along Redwillow River on the Alberta border continued to be very active.

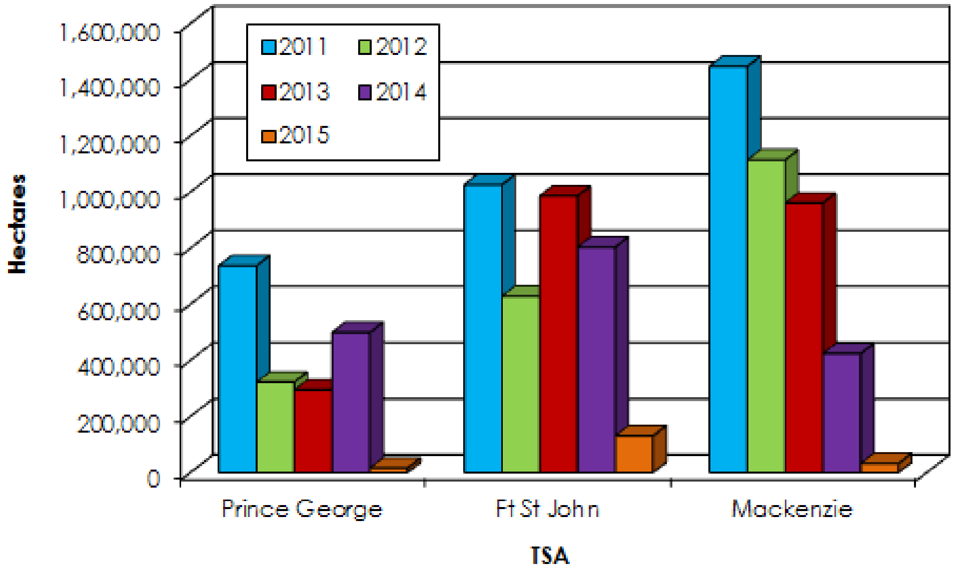


Figure 5. Infested area (ha) by mountain pine beetle from 2011 – 2015 in the Omineca and Northeast Regions (TSAs with more than 400,000 ha affected in 2014).

Mountain pine beetle damage in Omineca Region dropped five-fold since last year but infestations in Robson Valley TSA actually rose by 24% to 48,349 ha. It was noted by the regional entomologist that infestations in this TSA go from valley bottom to alpine primarily on west and south facing slopes, where temperatures are most conducive to beetle survival in this area. The largest disturbances were in the same general areas as 2014 from Moose Lake south to Hugh Allan Creek although intensity of mortality continued to increase, with this TSA containing 71% of the severe mortality in the province this year. In 2011 mountain pine beetle attack was noted to be the highest in Mackenzie TSA but it has since declined rapidly every year to only 31,959 ha in 2015 (Figure 5) with most of the remaining mortality (low intensity) situated in the western third of the TSA. A total of 15,765 ha of attack were recorded in Prince George TSA this year which was only 3% of the 2014 area affected. Most of the remaining disturbances were located in the northern third of Fort St. James District from Sustut River to Frypan Peak.

Mountain pine beetle mortality Robson Valley TSA adjacent to the alpine

Attack in Skeena Region continued to steeply decline, with 10,574 ha mapped in 2015, down from 224,696 ha last year. Damage was down in all TSAs primarily because large trace polygons identified last year were not observed this year. Bulkley TSA contained 8,409 ha of mountain pine beetle attack with concentrations around Hudson Bay Mtn., and Trout, Reiseter and Price Creeks. Disturbances mapped in Morice TSA totalled 829 ha of small polygons near Whitesail Lake, Goosly Lake, Tsalit Mtn and Saddle Hill, with scattered spot infestations. Attack in Lakes TSA totalled 725 ha, mainly south of Tweedsmuir Peak and near Pondosy Lake. The remaining mountain pine beetle damage in the region was less than 310 ha per each TSA.

Southern Interior Damage

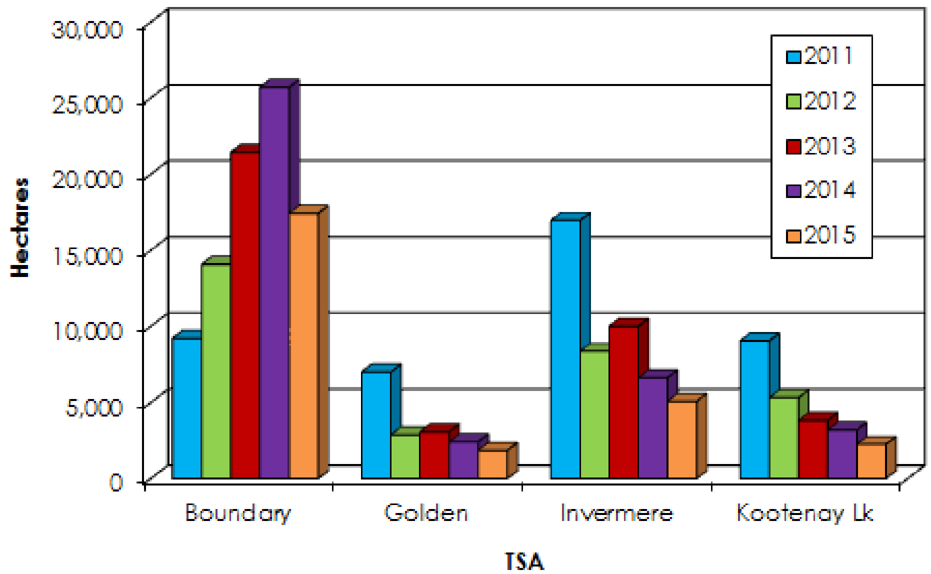


Figure 6. Infested area (ha) by mountain pine beetle from 2011 – 2015 in the Kootenay/Boundary Region (TSAs with more than 1,800 ha affected in 2015).

Area attacked by mountain pine beetle in Kootenay/ Boundary Region has remained relatively static over the past few years, primarily due to increasing populations in Boundary TSA being offset by decreases in the other TSAs (Figure 6). In 2015 however, mapped attack declined in Boundary TSA as well, resulting in a regional decline of 28% since last year to 30,027 ha. Boundary TSA continued to be the most affected with 17,436 ha mapped throughout the TSA, with the largest concentration in the northern tip south of Lightning Peak. Invermere TSA damage was assessed at 5,087 ha, with most disturbances continuing to be scattered throughout the western half of the TSA. Kooteney Lake had 2,245 ha of attack with the largest concentration east of Argenta. Scattered mortality in Golden TSA accounted for 1,848 ha. Disturbances were similarly dispersed in Arrow TSA with 1,537 ha mapped. Cranbrook TSA contained 940 ha of damage, primarily in the western portion of the TSA. The remaining 934 ha were located in Revelstoke TSA, with one large infestation just south of Revelstoke.

Mountain pine beetle infestations in Thompson/Okanagan Region generally occurred in the same areas as last year, with only a slight (8%) decline to 8,540 ha of attack. Damaged area in Lillooet TSA increased somewhat to 5,851 ha, with a fairly large active (moderate to high intensity) concentration around Bridge River west of Downton Lake. Okanagan TSA contained small scattered disturbances amounting to 2,043 ha, primarily in the south on the east and west boundaries. Almost all of the 646 ha mapped in Merritt TSA occurred in the McNulty Creek area on the eastern border of the TSA.

Cariboo Region infestations actually increased slightly with 1,899 ha mapped, all in Williams Lake TSA. With the exception of a few scattered spot infestations, all the attack was located in the south along the Lillooet TSA boundary. The damage noted in the Taseko River area was confined to the older age component of higher elevation lodgepole and whitebark pine stands.

Coastal Damage

Mountain pine beetle damage in South Coast Region increased marginally from 277 ha last year to 333 ha. Nearly all of the attack occurred in Soo TSA, primarily north and south of Blackcomb Peak and near Green and Lillooet Rivers. Only one spot infestation occurred in Fraser TSA south of Boothroyd.

Attack in the West Coast Region remained constant with 44 ha of damage all mapped in Mid Coast TSA east of Mt. Walker.

Neodiprion sawfly, *Neodiprion nanulus contortae*

A total of 5,005 ha of defoliation were mapped this year at the south tip of Moresby Island in Haida Gwaii TSA of the West Coast Region. Damage was assessed as 2,665 ha (53%) light, 2,296 ha (46%) moderate and 44 ha (1%) severe, all limited to small shore pine growing on thin soils in or adjacent to bogs. Damage in this same general area was mapped as Neodiprion sawfly in 2013 but difficult access limited ground checks, so identification was based on positive collections in other coastal stands. No other sawfly infestations were noted in 2014 - damage in this stand was (possibly incorrectly) recorded in 2014 as suspect needle disease, causal agent unknown. In 2015 three ground checks (near Huxley Island in Gwaii Haanas) were possible and Neodiprion sawfly was confirmed as the primary damage agent, though in a few stands an unidentified needle disease was still suspected. Neodiprion sawfly defoliation was also noted from ground surveys in other areas of Haida Gwaii TSA, but damage was not visible from the air.

Neodiprion sawfly defoliation on Moresby Island

Pine needle sheathminer, *Zelleria haimbachi*

For the fifth consecutive year pine needle sheathminer damaged young lodgepole pine, with the affected area increasing three-fold since last year to 5,531 ha (Figure 7). Intensity of defoliation decreased however with 3,916 ha (71%) light and 1,615 ha (29%) moderate. Stands with multiple years of attack are suffering from the cumulative effects and are producing only short new needles, on which current damage is difficult to see from the height of the AOS, thus there is actually more damage than was mapped.

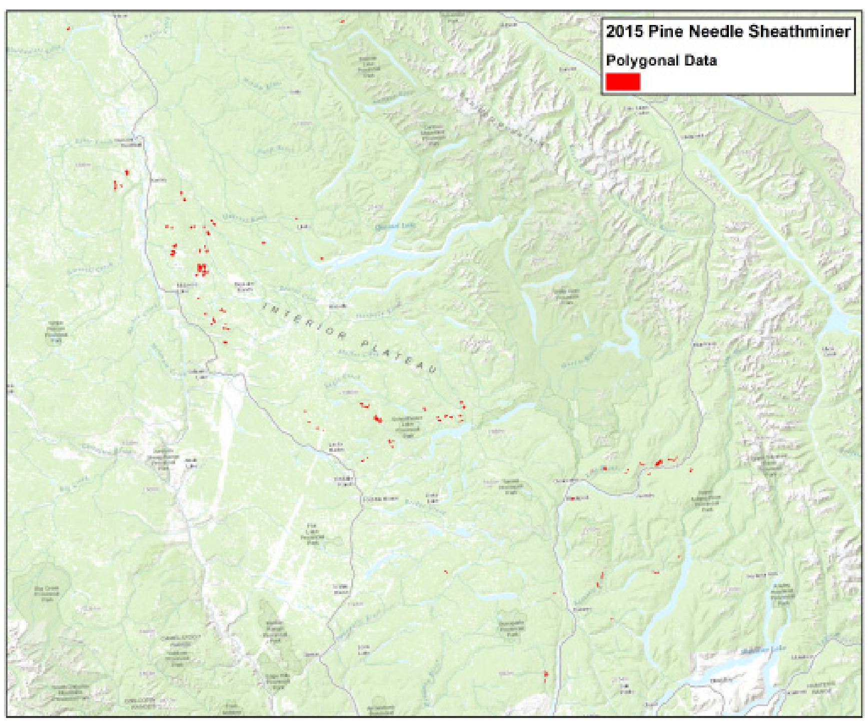


Figure 7. Pine needle sheathminer damage recorded in BC in 2015.

The majority of the attack (4,313 ha) occurred in the Cariboo Region, where the defoliation has been mapped for two consecutive

Pine needle sheathminer needle damage

years. Infestations mapped in Williams Lake TSA totalled 1,917 ha with scattered blocks east of the Fraser River from Hawks Creek north to the Quesnel TSA border and east to Mt. Warren. Ground observations revealed that attack was much more extensive in this TSA than had been mapped from the air. The damage often occurred in mixed species stands where the signature would be very difficult to see at the height of the AOS. Defoliation in 100 Mile House TSA amounted to 1,342 ha in the north tip of the TSA, scattered from Lac La Hache east to the Canim Lake area. The remaining 1,054 ha recorded in the region occurred in Quesnel TSA on both sides of the Fraser River from Marguerite north to Deserters Creek, and one polygon in the north tip southeast of Punchaw Lake.

All pine needle sheathminer damage in the Thompson/ Okanagan Region occurred in Kamloops TSA, with 1,124 ha mapped mid TSA from Jamieson Creek north to Raft Mountain. It was noted that in this region, some stands have only been affected for one year but others have been damaged for up to five consecutive years.

Pine needle sheathminer defoliation in Kamloops TSA

One 72 ha disturbance was recorded in Prince George TSA (Omineca Region) southwest of Cariboo Mountain.

The remaining 22 ha were mapped in two small polygons in Soo TSA (South Coast Region) along the Lillooet River north of Glacier Lake.

Dothistroma needle blight, *Dothistroma septosporum*

Small scattered areas damaged by Dothistroma needle blight have historically been recorded throughout the interior of BC but since the early 2000s it has become a significant problem in Skeena Region. AOS surveyors often underestimate Dothistroma damage due to the subtle foliage signature, particularly in stands that have been infected for several years as the remaining needles are scarce and smaller in size.

This year Dothistroma needle blight damage was recorded during the AOS across 4,441 ha in BC, almost triple that observed last year but far less than the peak in 2008 of 27,255 ha. All disturbances were in young stands. Intensity of noted damage remained relatively constant at 1,156 ha (26%) light, 2,024 ha (46%) moderate and 1,261 ha (28%) severe.

Dothistroma damage in Prince George TSA

The majority of the damage occurred in Omineca Region with 3,211 ha mapped in Prince George TSA. The disturbances were scattered but two general clumps occurred west of Pinkerton Peak and at the confluence of the Fraser and McGregor Rivers. There was some concern that the southern damage may have been pine needle sheathminer (which was active in the adjacent Cariboo Region) but the aerial signature (damage more visible at an oblique angle, indicating more damage in the lower crown) was felt to be Dothistroma needle blight and the damaging agent was confirmed at a few sites on the ground.

Skeena Region had 625 ha of visible damage. A total of 313 ha were mapped in Nass TSA on the west side of the Nass River north of Kwinamuck Lake. The regional pathologist also noted that Dothistroma damage was more visible along Highway 37 in this TSA than has been noted over the last 10 years. Infected stands totalling 312 ha were also mapped in Kalum TSA on the east side of the Nass River near New Aiyansh. Considering the warm, wet summer in the Skeena Region this year (and predicted for 2016 as well, due to El Nino) Dothistroma needle blight damage is anticipated to increase in the near future.

In the Thompson/Okanagan Region 604 ha were affected. Okanagan TSA sustained 308 ha of damage in the northeast near Mabel Lake and Sugar Lake. Kamloops TSA contained 296 ha of Dothistroma needle blight damage also in the northeast near Blue River and east of Groundhog Mtn.

Comandra blister rust, *Cronartium comandrae*

Damage caused by the hard pine stem rusts that are common in BC (Comandra blister rust, *Cronatium comandrae*, Stalactiform blister rust, *Cronartium coleosporiodes* and western gall rust, *Endocronartium harknesii*) is greatly underestimated during the AOS because the damage is only visible if substantial mortality is present, which seldom occurs.

Damage due to hard rusts has not been observed during the AOS since 2003, when 2,036 ha were mapped primarily in Prince George TSA of the Omineca Region. This damage was attributed to Comandra blister rust which is the most likely of the three to cause mortality, though it was acknowledged that the other two rusts were probably present and exacerbated the damage. This is also most likely the case in 2015, when 425 ha of Comandra blister rust damage was delineated in Lakes TSA (Skeena Region). Intensity of damage was rated as 176 ha (42%) trace and 249 ha (58%) light in young lodgepole pine stands. Six widely spaced damaged stands were identified mid TSA. Although the stands were not ground truthed, local knowledge combined with the observed aerial damage signal indicated rust. Damage was scattered (unlike secondary beetle attack which tends to be found in small clumps) and crown colour was relatively uniform (as opposed to bear damage where foliage ranges from new chlorotic colour to red).

White pine blister rust, *Cronartium ribicola*

White pine blister rust infections are underestimated during the AOS because the damage is primarily visible in older trees when mortality or top kill occurs. For the past three years white pine blister rust damage has been recorded over a higher than average total area provincially (over 1,200 ha per year) but the majority of disturbance intensities were at trace level.

In 2015 total damage in BC dropped to 417 ha but intensity increased with 310 ha (74%) trace, 85 ha (21%) light and 22 ha (5%) severe. Since the provincial government has been responsible for the AOS surveys, most of the white pine blister rust damage mapped has been in the coastal regions, with minor damage occasionally noted in the Kootenay/Boundary Region. This year the majority of the observed damage (362 ha) occurred in Kamloops TSA northwest of Celista in the Thompson/Okanagan Region.

Rust damage declined in the South Coast Region to only 50 ha. Scattered damage in the southern third of Fraser TSA increased since 2014 to 26 ha. The largest reduction occurred in Sunshine TSA where 22 ha were recorded, primarily on Texada Island as very small polygons and scattered spots, as opposed to two large trace disturbances mapped in the same area last year. Seven scattered spots of damage totalled 2 ha in Soo TSA.

All white pine blister rust damage mapped in the West Coast Region was in scattered spots, with 3 ha in Strathcona TSA and 2 ha in Arrowsmith TSA.

Mortality caused by white pine blister rust

Damaging Agents of Douglas-fir

Douglas-fir beetle, *Dendroctonus pseudotsugae*

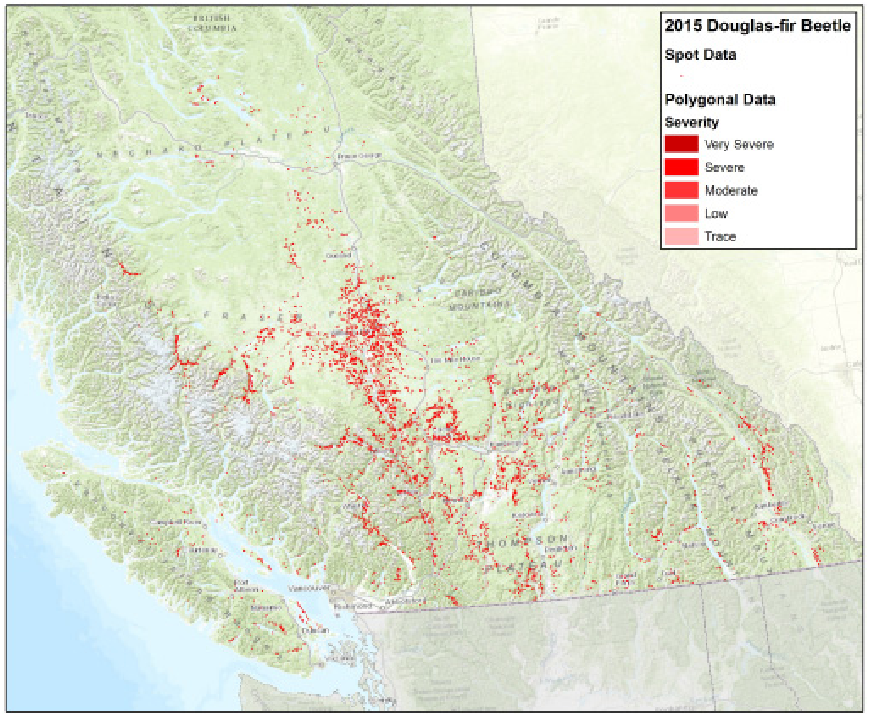


Figure 8. Douglas-fir beetle attack recorded in BC in 2015, by mortality intensity.

Douglas-fir beetle infestations had a peak in 2009 of 100,726 ha provincially. For the next four years (2010 – 2013) recorded damage was 21,000 ha or less per year. In 2014 mapped disturbances rose to 39,481 ha and this upward swing continued this year to 47,628 ha (Figure 8). Mortality intensity remained virtually the same as last year with 6,041 ha (13%) trace, 31,845 ha (67%) light, 6,723 ha (14%) moderate, 2,900 ha (6%) severe and 119 ha (<1%) very severe.

The majority of the Douglas-fir beetle attack continued to occur in the Cariboo Region with a 20% expansion since last year to 33,252 ha. Many new infestations were mapped this year in areas with no recent history of bark beetle damage. The large spotty wildfires of 2009 and 2010 combined with favourable winter conditions have greatly contributed to the Cariboo Region outbreak.

Directed by the results from the AOS, detailed (rotary wing) aerial surveys were conducted in the Cariboo Region again this year. The number of spot infestations mapped were slightly higher than last year with 2,373 spots containing 21,125 ha of recent attack. However, the attack pattern in many cases was widely scattered, resulting in much larger polygon delineations totalling 52,251 ha (compared to 16,559 ha in 2014) though the mortality intensity was primarily trace.

The majority of the Cariboo Region damage continued to occur in Williams Lake TSA where 27,404 ha were mapped. Most of the infestations continued to occur east and west of the Fraser River mid TSA. In addition, new attack centers were substantial, particularly in the west near Tatlayoko Lake, Middle Lake and Tatla Hill, and small infestations (primarily spot) were also scattered in the east in more mixed species stands. Douglas-fir beetle attack also grew in 100 Mile House TSA to 5,547 ha. Damage was concentrated along the southwest borders of the TSA, with the largest expansions occurring around Canoe Creek and south west of Jesmond. Though the total number of infested hectares in Quesnel TSA dropped slightly to 301 ha, smaller infestations (mainly spot) were more widely dispersed this year, particularly around the Nazko area.

Overwinter mortality studies were conducted in the Cariboo Region again in early 2015, with bark samples collected from 34 sites. The ratio of surviving brood to initial attack (R-values) were calculated. Values over 1.3 indicate increasing populations. R-values in the western portion of Williams Lake TSA were 3.3, in the eastern portion 6.1, and in Quesnel TSA 4.1, all indicating (for the third consecutive year) increasing populations.

FLNRO district, regional and BC timber sales staff, major licensees, community forest licensees, small scale salvagers and woodlot licence holders have been meeting on a regular basis since June to strategize and develop a comprehensive approach to treating Douglas-fir beetle in the Cariboo Region during the 2015-16 operating season. The group has developed a strategic Douglas-fir bark beetle management plan and implementation plan. Together these documents outline a coordinated approach to addressing the beetle. High priority treatment areas have been identified where a target to treat 80-100% of the Douglas-fir beetle infestations has been established. Minor changes in policy within Old Growth Management Areas (OGMA's) and Mule Deer Winter Ranges (MDWR's) will improve the ability to address infestations in these areas.

Douglas-fir beetle infestations in the Thompson/Okanagan Region rose by a third since 2014 to 5,207 ha. Lillooet TSA contained 2,248 ha of mostly small, dispersed infestations, with larger concentrations along the Stein River and Carpenter Lake. Damage in Okanagan and Merritt TSAs continued to be widely scattered in small disturbances with 1,450 ha and 499 ha mapped, respectively. Attack in Kamloops TSA increased to 1,010 ha in the southern half of the TSA, with the largest concentration occurring in the hills north of Ashcroft east to McQueen Lake and around Roche Lake.

South Coast Region sustained 4,909 ha of attack, triple that recorded in 2014. Almost all (4,272 ha) were mapped in Fraser TSA, with the largest disturbances around Cultus Lake, Anderson River and Nahatlatch Lake. Small scattered disturbances mainly along the eastern edge of Soo TSA accounted for 463 ha of damage. The remaining 174 ha in the region were observed in Sunshine TSA, chiefly in the south and particularly on Texada Island. The signature of Douglas-fir beetle attack in the South Coast Region tends to be small patches with old and new attack in old growth, with trees turning colour quickly. This most likely indicates root disease is present in these centers as well. This year, attack was also mapped as scattered, individual trees in larger light intensity polygons or spots, with brighter red foliage and slightly younger trees involved. It is suspected that drought was involved in tree mortality at these sites.

Infestations in Kootenay/Boundary Region declined by 40% from last year to 1,641 ha. Damage remained small (primarily spot size) and widely scattered. Douglas-fir beetle attack in Invermere TSA occurred chiefly in main river drainages with most of the 611 ha mapped along the Kootenay River. Boundary and Arrow TSA had similar levels of attack with 273 ha and 264 ha recorded,

Douglas-fir beetle mortality in Williams Lake TSA respectively. Beetle populations have been noted to be increasing in these two TSAs around previous wildfires so an aggressive funnel trapping program is being employed around the fires. Cranbrook TSA contained 179 ha of damage, some still around Grasmere with some new areas around Cranbrook and along the Wild Horse River. The remaining infestations in the region were small (under 120 ha per TSA).


Douglas-fir beetle attack

Douglas-fir beetle mortality in the West Coast Region totalled 1,313 ha, up from only 198 ha last year. Attack in Strathcona TSA was 489 ha, with concentrations around Wolf River, Campbell Lake and Gold River. A total of 308 ha occurred in the eastern half of Mid Coast TSA, primarily along Dean River and Elbow Lake southward. Arrowsmith TSA sustained 260 ha of dispersed attack with a small concentration on Cous Creek. A total of 250 ha of mortality was recorded in Kingcome TSA, primarily in the northeast tip of the TSA.

Attack in Omineca Region decreased to a third of what was recorded last year to 1,304 ha. With the exception of one spot infestation on the southern edge of Mackenzie TSA, all of the damage continued to occur in Prince George TSA. Attack in Prince George District continued to occur along the western edge, though infestation sizes were much diminished. This was also the case for attack in the southern quarter of Fort St. James District. The only increases occurred in Vanderhoof District on the south shore of Francois Lake, which is in a park. This infestation extended into Skeena Region last year with one 733 ha disturbance noted on the north side of Francois Lake. In 2015 however, this damage was reduced to only 5 spots.

Western spruce budworm, *Choristoneura occidentalis*

Recorded Defoliation

Western spruce budworm defoliation declined in BC for the fourth consecutive year to 9,135 ha. Intensity of damage increased slightly however to 8,011 ha (88%) light, 1,108 ha (12%) moderate and 16 ha (<1%) severe. This is well below the peak of 847,344 ha of damage in 2007. Defoliation in the southern interior was more widespread than what was recorded, generally occurring in the understory which was not detected by the AOS.

Western spruce budworm defoliation in the Cariboo Region dropped almost eight fold since last year to 5,083 ha. Disturbances in Williams Lake TSA totalling 3,754 ha were mapped along the Fraser River, Chimney Creek, and south of Sugarcane. An additional 1,329 ha in three polygons were located in 100 Mile House TSA between 111 Mile Creek and 100 Mile House. Defoliation noted from the ground in these two TSAs was considerably heavier in the lower two-thirds of the stands rather than the more conventional upper one-third, which made aerial detection difficult.

Defoliation mapped in Thompson/Okanagan Region this year was half that noted in 2014 at 1,908 ha. Most of the damage (1,484 ha) occurred in Okanagan TSA, primarily north of Summerland.

Four polygons west of Stemwinder Mtn. in Merritt TSA covered 271 ha and the remaining 153 ha were mapped west of Lac Du Bois in Kamloops TSA.

Western spruce budworm larvae

Kootenay/Boundary Region sustained 1,580 ha of attack. Boundary TSA encompassed almost all of the disturbances with 1,531 ha delineated, chiefly northwest of Greenwood and south of Mt. Morrissey. Three small polygons in Cranbrook TSA near Fernie covered 33 ha and one 16 ha disturbance was located in Arrow TSA south of Lost Mountain near the USA border. Larvae collected from tree beatings in this region concur that all defoliator populations are still very low.

The only damage noted in the South Coast Region was 564 ha in Soo TSA north of Mt. Job on the Lillooet River.

Cariboo Region spray swath

2015 Treatment Program

High value Douglas-fir stands (that 2014 and early season 2015 egg mass surveys predicted would undergo moderate defoliation in the spring of 2015) were targeted for treatment. The biological control agent *Bacillus thuringiensis* var. *kurstaki* (*Btk*), formulation Foray 48B®, was applied aerially at a rate of 2.4 litres/ha in a single application.

A total of seven blocks covering 15,867 ha in the Cariboo Region were treated with two fixed wing AT 802 Air Tractors operated by Conair Aerial Firefighting that were provided by the Provincial Air Tanker Center. Two large blocks in Williams Lake TSA near Buckskin Lake and Meldrum Creek and five smaller blocks in 100 Mile House TSA near Lac La Hache, 70 Mile House and Loon Creek were sprayed. The 2015 Cariboo spray program was overseen by Thompson/Okanagan Regional staff and treatment was conducted over three days, from June 13th to 15th.

Population Monitoring 2015

Egg mass surveys were conducted in the fall of 2015 to predict western spruce budworm populations and defoliation levels for 2016 (Table 4). Results continued to reflect a decreasing budworm population, with average predicted severities falling for a fourth consecutive year. Sites with moderate defoliation predicted decreased provincially to 17 from 25 last year and only one site had severe defoliation predicted.

The majority of sites predicted to have moderate defoliation continued to be in the Cariboo Region. Williams Lake TSA had nine sites around Brunson Lake, Alixton Lake, Word Creek and Lac La Hache. 100 Mile House TSA contained four sites near Dougherty Lake and Poison Lake.

Region	TSA	Number of Sites by Defoliation Category				Total Sites
		Nil	Light	Moderate	Severe	
Cariboo	100 Mile House	10	47	4	0	61
	Williams Lake	12	53	9	0	74
	Quesnel	2	2	0	0	4
Thompson/ Okanagan	Kamloops	35	45	1	0	81
	Lillooet	9	11	0	0	20
	Merritt	28	21	0	0	49
	Okanagan	1	15	2	1	19
Kootenay/ Boundary	Boundary	4	13	1	0	18
	Cranbrook	6	4	0	0	10
	Total	**107**	**211**	**17**	**1**	**336**

Table 4. Summary of western spruce budworm defoliation predictions for 2016 based on the 2015 egg mass survey results.

Thompson/Okanagan Region had two moderate and one severe sites in the Garnet Valley area of Okanagan TSA and one moderate site in the Sabiston/Criss Creek area of Kamloops TSA. Kootenay/Boundary Region had only one moderate site predicted on the Rock Creek/Bridesville Road west of Rock Creek in Boundary TSA. No sampling was conducted in South Coast Region this year.

Overall, sites with significant defoliation predicted for next spring were small and scattered. No *Btk* treatment program is planned for 2016.

Laminated root disease, *Phellinus sulphurascens*

Although laminated root disease is present throughout many areas of southern BC, it is rarely identified during the AOS. Root disease disturbances change slowly, so large changes recorded during the overview surveys are most likely due to varying surveyor knowledge and visibility conditions. Most infection centers are identified in the South and West Coast Regions, due to local ground knowledge of the surveyors.

After a marked decrease to only 79 ha last year, total observed laminated root disease damage rebounded to 525 ha in the coast regions. Intensity of damage was rated as 142 ha (27%) trace, 310 ha (59%) light, 24 ha (5%) moderate and 49 ha (9%) severe (which were all spot disturbances). Infection centers were small and widely scattered.

West Coast Region contained 382 ha of damage, of which the majority (362 ha) was located in Arrowsmith TSA. The remaining disturbances in Strathcona and Kingcome TSAs totalled 12 ha and 9 ha, respectively.

Laminated root disease damage in South Coast TSA totalled 143 ha. Fraser TSA was most affected with 100 ha while Sunshine TSA and Soo TSA had 41 ha and 2 ha of damage, respectively.

Douglas-fir tussock moth, *Orgyia pseudotsugata*

The Thompson/Okanagan Region sustained a Douglas-fir tussock moth outbreak from 2009 to 2011. Since then defoliation has been very low to nil, with no current damage observed during the AOS for the past three years. Three-tree beatings at permanent sample plots in historical Douglas-fir tussock moth outbreak areas also produced nil to very low numbers of larvae.

Douglas-fir tussock moth outbreaks usually develop rapidly and can result in substantial mortality. Populations are monitored annually with six-trap clusters of pheromone-baited 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 5) and were well below the outbreak threshold again this year. Based on these results, no treatment program is planned for 2016.

	TSA					
Year	100 Mile House	Boundary	Kamloops	Lillooet	Merritt	Okanagan
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)
2015	0.1 (16)	0.2(8)	2.3 (19)	0.2 (2)	0.8 (9)	0.6 (11)

Table 5. Average number of male Douglas-fir tussock moths caught per trap by TSA, 2010 – 2015 at six trap cluster sites; number of sites in brackets.

Damaging Agents of Spruce

Spruce beetle, *Dendroctonus rufipennis*

After a peak of 315,953 ha of spruce beetle mortality in 2003, BC damage remained relatively low until last year when area affected rose sharply to 288,892 ha. This year total area mapped declined to 194,050 ha (Figure 9). Area of attack does not show the whole story however: disturbances mapped last year in central BC were very large with low mortality intensity. In 2015 infestations were mapped in the same general areas but they were more precisely defined in the most affected TSAs, hence the polygons overall were smaller with higher intensities (Figure 10). Provincially, mortality intensity in 2015 was 39,061 ha (20%) trace, 83,716 ha (43%) light, 58,012 ha (30%) moderate, 13,003 ha (7%) severe and 259 ha (<1%) very severe.

The Omineca Region continued to contain the majority of the damage with 156,057 ha mapped. Prince George TSA sustained 93,768 ha of attack, with the bulk located in the northern half of Prince George District, while area affected in Fort St. James District decreased but attack intensified in the lower third of the district. A total of 62,176 ha of spruce beetle mortality was mapped in Mackenzie TSA with the highest intensities concentrated in the southeast tip of the TSA. New low intensity polygons were also noted on the west side of Williston Lake from Ole Creek south to

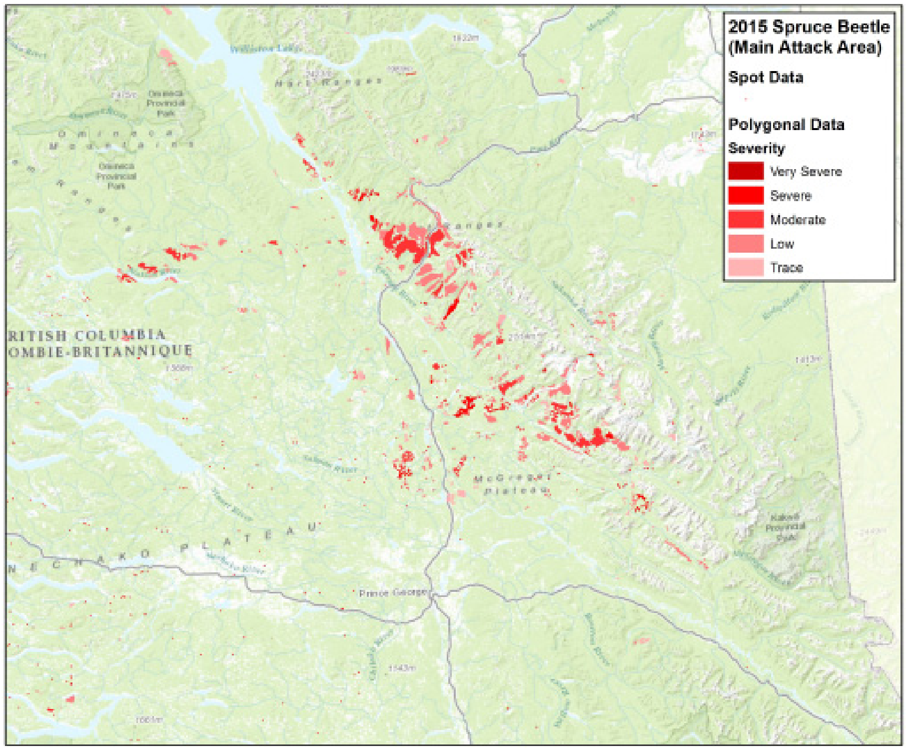


Figure 9. Spruce beetle infestations recorded in 2015 in central BC, by mortality intensity.

Omineca Arm. In Robson Valley TSA, small light disturbances and spot infestations accounted for 113 ha along the western edge of the TSA.

Prince George and Mackenzie District staff and the regional entomologist observed that a small percentage of spruce beetle attack has moved into a one year life cycle, most likely due to the warm, early spring with an early (late May) beetle flight. It was also noted that an early spring tends to cause attacked trees to change colour sooner. It is possible to not see colour change until as late as 30 months after attack but this has not been the case since 2012 in this region, with 13 to 15 months more the norm since then. The aerial surveyors in central BC also noted that in general the colour of attacked trees was far more vibrant than usual and that the colour stayed that way for a longer period of time than normal. Both Prince George and Mackenzie District staff have developed working groups with licensees and other agencies to address the strategic direction for the spruce beetle outbreak. Low level detailed flights have been conducted and walkthrough probe survey contracts have been undertaken since the 2014 AOS. To respond to this serious forest manag-ement issue, the Omineca Region has appointed a Spruce Beetle Project Manager. The manager's role will be to coordinate and communicate FLNRO's efforts to protect mid-term timber supply and ecosystem functions. Infestations in Vanderhoof District are relatively small and discrete. Detailed flights were conducted in the fall with district staff and

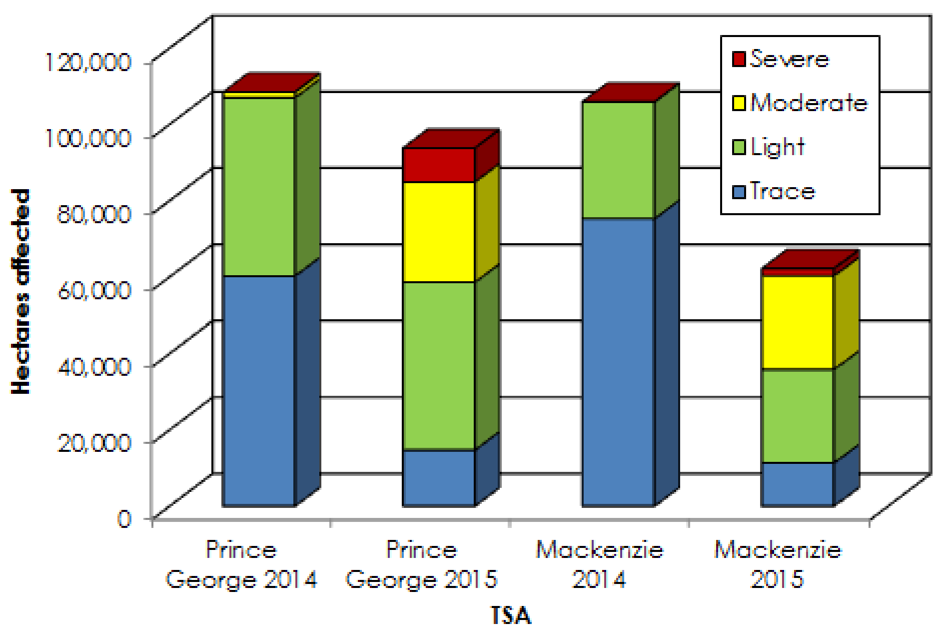
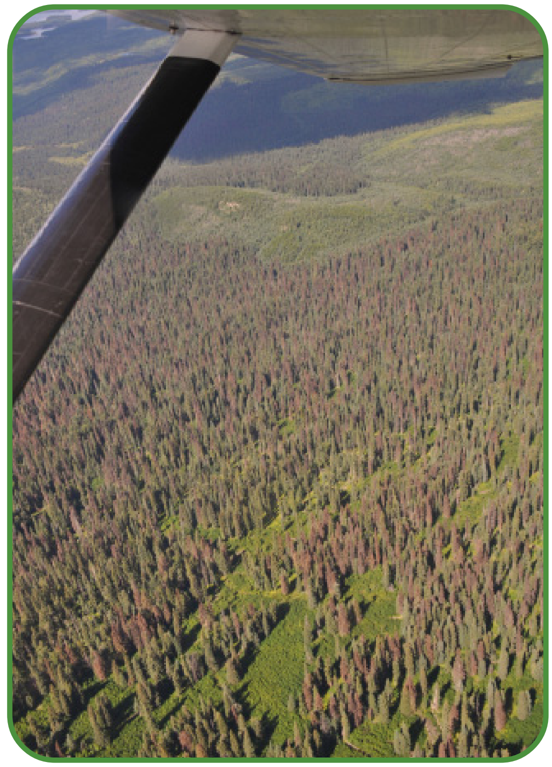


Figure 10. Change in mortality intensities in Prince George and Mackenzie TSAs from 2014 to 2015.

licensees complemented by walkthrough surveys. The only areas of concern are south of Anzus Lake and the Sutherland area in the northwest corner of the district. These areas are being addressed with trap trees and harvesting.



Spruce beetle mortality in Prince George TSA

In the Northeast Region spruce beetle infestations totalled 14,335 ha in 2015. Dawson Creek TSA sustained 9,440 ha of attack, primarily around Hook Lake and Mt. Garbitt on the western edge of the TSA. A total of 3,154 ha were mapped in Fort St. John TSA in small scattered infestations primarily in the northeast section. Fort Nelson TSA had 1,741 ha of attack located mainly along the Hay River in the southeast.

Spruce beetle mortality in Skeena Region was double that recorded last year at 8,406 ha. Morice TSA contained 2,649 ha, chiefly concentrated around Tsalit Mtn. area and north of Saddle Hill. Attack in Kispiox TSA amounted to 2,368 ha west of French Peak and on Le Clair Creek north of Babine River, with a few other scattered spot infestations. Disturbances scattered throughout the northern half of Lakes TSA accounted for 1,285 ha. Aside from a few spot infestations, all the attack noted in Nass TSA occurred in two polygons between Panorama and Muskaboo Creeks. Almost all the 779 ha mapped in Bulkley TSA occurred northwest of Torkelsen Lake and west of Kitseguecla Lake. Cassiar and Kalum TSAs had minor disturbances totalling 173 ha and 13 ha, respectively.

Infestations also doubled since 2014 in the Thompson/Okanagan Region, where 5,295 ha were attacked. Lillooet TSA continued to be the most affected, with 3,129 ha mapped, primarily from Cayoosh Mtn. to Riley Creek and Relay to Tyaughton Creeks. Aerial observers noted that the aerial signature of the attack in Lillooet TSA was unusual (a strange brownish colour). The majority of the mortality in this TSA was recorded as moderate to severe. Kamloops TSA sustained 1,378 ha of spruce beetle attack, primarily north of Hobson Lake and around Falls Lake with smaller disturbances around Criss Creek. All 724 ha recorded in Merritt TSA occurred in the southern tip near the US border. This infestation continued into Okanagan TSA near Ashnola River with 64 ha mapped.

Spruce beetle damage in Kootenay/Boundary Region rose slightly this year to 5,190 ha. Almost all the 3,745 ha recorded in Invermere TSA occurred south of Palliser River through North White River. Ground observations in this area reported aggressive beetle populations with attack in 10 to 15 cm DBH trees (a very rare occurrence). Golden TSA sustained 1,070 ha of attack, primarily located from Illecillewaet River north to Iconoclast Mtn. Minor disturbances were noted in Revelstoke, Kootenay Lake and Arrow TSAs of 106 ha, 44 ha and 38 ha, respectively.

Attack in the Cariboo Region remained relatively static with 2,900 ha affected. Most of this occurred in Williams Lake TSA (2,573 ha), primarily from Horsefly Lake north to Mitchell Lake. Two small disturbances near Mt. Hendrix and west of Clinton accounted for the majority of the 216 ha observed in 100 Mile House TSA. The remaining 111 ha in the region was mapped in small widely dispersed infestations in Quesnel TSA.

The West Coast Region sustained 1,663 ha of damage, up substantially from only 117 ha last year. The large change was due to several new large trace polygons totalling 1,291 ha mapped on Moresby Island in Haida Gwaii TSA. Infestations remained widely dispersed in Mid Coast TSA, accounting for 230 ha. Minor disturbances were also recorded in Strathcona, Kingcome and Arrowsmith TSAs at 81 ha, 42 ha and 19 ha, respectively.

Spruce beetle mortality in Mackenzie TSA

Spruce beetle infestations in South Coast Region remained minor with 203 ha mapped. Almost all the 120 ha of damage observed in Fraser TSA came from Merritt TSA around Chuwanten Mtn. in the southeast. The remaining 83 ha occurred in Soo TSA near Cheakamus Lake and east of Twin Goat Mtn.

Green spruce aphid, *Elatobium abietinum*

Only a thin strip of Sitka spruce by the ocean is usually noticeably affected by green spruce aphid in BC, as that is the zone that has moderate enough temperatures to allow feeding throughout the year. This tiny (and difficult to see) aphid feeds primarily in shaded locations on older needles, though during high populations new needles can be affected. All ages of trees can be damaged but most of the defoliation observed this year was on mature trees. The damage signature is a ragged, patchy foliage appearance, similar to larval defoliation but without any webbing or frass present.

This damage is rarely visible from the height of the AOS, though this year 578 ha were mapped on Haida Gwaii TSA. Damage was assessed as 55 ha (10%) light and 523 ha (90%) moderate. The disturbances were noted at the north end of Graham Island, on Kumdis and Chaatle Islands and south of Gray Point on Moresby Island. Additionally, damage was observed from the ground along the shoreline in Campbell River and on Quadra Island.

Damaging Agents of True Fir

Western balsam bark beetle, *Dryocoetes confusus*

In 2015, the northeastern portion of Mackenzie TSA and the majority of Cassiar TSA were not flown therefore the hectares killed by western balsam bark beetle is likely underestimated. After three years of increasing damage by western balsam bark beetle, damage dropped by almost a quarter of that recorded last year to 2,349,470 ha (Figure 11). Intensity remained relatively stable with 1,861,260 ha (79%) trace, 435,123 ha (19%) light, 50,452 ha (2%) moderate and 2,635 ha (<1%) severe.

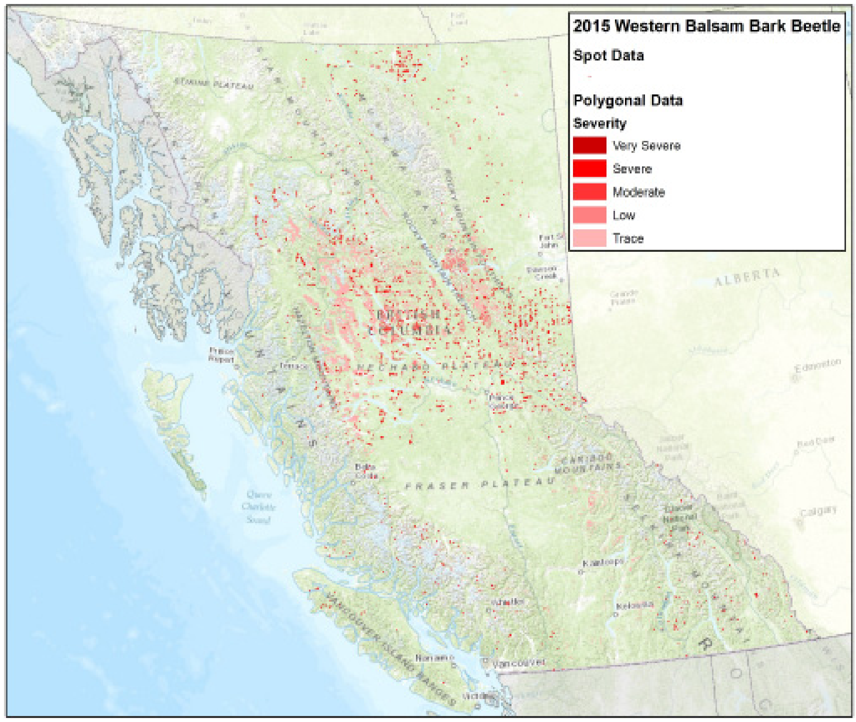


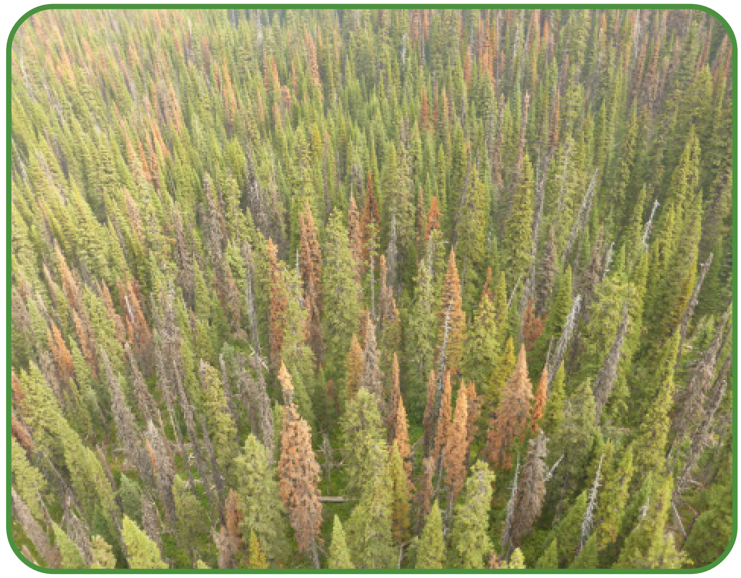
Figure 11. Western balsam bark beetle damage mapped in 2015, by severity classes.

Infestations continued to be highest in the Omineca Region with 1,036,055 ha of mortality mapped, down 19% from last year. Attack in Prince George TSA was similar to 2014 with 629,212 ha recorded with highest concentrations and the majority of the moderate to severe intensity disturbances noted provincially were located in Fort St. James District. Mortality was observed over 390,245 ha in Mackenzie TSA with some moderate levels noted near Lavitah Mtn. and the south end of Parsnip Reach. Smaller, scattered trace to light infestations were noted on 16,598 ha in Robson Valley TSA.

Western balsam bark beetle infestations this year were two-thirds of that recorded in 2014 in the Skeena Region, with 818,700 ha in affected. The majority of the disturbances were large but at trace intensity. Damage in Kispiox, Bulkley and Morice TSAs were in the same general areas as last year and remained similar in size with 218,083 ha, 211,709 ha and 202,926 ha attacked, respectively. Lakes TSA disturbances decreased slightly to 91,904 ha, with most of the mortality continuing to occur in the southwest tip of the TSA. Attack in Nass TSA declined to 75,986 ha with all damage continuing to occur in the northern half. Infestations mapped in the Cassiar TSA declined sharply to 10,164 ha in small disturbances in the southeast, but this was the only part of the TSA surveyed in 2015. Western balsam bark beetle attack observed in Kalum TSA was slightly more dispersed this year, primarily along the eastern edge of the TSA, with 3,971 ha affected. Only eight scattered spot infestations were seen in North Coast TSA in 2015.

Infestations decreased by 22% this year to 212,235 ha in the Northeast Region. Attack occurred in the same general locations but mapped disturbances were smaller overall. The exception was Dawson Creek TSA, where disturbances rose to 127,235 ha, primarily along the western edge of the TSA with small scattered patches of mortality noted to the east. Fort Nelson TSA sustained 43,523 ha of damage with concentrations north of Liard/Toad River to the border and near the Muskwa River/Cheves Creek junction. The majority of the 41,477 ha recorded in Fort St. John TSA continued to be noted south of Halfway River.

In the southern part of the province western balsam bark beetle disturbances continued to be most prevalent in the Thompson/Okanagan Region, where 187,374 ha were affected at a similar level and in the same general areas as 2014. Most of the attack was recorded at trace level. Kamloops TSA contained 102,380 ha of damage primarily in the northern half of the TSA, with some light intensity concentrations north of Table Mountain. The 55,911 ha mapped in Okanagan TSA were more dispersed though larger disturbances continued to be noted around Jubilee, Tahetkum, Mara and Pukeashun Mountains. Infestations totalling 15,871 ha in Merritt TSA were mainly located along the western edge of the TSA and in the east around McNulty Creek. Attack in Lillooet TSA was widely dispersed, covering 13,212 ha.



Western balsam bark beetle mortality in Kamloops TSA

Damage in the Cariboo Region rose by a third since 2014 to 38,776 ha. Infestations tended to be smaller than in most of the province with the exception of Kootenay/Boundary Region; conversely, the intensity of mortality was higher with 58% rated light and 2% moderate. The damage was observed to be quite variable with attack prevalent in one drainage while there was none visible in an adjacent drainage. Williams Lake TSA contained 28,245 ha with concentrations continuing to occur along the southwest border and in the northeast tip. Infestations in the northeast tip of 100 Mile House declined somewhat to 3,693 ha. Quesnel TSA experienced a substantial increase to 6,838 ha of western balsam bark beetle attack, primarily north of Tzenzaicut Lake and around Barkerville.

Attack in the South Coast Region remained relatively stable with 22,072 ha affected in the same general areas as last year. A total of 15,010 ha were mapped in the eastern half of Soo TSA. Fraser TSA contained 4,600 ha of disturbances, primarily along the northeast edge of the TSA. Sunshine TSA sustained 2,462 ha of damage, with the largest concentration and the highest intensity of attack occurring along Bishop River in the northeast.

Western balsam bark beetle mortality was widely dispersed in very small disturbances in Kootenay/Boundary Region compared to the rest of BC, with a total of 21,046 ha attacked, up 17% over 2014. Golden and Invermere TSAs were most affected with 6,232 ha and 5,753 ha, respectively. Arrow TSA had 3,191 ha of damage and Cranbrook TSA sustained 2,114 ha of attack. Boundary and Kootenay Lake TSAs were similarly affected, with 1,679 ha and 1,378 ha mapped, respectively. The remaining 698 ha of mortality in the region occurred in Revelstoke TSA.

Infestations in the West Coast Region continued to increase, with 17,213 ha noted. Most of the damage (14,789 ha) continued to occur in Mid Coast TSA in the eastern third of the TSA. Kingcome TSA contained 2,318 ha of the attack with all but scattered spot infestations occurring in the northeast tip of the TSA. All infestations were scattered spots in Strathcona TSA with the exception of a tight clump of lightly affected polygons on Mt. Osmington. A total of 104 ha were mapped in this TSA. Arrowsmith TSA contained only three spot infestations.

Two-year-cycle budworm, *Choristoneura biennis*

Two-year-cycle budworm defoliation in BC was a quarter of that recorded last year with 46,420 ha affected (Figure 12). Intensity of damage was substantially higher however, with 26,132 ha (56%) light, 19,786 ha (43%) moderate and 502 ha (1%) severe.

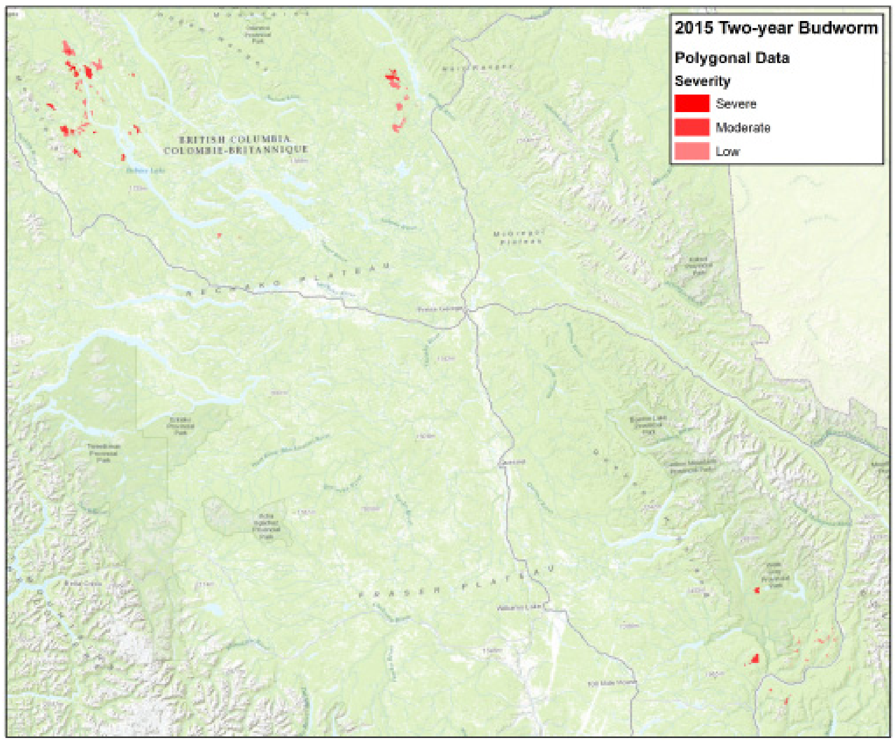


Figure 12. Two-year-cycle budworm defoliation mapped in 2015, by defoliation intensity.

The majority of the defoliation was observed in northern BC, where this budworm is in the second year of its two-year life cycle. The budworm populations in the Skeena Region collapsed in 2012 (less than 210 ha of damage recorded annually) after a peak of 80,020 ha in 2011. This year observed defoliation rose dramatically to 28,009 ha. Defoliation ranged from light to severe, with the highest damage located around Nilkitkwa Lake, Fulton River, Granisle Lake and Nizik Lake. Infestations totalling 19,887 ha were mapped in the northeast portion of Bulkley TSA. Damage also occurred in the northern tip of Morice TSA where 7,429 ha were delineated. The remaining 693 ha in the region occurred in two polygons west of Taltapin Mtn. in Lakes TSA.

Similarly, two-year-cycle budworm defoliation in the Omineca Region has only occurred south of Prince George and in Robson Valley TSA where populations are in an even year cycle since 2012, when 89,185 ha of defoliation was observed. In 2015 11,182 ha of disturbances were mapped. Most (10,917 ha) occurred in the southern portion of Mackenzie TSA south of Nation Arm of Williston Lake. Moderate defoliation was only seen north of Mt. Scovil. Two small disturbances totalling 265 ha were also observed in Prince George TSA near the northwest arm of Takla Lake.

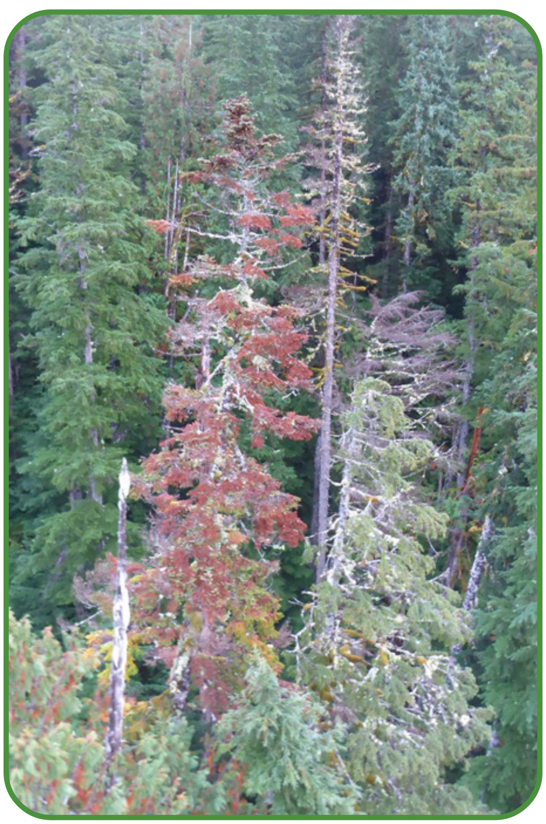
Although two-year-cycle budworm is on an even year cycle in the Thompson/Okanagan Region, 7,123 ha of defoliation was mapped in Kamloops TSA. The infestations occurred mid TSA from Dunn Peak north to Kostal Lake. Damage was highest (moderate severity) near Granite Mtn., Lizard Head Mtn. and Kostal Lake.

Two-year-cycle budworm defoliation in Bulkley TSA.

Defoliation seen during the AOS in the Cariboo Region was minimal, with two light disturbances totalling 106 ha noted north of Wasko Lakes. However, ground observations noted that light defoliation was quite widespread in susceptible stands.

Balsam Woolly Adelgid, *Adelges piceae*

After a peak of 415 ha of balsam woolly adelgid damage in 2012, mapped disturbances have been under 100 ha per year provincially until this year, when 294 ha were mapped. Intensity was rated lower though at 230 ha (78%) trace, 63 ha (22%) light and three spot infestations rated as severe.



Balsam woolly adelgid damage

West Coast Region sustained 237 ha of damage. Strathcona TSA had two disturbances adjacent to Mt. Seaton, three polygons on Stafford River and three spots on the south side of Ououkinsh Inlet, for a total of 119 ha. One area of damage covered 88 ha in Kingcome TSA on Kwalate Creek west of Knight Inlet. The remaining 30 ha in the region were observed in Arrowsmith TSA on Cameron River east of Port Alberni.

South Coast Region had only one balsam woolly adelgid disturbance of 23 ha mapped in Sunshine TSA south of Granite Peak near Bute Inlet. No disturbances were noted in Fraser TSA, where all of the damage was observed last year.

In Kootenay/Boundary Region, 35 ha of suspected balsam woolly adelgid damage was mapped in Arrow TSA between Trail and Mount Mackie. This disturbance was not ground confirmed.

Balsam fir tip blight, *Delphinella* spp.

Balsam fir tip blight, also known as Delphinella needle cast, was first recorded during AOS in 2009 on 3,334 ha in Kalum TSA, and again in the same general area on 1,331 ha in 2011. Since then, no damage caused by this disease has been noted. In 2015 21 ha of moderate intensity damage was mapped in the Kootenay/Boundary Region in Kootenay Lake TSA, between Kootenay River and Baldy Mountain in a young subalpine fir stand.

Ground observations found that balsam fir tip blight was far more prevalent than was mapped, but since the damage was very spotty, often occurring on only scattered trees in a stand or even on only part of a tree, it was very difficult to see at the height of the AOS. Damage was seen in Kootenay/Boundary Region throughout subalpine fir stands and was also widespread at lower elevations on grand fir. It was also noted in subalpine fir stands in Thompson/Okanagan Region, primarily in the northern portion of Kamloops TSA.

Balsam fir tip blight damage

Damaging Agents of Hemlock

Western blackheaded budworm, *Acleris gloverana*

Western blackheaded budworm outbreaks tend to expand rapidly and decline quickly in a given geographic area. A recent outbreak started in Haida Gwaii TSA in 2009 and peaked in 2010 with 87,497 ha of defoliation (Figure 13). This infestation was followed by defoliation of just under 30,000 ha in Kingcome TSA in 2012 and 2013 which declined last year. There were minor infestations during this period in other TSAs. Provincially, current attack totalled 3,129 ha in 2014 with infestations continuing to drop to only 284 ha this year. Intensity of defoliation was rated as 104 ha (37%) light, 145 ha (51%) moderate and 35 ha (12%) severe.

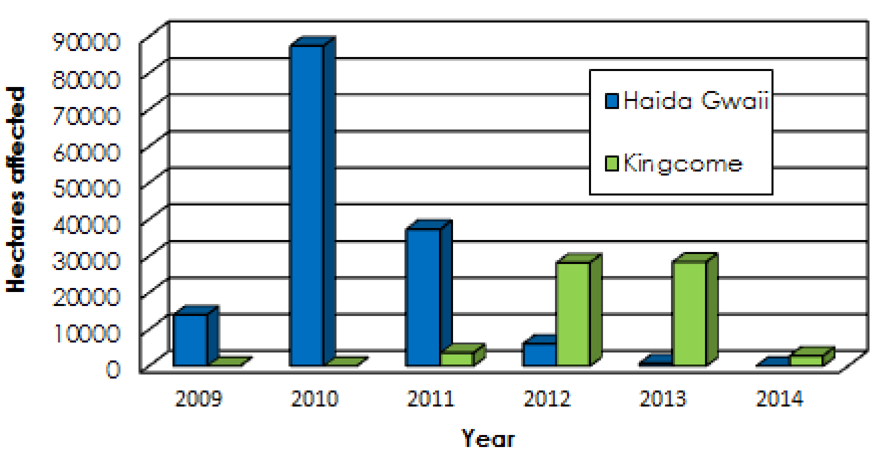


Figure 13. Current annual western blackheaded budworm defoliation by TSA, 2009 – 2014 (for TSAs with more than 28,000 ha of peak year damage).

All the damage was mapped in the West Coast Region. Haida Gwaii contained all the current damage mid TSA in small scattered disturbances from Kano Inlet south to Louise Island. One additional 17 ha polygon of mortality caused by repeated western blackheaded budworm defoliation was delineated west of O'Connell Lake in Kingcome TSA.

Western hemlock looper, *Lambdina fiscellaria lugubrosa*

After a western hemlock looper outbreak in the southern interior peaked in 2012 at 8,103 ha of defoliation, current damage declined rapidly (partially due to a successful treatment program in 2012) and no new disturbances have been observed for the past two years.

Pheromone traps at permanent sampling sites have been monitoring western hemlock looper populations in three TSAs 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 continued for three years (Table 6). The number of moths caught began to increase on average this year in Kamloops and Okanagan TSAs. The average increase in Kamloops TSA was due to a modest increase at all sampling sites. Increases also occurred at all sites in Okanagan TSA. The number of moths caught at Yard Creek rose sharply from 33 to 141 and remained at a relatively high level for the third consecutive year at Noisy Creek with 107 caught. Larval three-tree beatings were also conducted at permanent sample sites throughout Kootenay/Boundary and Thompson/Okanagan Regions and very few western hemlock looper larvae were found. Hence, both sources indicate that populations are generally still low so no treatment program is planned for 2016.

Year	TSA (# sites)		
	Kamloops (6)	Okanagan (10)	Revelstoke (11)
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
2015	22.0	61.6	6.2

Table 6. Average number of western hemlock looper male moths caught per trap at various FLNRO monitoring sites (6-trap clusters per site), 2011 - 2015.

Damaging Agents of Larch

Larch needle blight, *Hypodermella laricis*

After a large increase in 2011 and 2012 to just over 30,000 ha of damage, the effects of larch needle blight continued to be relatively low for the third consecutive year with only 4,768 ha mapped. Intensity of damage increased however, with 1,669 ha (35%) light, 3,095 ha (65%) moderate and 3 ha (<1%) severe. Host species were an even mix of alpine and western larch in 2013 but like 2014 the majority of the damage this year occurred in western larch stands. Almost all the noted infections were in younger stands.

Larch needle blight damage

Kootenay/Boundary Region continued to sustain the majority of the damage, with 4,602 ha mapped. Arrow TSA contained 1,894 ha of damage primarily in small scattered polygons and two larger infection centers just south of Edgewood, where some mature larch was also showing signs of infection. A total of 1,119 ha were mapped in Cranbrook TSA northwest of St. Mary Lake. Boundary TSA has 865 ha of larch needle blight damage, mainly in one polygon between Mt. Sloan and Tenderloin Mtn. The remaining damage in the region was observed in small scattered disturbances in Kootenay Lake (394 ha) and Invermere (351 ha) TSAs.

Larch needle blight damage remained low in Thompson/Okanagan Region, with 145 ha delineated in very small polygons. Almost all of the damage (135 ha) occurred in Okanagan TSA, primarily around Shuswap Lake. Kamloops TSA had a total of 10 ha of damage in two polygons near North Barriere Lake and Raft Mtn.

Larch casebearer, *Coleophora laricella*

Larch casebearer is an introduced defoliator, first recorded in BC at Rossland in 1966. A biological control program initiated in 1969 has been effective at keeping populations low and only minor damage (under 100 ha) has been noted during the AOS in 1995, 2010 and 2011. This year 32 ha of defoliation were mapped south of Coldstream in Okanagan TSA in the same general area that damage was found in 2011. One 6 ha polygon was rated as moderate intensity, with the remaining 26 ha recorded as light in another polygon.

Damaging Agents of Cedar

Yellow-cedar decline

Yellow-cedar decline damage remained relatively constant in the coastal areas of BC with 37,540 ha mapped (Figure 14). Intensity of damage was similar as well with 22,887 ha (61%) trace, 10,527 ha (28%) light, 3,309 ha (9%) moderate, 749 ha (2%) severe and 68 ha (<1%) very severe.

West Coast Region continued to sustain the majority of the damage with 26,827 ha delineated. Disturbances in Mid Coast TSA remained stable with 11,123 ha observed throughout the western portion of the TSA, particularly along inlets. Yellow-cedar decline damage in Kingcome TSA quadrupled to 8,948 ha. Disturbances were primarily noted from Wentworth sound to Kingcome Inlet and north of Knight Inlet. Damage in Haida Gwaii TSA dropped to a quarter of what was observed last year with 6,756 ha mapped. The disturbances were small and scattered throughout the TSA with most of the mortality noted in the north.

Yellow-cedar decline damage remained constant in Skeena Region at 10,714 ha. North Coast TSA continued to have the majority of the damage with 10,163 ha mapped along the entire coastline. Kalum TSA had 764 ha of damage, primarily around Devastation Channel and Tezwa River. One 102 ha disturbance was located in Lakes TSA west of Tesla Lake.

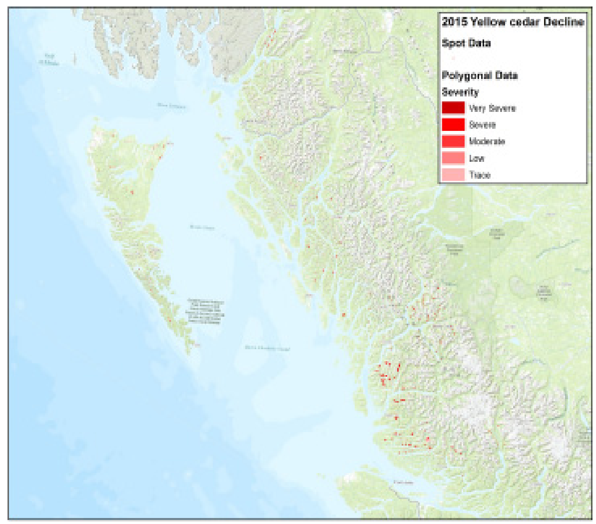


Figure 14. Yellow-cedar decline damage mapped in 2015, by mortality intensity.

Yellow-cedar decline in Haida Gwaii TSA

Damaging Agents of Deciduous Trees

Aspen (serpentine) leaf miner, *Phyllocnistis populiella*

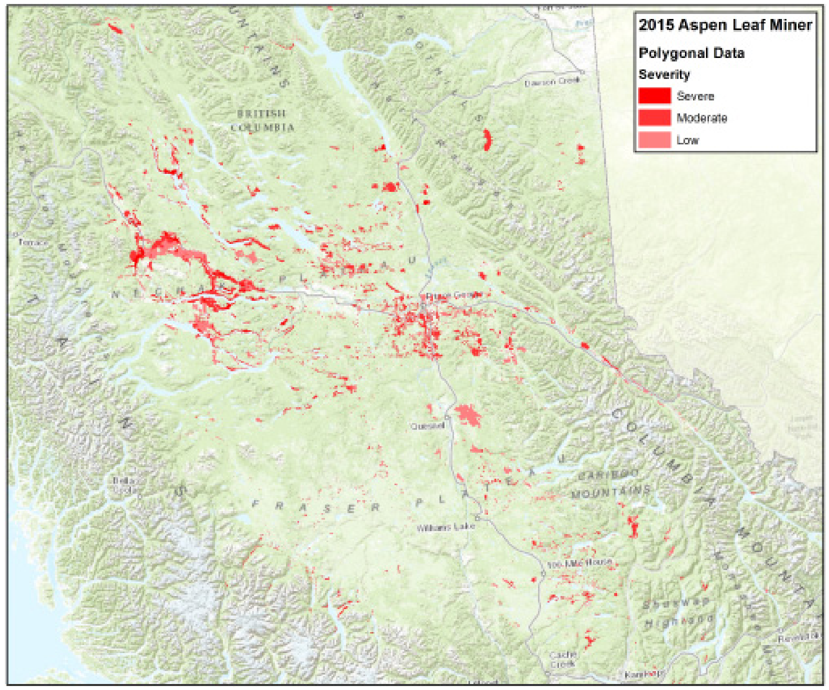


Figure 15. Aspen leaf miner defoliation mapped in 2015 by defoliation intensity.

The current aspen leaf miner outbreak has caused widespread damage since 2009, increasing annually to a record peak of 3,616,055 ha last year. In 2015 damage declined 74% to 942,085 ha (Figure 15). Intensity of attack (mapped as percentage of trees affected in a mapped disturbance) was classified as 376,044 ha (40%) light, 496,619 ha (53%) moderate and 69,421 ha (7%) severe, which was similar to last year. For the second consecutive year however, ground observers reported that the intensity of attack on a tree by tree basis was lighter than previously and fewer moths were noted in the spring. This combined with the drop in area damaged indicates that populations are generally declining. Many stands though have suffered several consecutive years of serpentine leaf miner combined with other defoliators and Venturia blight, particularly in north-central BC. This repeated defoliation has resulted in tree decline in the form of slower growth, smaller leaves and thinner crowns.

Trembling aspen continued to be the primary host but 950 ha of cottonwood leading stands were also damaged and a further 75,000 ha of attacked trembling aspen stands contained a component of damaged cottonwood as well.

Aspen leaf miner moth

Defoliation in the Omineca Region dropped a third since last year to 373,538 ha with decreases noted in all TSAs. Prince George TSA continued to have the bulk of the damage with 340,183 ha delineated, with heaviest concentrations in the southwestern portion of Prince George District. Smaller infestations were scattered throughout Vanderhoof District and damage in Fort St. James District was primarily found in the southern tip of the district. Defoliation in Robson Valley TSA continued to be noted along the Fraser River with a total of 18,063 ha mapped. Attack in Mackenzie TSA was confined to the Osilinka River area, one disturbance north of Ospika Arm, and the southern tip of the TSA with a total of 15,292 ha delineated. Portions of this TSA could not be flown in 2014 or 2015 and so the total defoliation for the TSA was probably higher for both years.

Aspen leaf miner defoliation decreased more than five-fold since 2014 in Skeena Region with 319,232 ha mapped. Damage decreased substantially in all TSAs in this region. Although some of the region couldn't be flown until the deciduous trees were undergoing normal fall colour change, it was still possible to differentiate the signature of trees damaged by aspen leaf miner. Disturbances of reduced size were noted in the same general areas as last year in the northern half of Lakes TSA, particularly along large lakes, where 192,592 ha were delineated. Most of the 105,180 ha recorded in Morice TSA occurred mid-TSA, with infestations in the north tip greatly reduced this year. The greatest decrease occurred in Bulkley TSA where 21,319 ha of damage were mapped this year, primarily near the Bulkley River. Only 141 ha of defoliation was noted in North Coast TSA along Alice Arm. Kispiox, Nass, Cassiar and Kalum TSAs all had substantial aspen leaf miner damage noted in 2014 but nothing was observed this year, though much less of the Cassiar TSA was surveyed in 2015.

Total area affected in the Cariboo Region actually remained the same as last year at 174,048 ha. This was due to mapped attack doubling in Quesnel TSA to 65,576 ha. Most of this increase was due to three large disturbances on Narcosli Creek, east of Marguerite and west of Coldspring House. Attack was recorded in similar areas as last year in Williams Lake and 100 Mile House TSAs with minor reductions to 59,848 ha and 48,624 ha, respectively. Infestations in Williams Lake TSA primarily occurred mid TSA south of Quesnel Lake and others were scattered throughout 100 Mile House TSA, particularly in the eastern half.

Aspen leaf miner damage in Lakes TSA

Aspen leaf miner attack remained steady in Thompson/Okanagan Region with 36,399 ha of damage delineated in generally the same areas as last year. Kamloops TSA sustained 32,009 ha of defoliation primarily mid TSA. Small scattered disturbances were chiefly located in the northern half of Okanagan TSA and accounted for 4,284 ha. Only one 106 ha polygon was delineated in Merritt TSA east of Murray Lake.

The largest decrease in aspen leaf miner defoliation occurred in the Northeast Region, where damage dropped from over a million hectares last year to 23,257 ha in 2015. Disturbances actually increased in Dawson Creek TSA more than four-fold to 18,415 ha, mainly on the Sukunka River and around Blackhawk Lake. This is most likely an artificial increase however, as damage was 34,295 ha in 2015 and the bulk of the deciduous defoliation couldn't be assessed in 2014 since most of this TSA was flown late in the year. Most of the regional decrease in damage occurred in Fort Nelson TSA, where widespread defoliation dropped to 4,842 ha, primarily located around the Fort Nelson and Liard River junction. None of the 19,724 ha of damage noted last year in Fort St. John TSA was visible this year.

Defoliation in Kootenay/Boundary Region dropped by a quarter since 2014 to 13,850 ha. Infestations actually rose slightly in Arrow TSA to 5,055 ha with concentrations north of New Denver and around Castlegar. Damage decreased slightly in Kootenay Lake TSA to 3,828 ha scattered throughout the TSA. Small disturbances in the southern half of Revelstoke TSA accounted for 1,432 ha. The largest decrease occurred in Golden TSA, where widespread attack last year contracted to only five disturbances totalling 2,432 ha, mainly along Blackwater Creek and on Wood Arm. Remaining aspen leaf miner damage was less than 800 ha per TSA in this region.

Damage in West Coast Region dropped by 80% since last year to 1,760 ha. The majority continued to be mapped in Mid Coast TSA (1,403 ha), all in the northeast tip around Qualcho Lake. The remaining 357 ha were located in Kingcome TSA north of Trophy Lake on Klinaklini River.

Forest tent caterpillar, *Malacosoma disstria*

A forest tent caterpillar outbreak located primarily in central BC began around 2008, with damage fluctuating annually between 200,000 ha to a peak of 711,297 ha last year. In 2015 area affected decreased to 609,999 ha, though intensity remained similar at 176,551 ha (29%) light, 236,126 ha (39%) moderate and 197,323 ha (32%) severe. The highest level of damage occurred around Prince George with scattered moderate defoliation northward, and light defoliation southward (Figure 16).

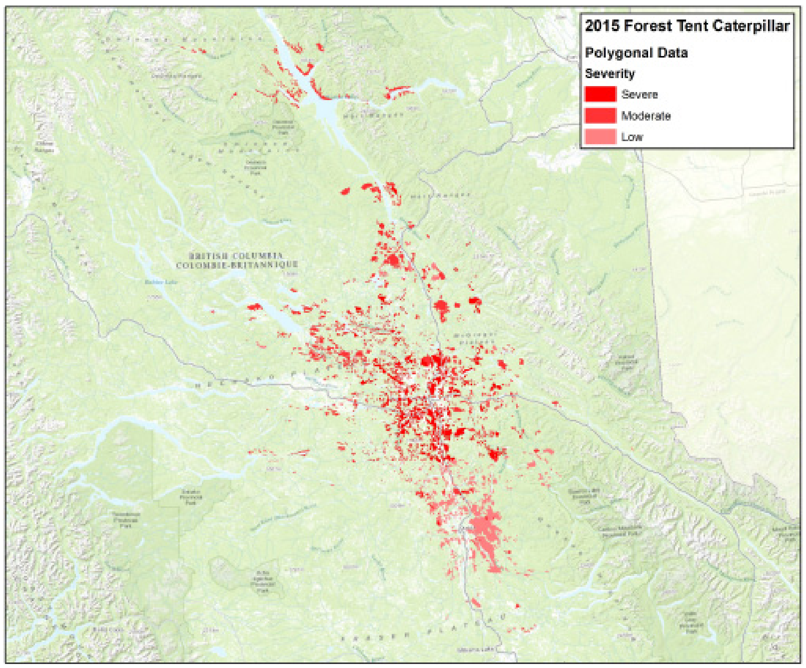


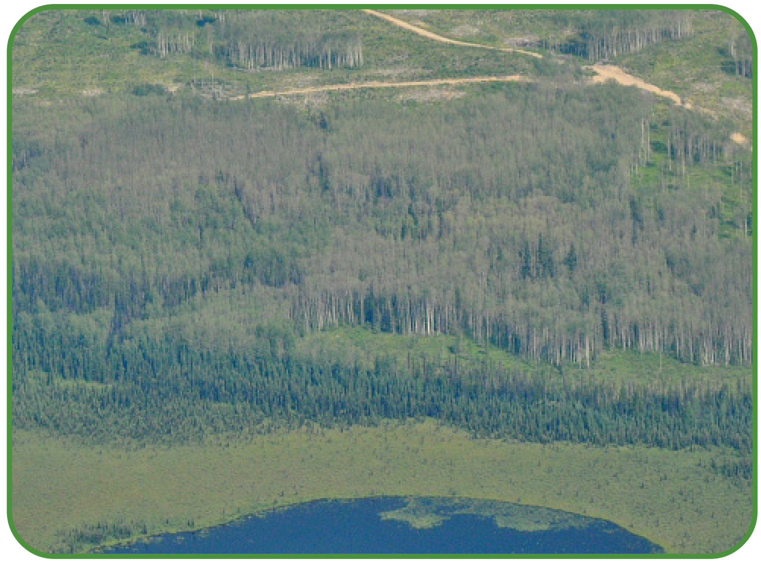
Figure 16. Forest tent caterpillar defoliation mapped in 2015 by defoliation intensity.

The main host species was trembling aspen, though 83,955 ha of attack included a cottonwood component. Most of the affected stands were mature. A lot of the defoliation was noted to be mixed with aspen leaf miner damage.

Attack continued to be most prevalent in Omineca Region with 478,334 ha mapped. The majority of this defoliation occurred in Prince George TSA (411,106 ha), with most of the disturbances mapped in the western portion of Prince George District, with some damage still occurring in the south tip of Fort St. James District and in the eastern half of Vanderhoof District. A total of 68,249 ha were mapped in Mackenzie TSA in 2013 but none was observed last year, due to the survey being flown too late for deciduous damage to be visible. This year 66,957 ha were mapped in Mackenzie TSA in the same general areas as 2013, which indicated damage occurred last year as well. Forest tent caterpillar defoliation in Robson Valley TSA declined to only one 271 ha disturbance along the Fraser River south of Mt. Rider.

Forest tent caterpillar defoliation noted in Cariboo Region increased slightly to 131,665 ha. Damage in Quesnel TSA remained virtually the same with 123,653 ha affected mid TSA, from Puntchesakut Lake east to the Sovereign Mountain area. This infestation pushed further southward into Williams Lake TSA this year, with damage more than doubling to 8,012 ha. Disturbances were mapped as far south as Bose Lake.

The relatively rare infestation noted in Fraser TSA of the South Coast Region last year was not visible during the AOS in 2015. However, some minimal damage was still visible from the ground in this TSA on roadside alder and was combined with western tent caterpillar.



Forest tent caterpillar defoliation in Prince George TSA

Bruce spanworm, *Operophtera bruceata*

A recent Bruce spanworm outbreak peaked in Northeast Region in 2010 at 1.7 million hectares. Defoliation dropped dramatically to only 9,043 ha in 2011 and damage since then has been endemic and not visible during the AOS. This year visible Bruce spanworm defoliation returned with 22,452 ha mapped in Dawson Creek TSA (Northeast Region), (Figure 17). Intensity of damage was rated as 4,212 ha (19%) light, 17,880 ha (80%) moderate and 360 ha (1%) severe. Aspen stands were most commonly affected, though cottonwood was noted as a secondary host species in some disturbances. Infestations were concentrated around Sukunka River and east of Tumbler Ridge, with a smaller area of damage around Indian Head on Williston Lake.

As several types of moths can defoliate aspen and cottonwood, district staff were able to ground confirm the causal agent. Most of the damage was caused by Bruce spanworm, though low populations of forest tent caterpillar were also observed. It is uncertain whether any damage may have been visible from the air last year as the survey was conducted in October in this area, when leaves were already shed naturally.

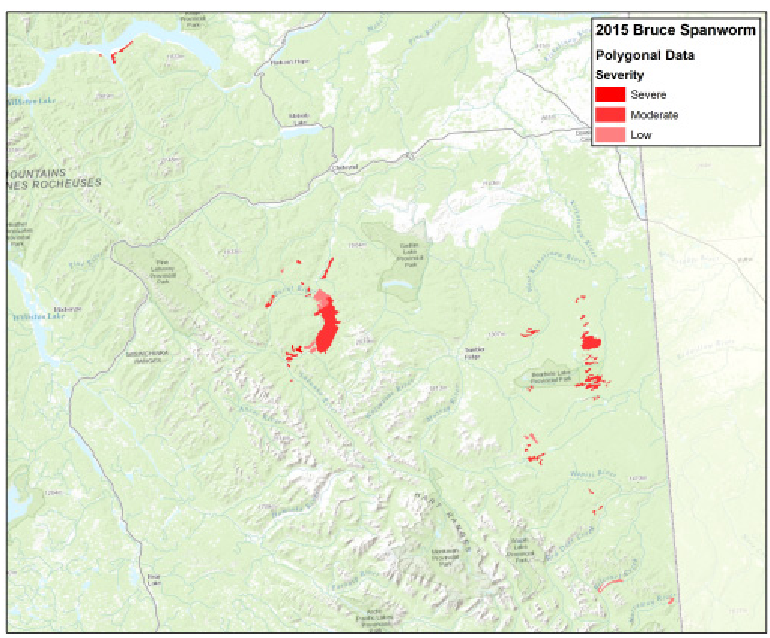


Figure 17. Bruce spanworm defoliation mapped in 2015 by defoliation intensity.

Venturia blight, *Venturia spp.*

Venturia blight damage (also known as aspen and poplar leaf and twig blight) recorded during the AOS peaked in 2013 at 837,586 ha, with almost all observed damage occurring in the northern half of the province. Last year damage declined to 559,583 ha and in 2015 the area infected by Venturia blight dropped again to only 13,636 ha. The relatively dry 2013 and 2014 summers most likely resulted in fewer infections. Intensity of damage increased however this year to 2,222 ha (16%) light, 9,171 ha (67%) moderate and 2,243 ha (17%) severe. Historically the most affected host has been trembling aspen. This year though in the two TSAs that contained the highest amount of damage (Kalum and North Coast) all the affected stands were cottonwood along lakes and rivers.

Disturbances were mapped on 9,662 ha in the Skeena Region in 2015. The majority (6,159 ha) occurred in Kalum TSA along Nass River east of Mill Bay. North Coast TSA sustained 2,310 ha of damage near Alice Arm. Damage in these TSAs was mapped late (October 3rd) and the trees were turning colour, but the distinct brownish tinge associated with Venturia blight damage in mature trees as seen from the height of the AOS was still visible and differed in tone from non-infected fall colour stands. Small very scattered infection centers covered 736 ha in Lakes TSA. Three disturbances northwest of Francois Lake in Morice TSA totalled 395 ha. One area of damage affected 62 ha in Kispiox TSA along the Skeena River west of Kitseguecla. Due to the warm wet late summer the Skeena Region experienced in 2015, Venturia blight infections may increase next year.

Aspen clone damaged by Venturia blight amidst healthy and aspen leaf miner affected trees

Omineca Region sustained 2,790 ha of damage. Of this, Prince George TSA contained 1,723 ha mostly in the Vanderhoof District along the Nechako River near Mt. Hobson. All 1,067 ha of Venturia blight damage in Mackenzie TSA occurred near Nation Arm of Williston Lake.

The largest decrease in Venturia blight damage occurred in the Northeast Region, where dry conditions were attributed for a drop from 429,269 ha in 2014 to 1,138 ha this year. Disturbances were all small and widely scattered throughout with 578 ha in Fort Nelson TSA, 311 ha in Fort St. John TSA and 249 ha in Dawson Creek TSA.

Two disturbances were noted in the northeast tip of Mid Coast TSA in West Coast Region. This damage was located north of Qualcho Lake and totalled 36 ha.

One 10 ha polygon was observed south of Batnuni Lake in Quesnel TSA in Cariboo Region.

Gypsy moth, *Lymantria dispar*

In 2014, Canadian Food Inspection Agency delimiting trapping in Surrey and Delta and follow-up ground inspections revealed an active and growing population of gypsy moth in these two locations. To address this potential threat of establishment, the BC. Gypsy Moth Technical Advisory Committee proposed a 4,576 ha aerial spray block in Surrey and a 204 ha spray area in Delta (Figure 18). Several weeks after the Pesticide Use Permit (PUP) Application for the aerial spray project was submitted to BC. Ministry of Environment, a late report of a positive find located directly south of the Surrey aerial spray block was recommended for treatment by ground spraying.

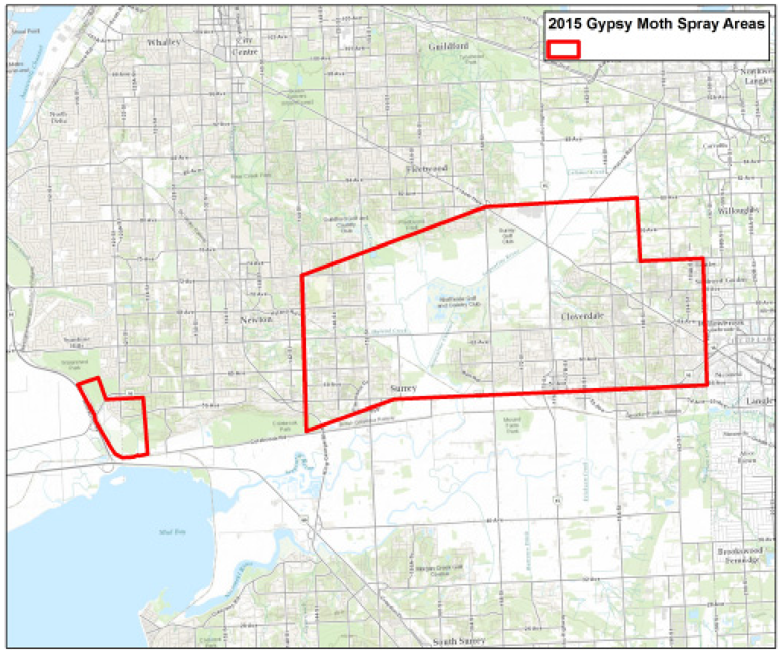


Figure 18. Areas aerially sprayed in 2015 for gypsy moth eradication.

Gypsy moth treatment conducted over Surrey

The Pesticide Use Permit was issued on February 16, 2015, and the first application began on April 15, 2015. As in previous spray projects, the Canadian Forest Service's Biosim model was used to determine treatment timing. An unusually warm winter and early spring resulted in the earliest possible initiation of the spray project allowed by the PUP. Treatment was conducted by Zimmer Air Services Inc. from Blenheim, Ontario, who used three helicopters – two twin engine, AS355F2 Eurocopters to treat the built up areas (residential/commercial areas) and one single-engine Bell 206 Long Ranger to treat the agricultural/non-built up areas. Foray 48B was applied three times at a rate of 4.0 litres/ha. A low flight exemption was obtained from Transport Canada to allow application heights over built up areas to be as low as 100 feet above the tallest building. Each application took approximately four days to complete and weather issues were minimal. As expected, there was intense public opposition to the treatment once it began which highlighted the difficulty of providing adequate notification to a large densely populated area.

Treatments were completed on May 12th and CFIA carried out a delimiting trapping program over the treatment area as well around locations of positive finds from 2014. CFIA also placed ~5,000 traps throughout the province in high risk areas (i.e., travel corridors, ports, etc.) and the FLNRO supplemented this monitoring by trapping high-use recreation sites. Trapping results were very encouraging as there were only 2 male moths caught within the Surrey treatment area, none in the Delta spray block and a total of only 31 moths in the entire province (Figure 19). Unfortunately, one Asian gypsy moth was trapped in Vancouver. The BC Gypsy Moth Committee reviewed the trap data and developed recommendations for follow up actions. No treatments are planned for the spring of 2016. All positive finds will be intensively trapped in the summer of 2016 and the results will available by late fall.

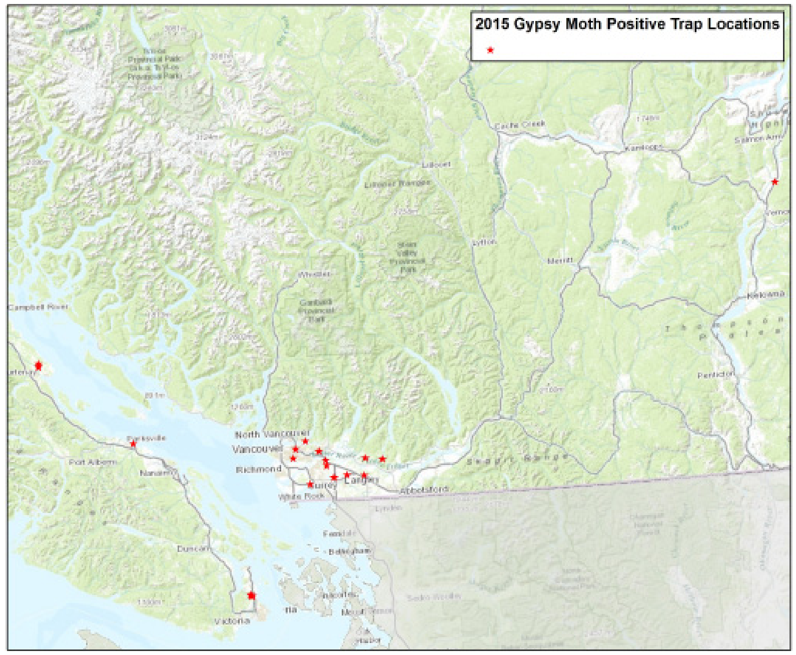


Figure 19. Locations where male gypsy moths were captured in gypsy moth traps in 2015.

Birch leaf miner, *Fenusa pusilla*

Both intensity and area of damage by birch leaf miner remained relatively constant compared to last year in BC, with 1,742 ha mapped at 689 ha (40%) light, 938 ha (54%) moderate and 115 ha (1%) severe.

For the second consecutive year the majority of the damage continued to occur in Thompson/ Okanagan Region where 1,646 ha of defoliation was observed. Kamloops TSA sustained 950 ha of damage, primarily in creek drainages off the south tip of Adams Lake with an additional three small polygons scattered around the Vavenby area. Attack in Okanagan TSA totalled 696 ha, mainly between Pritchard and White Lake with a few small polygons around Sugar Lake.

Light defoliation was observed in three polygons totalling 73 ha in Kootenay Lake TSA (Kootenay/ Boundary Region) on La France Creek southeast of Procter.

The remaining 22 ha occurred in Soo TSA (South Coast Region) in one polygon along Snowcap Creek.

Cottonwood leaf rust, *Melampsora occidentalis*

Cottonwood leaf rust damage was less than a third of that observed last year with 338 ha mapped provincially. Intensity of damage also decreased to 253 ha (75%) light and 85 ha (25%) moderate.

The majority of the disturbances continued to occur in Thompson/Okanagan Region, with 300 ha delineated. Most of this (222 ha) was noted in Okanagan TSA in two polygons at the south end of Mabel Lake. Several small polygons covered 77 ha in Kamloops TSA around Vavenby.

The remaining 39 ha of damage was noted in Mid Coast TSA of the West Coast Region, in two small polygons east of Bella Coola.

Aspen decline

For the fifth consecutive year, aspen decline was mapped during the AOS, but at a much lower level than previous years. Only 174 ha were mapped provincially, with mortality assessed as 128 ha (74%) moderate and 46 ha (26%) severe. It is recognized that deciduous declines are difficult to detect from the height of the aerial overview surveys and are most likely underestimated.

Five polygons east of Douglas Lake in Merritt TSA of (Thompson/Okanagan Region) totalled 122 ha. Three disturbances accounted for 47 ha near Hudson's Hope in Dawson Creek TSA (Northeast Region). The remaining 5 ha of damage was mapped east of Gustafsen Lake in 100 Mile House TSA (Cariboo Region).

Aspen decline in the northern part of the province is suspected to primarily be caused by a combination of several years of significant aspen leaf miner defoliation, Venturia blight infections, and other defoliators in specific areas. Trees thus weakened are also being infected by Cytospora and other cankers. This damage results in a general signature of trees with smaller leaves and smaller crowns.

Satin moth, Leucoma salicis

After a small peak in satin moth defoliation of 445 ha last year, damage in 2015 decreased to 131 ha in Thompson/Okanagan Region. Intensity was rated as 55 ha (42%) light, 49 ha (37%) moderate and 27 ha (20%) severe. All polygons were small (<20 ha).

Defoliation totalling 71 ha was scattered throughout the southern half of Okanagan TSA. In Merritt TSA, most of the 55 ha recorded were located west of Kingsvale. One 5 ha polygon was located north of Dunn Lake in Kamloops TSA.

Damaging Agents of Multiple Host Species

Abiotic injury and associated forest health factors

Wildfire damage in Prince George TSA

Wildfire damage was almost half that recorded last year with 265,788 ha burnt. Most of the fire data was obtained from the BC Wildfire Service (BCWS) as they GPS fire boundaries, which is more accurate than sketch mapping. Using BCWS figures allows for capture of all fires in a given year, including fires that occur after the AOS has been conducted. Fires obtained from this data set are given a default intensity of severe (fire damage often varies greatly).

The Northeast Region sustained the most wildfire damage with 146,145 ha burnt. Fires in Fort Nelson TSA were scattered throughout and many were very large (the largest was 43,737 ha) with a total of 130,593 ha of damage recorded. Fort St. John TSA had 15,469 ha burnt primarily in the northeast, with one 13,497 ha fire on the Alberta border near Etthithun Lake. Omineca TSA had 38,176 ha of wildfires. Most were very small and scattered with two exceptions: an 11,811 ha fire in Prince George TSA northwest of Bobtail Mtn. and a 4,966 ha fire in Mackenzie TSA northeast of Ospika Arm. South Coast Region had an unusually high level of wildfire damage (23,976 ha). Soo TSA contained 19,187 ha of this damage, primarily in two wildfires: one south of Mt. Athelstan around the Lillooet River and the other between Mt. Wilson and Exodus Peak. Fraser TSA had 4,320 ha burnt, mainly in two areas on Harrison Lake and the Nahatlatch River. Although the majority of the Skeena Region was too wet for significant fires this year 21,268 ha were damaged, chiefly in Cassiar TSA (19,398 ha) in two fires on Inklin River and south of Hayes Peak in the northwest. Most of the 14,248 ha burnt in Kootenay/Boundary Region were in the southern half of the southernmost TSAs. Of particular note was a 4,417 ha interface fire southeast of Westbridge in Boundary TSA. The Thompson/Okanagan Region had 10,948 ha damaged in mainly small scattered fires with the exception of one 5,174 ha interface fire north of Osoyoos in Okanagan TSA. The situation was similar in Cariboo Region where 10,087 ha were affected, with one large fire (8,059 ha) in Williams Lake TSA north of Puntzi Lake. The remaining 940 ha of damage occurred in the West Coast Region.

Post-wildfire damage was added as a category four years ago to capture mortality of trees due to varying factors (a combination of abiotic and beetle) within areas damaged by previous wildfires. Damage annually for the past three years was under 15,000 ha. In 2015, post-wildfire damage was substantially greater at 147,638 ha. Intensity of mortality was rated as 2,285 ha (2%) trace, 106,714 ha (72%) light, 36,197 ha (25%) moderate and 2,442 ha (2%) severe.

Most of the damage was mapped in Lakes TSA (Skeena Region) and Prince George TSA (Omineca Region) with 91,914 ha and 55,015 ha affected, respectively. Aside from a few minor disturbances, all the mortality was observed in lodgepole pine and spruce within a major 2014 wildfire on the boundary of the two TSAs around the Entiako River. Three polygons from this old wildfire fell into Mid Coast TSA (West Coast Region), accounting for 126 ha of damage. In the Cariboo Region small disturbances in Quesnel TSA (mainly north of Narcosli Lake) and Williams Lake TSA accounted for 513 ha of Douglas-fir, lodgepole pine and minor spruce damage. Two small polygons in the northern portion of Lillooet TSA and one in the south end of Okanagan TSA caused 71 ha of damage in the Thompson/Okanagan Region.

Drought damage continued to rise, most likely as a result of three consecutive dry, warm summers over most of the province, with the exception of Skeena Region. Damage almost tripled since last year to 72,053 ha. Intensity of mortality remained relatively constant at 6,432 ha (9%) light, 64,610 ha (90%) moderate and 1,011 ha (1%) severe.

Northeast Region continued to sustain the bulk of the damage (59,663 ha) in birch stands with some trembling aspen components (85%) and trembling aspen stands with minor cottonwood components (15%). Almost all this damage was rated as moderate; symptoms included wilted, chlorotic leaves. Fort Nelson TSA contained 48,837 ha, chiefly located in the southeast portion of the TSA. This continued into the northwest part of Fort St. John TSA, where 8,161 ha were affected. Smaller disturbances covered 2,665 ha in Dawson Creek TSA in the northeast corner of the TSA.

Drought damage in the Cariboo Region rose sharply to 8,354 ha affected from only 89 ha in 2014. Almost all (8,287 ha) of these disturbances occurred in lodgepole pine stands with minor Douglas-fir components scattered throughout the western third of Williams Lake TSA, primarily in the rain shadow of the Coast Mountains with the majority identified from Whitesaddle Mountain north to Chilanko River. An audit flight conducted after the AOS also noted extensive chlorotic lodgepole pine north of this area that may also be due to drought. Disturbances were noted to be typically on steeper slopes around dry rock outcroppings. Most of the trees were mature and though some were only affected with topkill, the majority of the trees appeared dead. Four small areas of redcedar damage in this TSA were mapped around Quesnel Lake. Two small polygons totalling 66 ha were also identified in Quesnel TSA.

Drought damage to lodgepole pine in Williams Lake TSA

West Coast Region also experienced a large increase in drought damage with 2,486 ha delineated. A total of 1,477 ha were mapped along the eastern edge of Mid Coast TSA. All affected stands were leading lodgepole pine and were an extension of the damage noted in Williams Lake TSA. Disturbances totalling 885 ha were observed primarily in amabalis fir north of Upper Quinsam Lake in Strathcona TSA. District staff also noted that drought was causing top dieback on Douglas-fir, particularly for young trees and on rocky outcrops.

Drought damage to Douglas-fir in West Coast Region

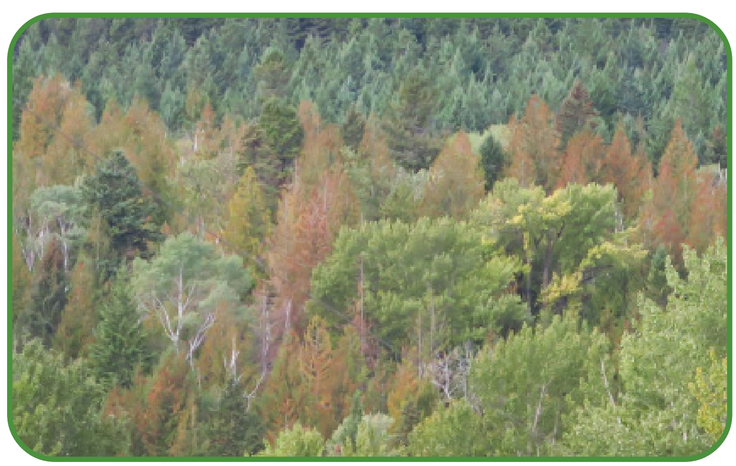
Other TSAs in the region had small scattered drought damage amounting to less than 50 ha per TSA.

Drought damage in Kootenay/Boundary Region covered 1,160 ha in 2015, with no damage noted last year. Most of the 564 ha delineated in Arrow TSA were composed of young trees with a minor amount of mature stands, with lodgepole pine and a small Douglas-fir component affected. Disturbances were mapped from Fosthall Creek south to Arrow Park on the west side of Arrow Lake. Ground checks found no sign of foliage disease and since both tree species were affected and needle damage was most prevalent to older needles, drought seemed to be the most logical agent. All 499 ha mapped in Cranbrook TSA south of Fernie were in redcedar stands. Damage was extensive enough throughout the stands that from the air it appeared to be moderate to severe defoliation, though ground checks confirmed the causal agent. Redcedar was also the species damaged in two disturbances totalling 49 ha on French Creek in Revelstoke TSA. The remaining 48 ha of damage in the region occurred in one disturbance in Kootenay Lake TSA near Ainsworth Hot Springs. The regional entomologist noted that redcedar drought damage was more extensive than mapped in this region and that it became more apparent in later summer after completion of the AOS. Damage occurred primarily on slopes at lower elevations, with redcedar turning chlorotic and exhibiting dead tops.

All 197 ha of drought damage mapped in Skeena Region occurred in redcedar stands. Kalum TSA contained two disturbances totalling 103 ha south of Kitseguicla and Kispiox TSA had 94 ha in two polygons north of Kitamaat Village.

Damage primarily to lodgepole pine and some spruce occurred in scattered disturbances in Prince George TSA (Omineca Region), with 113 ha affected.

South Coast Region contained 68 ha of observed drought damage. Almost all (64 ha) occurred in lodgepole pine in Sunshine TSA near Saumarez Bluff and Homathko River. District staff in this TSA also observed widespread chlorosis of redcedar due to drought. A few spot disturbances in various coniferous species were noted in Fraser and Soo TSAs. District staff in Fraser TSA also observed topkill on younger Douglas-fir along Harrison Lake on drier sites, and it is suspected some of the younger mature spots noted as Douglas-fir beetle in this TSA may be at least in part caused by drought.



Redcedar flagging caused by drought

Drought damage mapped in Thompson/Okanagan Region was over 12 ha in one Douglas-fir disturbance east of Grindrod in Okanagan TSA. After the AOS was complete in this region substantial redcedar flagging brought on by drought was noted in dry transitional zones, particularly around Falkland.

Flooding damage was only a third of what was mapped in 2014, with 13,158 ha observed across the province. As 2015 was the second consecutive warm dry summer across much of BC, a drop in flood damage was anticipated. Severity of damage was higher this year however, with 59 ha (<1%) trace, 1,241 ha (9%) light, 8,190 ha (62%) moderate, 3,651 ha (28%) severe and 17 ha (<1%) very severe. A large variety of conifer species were affected provincially, along with aspen in Fort Nelson TSA. Generally, disturbances were small and scattered throughout low-lying areas.

Northeast Region contained 6,884 ha of the damage. The flooding primarily occurred in boggy areas. Most of the mortality was in Fort Nelson TSA (5,595 ha), mainly in the eastern portion with concentrations between Fort Nelson River and Kotcho Lake. An additional 1,261 ha were observed in Fort St. John TSA chiefly in the north, east of Mt. Bigfoot and on Etthithun River. West Coast Region sustained 4,230 ha of flooding damage, primarily in Haida Gwaii TSA where 3,999 ha were affected. The Naikoon Park damage could not be ground checked but flooding seemed to be the most likely cause of the mortality noted in mature stands. South Coast Region contained 763 ha with most of the disturbances (718 ha) in the north tip of Soo TSA along Boulder Creek. Widely spread damage in Skeena Region totalled 430 ha, where the most affected TSA was Morice, with 119 ha delineated. Kootenay/Boundary Region disturbances covered 372 ha and Golden TSA had 107 ha of mortality, primarily along Mountain Creek west of Rogers Pass. Cariboo Region had 339 ha of damage with the majority (286 ha) mapped in scattered polygons and spots in Williams Lake TSA. Flooding damage in the remaining TSAs was less than 100 ha per TSA.

Flooding damage in Haida Gwaii TSA

Windthrow damage rebounded after a two year decline to 5,908 ha mapped provincially. Intensity was similar to last year with 8 ha (1%) trace, 126 ha (2%) light, 962 ha (16%) moderate, 4,226 ha (71%) severe and 586 ha (10%) mortality. Of the windthrow damage, 12% was attributed to snow/ice.

West Coast Region continued to be the most affected with 2,724 ha mapped, almost all of which (99%) occurred in scattered disturbances in Haida Gwaii TSA. Of the 1,028 ha noted in Cariboo Region, 984 ha were concentrated around Young Lake east to Bonaparte Lake in 100 Mile House TSA, primarily in Douglas-fir, lodgepole pine and spruce stands. All 598 ha of disturbances in the South Coast Region were mapped along the Fraser River north of Bridal Falls to Hope in the Fraser TSA. Kootenay/Boundary Region sustained 562 ha of scattered damage mainly in Douglas-fir and lodgepole pine stands. Most affected TSAs were Cranbrook (241 ha) and Invermere (174 ha). The majority of the windthrow damage in Northeast Region (total 431 ha) occurred in Fort

Nelson TSA in aspen stands just north of Old Fort Nelson. Skeena Region contained 400 ha of damage, most of which was scattered throughout Kalum TSA (302 ha) in primarily hemlock stands. Remaining windthrow disturbances across the province were minor and accounted for 100 ha or less per TSA.

Slides damaged double the area affected last year, with 5,620 ha mapped across BC. Whereas almost half the disturbances in 2014 were noted to be caused by snow avalanches, only 1% were identified as such this year. Intensity of damage was more varied in 2015, with 239 ha (4%) moderate, 1,593 ha (28%) severe and 3,788 ha (68%) very severe. Most of the disturbances were small (under 50 ha) and widely scattered. A large variety of tree species were affected.

Slide damage in Haida Gwaii TSA

Haida Gwaii TSA sustained the bulk of the damage provincially, with 5,142 ha recorded. All other TSAs had less than 100 ha of damage mapped per TSA.

Western redcedar weather damage affected 32,870 ha last year in the BC interior. Foliage damage was from the top down with the upper crown most affected and from the exterior inwards as opposed to regular redcedar flagging, where the oldest (interior) leaves are shed first from the bottom up. Damage was to all age classes on all aspects and slope positions but the heaviest damage occurred in sparsely treed, open canopy stands. In 2015 more typical redcedar flagging primarily due to drought was observed, but no new atypical damage was seen. A few mature stands south of Quesnel Lake appeared to have mortality due to last year's damage but this was not documented during the AOS.

Hail damage in Boundary TSA

Hail caused light damage to a variety of tree species in scattered stands on the north side of Highway 3 north of Eholt in Boundary TSA. Damage was not visible during the AOS but was observed on the ground.

Animal damage

Animal damage is often difficult to detect from the height the AOS is flown and is hence underestimated. The exception tends to be damage from substantial feeding that either results in tree mortality or significant top kill.

Black bear (*Ursus americanus*) damage across BC remained relatively stable with 3,680 ha affected. Mortality was assessed as 721 ha (20%) trace, 2,439 ha (66%) light, 127 ha (3%) moderate and 393 ha (11%) severe. Most of the damage occurred in young to intermediate aged stands. Lodgepole pine was the primary host in the interior but in coastal regions Douglas-fir and some redcedar and hemlock were attacked. All disturbances were small (most under 50 ha, none over 160 ha) and most were widely scattered across the landscape. Scattered mortality within young stands is marginally visible at AOS height, hence the lower the survey is flown the more attack is seen.

Kootenay/Boundary Region continued to have the highest level of bear damage with 1,743 ha mapped. Invermere sustained 532 ha of attack, primarily along the southern boundary and in the north tip of the TSA. Disturbances scattered throughout the southern half of Kootenay Lake TSA accounted for 333 ha. All 292 ha of damage mapped in Boundary TSA was along the eastern edge of the TSA; conversely almost all of the 275 ha of mortality in Cranbrook TSA was along the western edge. Attack totalling 273 ha in Arrow TSA occurred in the northwest portion of the TSA. Golden TSA had two disturbances of 38 ha mapped in total along the Bush Arm of Kinbasket Lake. Ground observations in this TSA also noted intensive bear damage east of Golden around Roth Creek and adjacent drainages in young lodgepole pine stands.

Bear damage to lodgepole pine in Williams Lake TSA

Bear damage in Cariboo Region continued to decrease to 1,212 ha. Disturbances in Williams Lake TSA were observed on 672 ha with the majority of the attack continuing to occur east of Wartig Lake. One polygon of diffuse bear damage in mature lodgepole pine was mapped in the west near Palmer Lake. All 384 ha in 100 Mile House TSA were mapped in the northeast tip of the TSA. Quesnel TSA sustained 156 ha of damage between Kimball and Ghost Lakes.

Bear damage is rarely recorded in the South Coast Region but 257 ha were mapped this year. Most (233 ha) was observed along the eastern edge of Fraser TSA. A further 23 ha were noted in Sunshine TSA on Horseshoe Lake, east of Okeover Inlet and north of Goat Island. Three spot areas were also recorded in Soo TSA.

Thompson/Okanagan Region bear damage was virtually the same as last year with 237 ha delineated. Okanagan TSA sustained 156 ha of scattered attack. Merritt and Kamloops TSAs had minor disturbances of 43 ha and 39 ha, respectively.

Bear damage in Omineca Region all occurred in widely scattered disturbances within Prince George TSA, totalling 131 ha. All other regions sustained very minor damage of less than 55 ha per region.

Snowshoe hare feeding on young lodgepole pine

Snowshoe hare (*Lepus americanus*) damage is usually on very young trees and is not visible from the height of the AOS. It was mapped however for the first time in 2013 in Skeena Region on 204 ha, and again in that region this year on 364 ha. Most of the damage this year (324 ha) was rated as severe with the remaining 40 ha assessed as light. Ground checks were conducted at some of the sites and damage was confirmed based on the feeding pattern and plentiful hare scat. The trees in these cases are older than usual (12 to 15 years) but the damage occurs in the upper portion of the trees when the snow is deep in the winter.

Two polygons totalling 200 ha of damage were noted north of Fulton Lake in Morice TSA. Three additional polygons and two spots in Lakes TSA affected 164 ha near Buckley Lake and north of Kapp Lake.

Porcupine (*Erethizon dorsatum*) damage noted as part of a complex of damaging agents in Fort Nelson TSA last year was not identified in 2015, though it is known that scattered feeding often results in topkill, particularly in northern BC stands.

Red squirrel (*Tamiasciurus hudsonicus*) feeding damage was observed from the ground this year on young lodgepole pine east of Okanagan Lake from Vernon south to Penticton in Okanagan TSA. Damage was primarily in the Montane Spruce biogeoclimatic zone, and many stands were classified as free growing.

Armillaria root disease, *Armillaria ostoyae*

Armillaria root disease is known to be prevalent throughout the southern half of the province but the damage is greatly underestimated during the AOS due to the difficulty of seeing the damage at the height flown. Additionally, some damage may be called Douglas-fir beetle although both agents may well be present. Most of the infection centers that are mapped are due to local ground knowledge by the surveyors.

Visible Armillaria root disease damage in 2015 was similar to last year with 575 ha mapped. Almost all of the damage noted was to Douglas-fir, though a few spot infections were hemlock. Intensity of damage was marginally higher than last year with 178 ha (31%) trace, 343 ha (60%) light, 21 ha (3%) moderate and 33 ha (6%) severe, all of which were spot infection centers.

The majority of the damage occurred in the West Coast Region. Strathcona TSA sustained 299 ha of the damage, primarily around Campbell Lake. Small scattered infestations affected 50 ha in Kingcome and 20 ha in the southern half of Arrowsmith TSAs. Infection centers were noted around Lardeau and north of Marblehead in Kootenay Lake TSA (Kootenay/Boundary Region), with 166 ha lightly affected. It was noted that Douglas-fir beetle is also a suspected agent in these disturbances. The remaining 39 ha of damage were located in the South Coast Region, with 37 ha scattered throughout Fraser TSA and four spot infestations in each of Soo and Sunshine TSAs.

Miscellaneous Damaging Agents

Unknown defoliator damage was recorded on 346 ha across the province with intensities of 182 ha (53%) moderate and 163 ha (47%) severe noted. The agent(s) of this defoliation could not be confirmed due to stand inaccessibility. All affected stands were mature. In the West Coast Region 182 ha were mapped in two moderate intensity hemlock disturbances on Lyell Island in Haida Gwaii TSA. Kootenay/Boundary Region sustained 142 ha of severe damage to hemlock stands. Two polygons totalling 71 ha occurred in Golden TSA and one disturbance of 71 ha was mapped in Kootenay Lake TSA. Judging by the aerial signature the regional entomologist suspects **grey spruce looper**, but this couldn't be confirmed. The remaining 22 ha of defoliation was observed in one stand of aspen on Kitsumkalum Lake in Kalum TSA of the Skeena Region, with a noted intensity of severe.

Apple ermine moth (*Yponomeuta malinellus*) defoliation was observed for the second consecutive year in the city of Terrace in Kalum TSA and also in Smithers of Bulkley TSA this year. Positive identification of the defoliator was made this year by the regional entomologist through rearing of larvae to adults. All species of apple trees in both communities were affected, with many trees in Terrace severely defoliated.

Apple ermine moth larvae

Fall webworm (*Hyphantria cunea*) defoliated shrubs and some aspen of all ages for the third consecutive year. Minor damage occurred at low elevations in the Thompson/Okanagan and Cariboo Regions. The most extensive damage continued to occur in transitional ecosystem areas between Kamloops and Barriere in Kamloops TSA. Affected hosts in this area were often completely stripped and covered in webbing.

Spruce weevil attack

Spruce weevil (*Pissodes strobi*) populations were observed to be very high in the northern half of the Kamloops TSA this year, particularly around Clearwater, Raft River and Spahats Creek areas. It is suspected that the warm and dry spring/early summer of 2015 allowed for an increased proportion of brood to successfully reach maturity and emerge that season, thus continuing to build on-site populations.

White pine butterfly (*Neophasia menapia*) caused a small patch of moderate defoliation in young ponderosa pine near Rock Creek in Boundary TSA. The majority of the insects were observed to have died of a disease in the larval stage.

Willow leaf blotch miner (*Micurapteryx salicifoliella*) defoliation was still quite prevalent for the sixth consecutive year in Fort Nelson, Fort St. John and Dawson Creek TSAs. Willow damage was also noted from the air in the mid portion of the Prince George TSA that was suspected to be willow leaf blotch miner, but this was not ground confirmed. Defoliation combined with drought damage is causing a decline in willow health. This damage was not mapped since willow is not a commercial tree species.

Willow leaf skeletonizer larvae of an unidentified species was noted to be attacking large clumps of willow in eastern side drainages of the North Thompson River in Kamloops TSA this spring.

Willow leaf skeletonizer damage

Yellow-headed spruce sawfly (*Pikonema alaskensis*) defoliation was noted on individual and small clumps of spruce trees scattered between Nelson, Salmo and Castlegar at lower elevations along the highway in the Arrow and Kootenay Lake TSAs. Some of the defoliation was significant enough that top kill is expected.

Forest Health Projects

Birch accelerated decline (BAD): new insight

Michael Murray Forest Pathologist, Kootenay/Boundary Region

Paper Birch (*Betula papyrifera*) is both economically and ecologically valuable in the Southern Interior of BC. This species provides syrup, veneer, beverage flavouring, medicinal tonic, and teeth cleansers. The presence of birch within conifer stands helps reduce spread of *Armillaria* root disease. Although no formal mapping has been conducted, BAD seems to be widespread throughout the Southern Interior and US Kootenays. Symptoms are primarily thinning foliage, top and branch die-back, and wilting leaves. These seem especially pronounced near crown tops, but often appear on entire trees. Within multi-stem clusters, individual trees often vary in degree of canopy kill. Many stands have had a majority of trees die. A variety of sites have been affected. No investigation of possible risk factors (e.g. aspect, soil moisture regime) has been performed.

Birch decline

Beginning in 2009, birch stands were visited to collect tree-ring samples and wood tissue infected with fungi. Twenty-five birch stands in the West Kootenays were visited. A subsequent sampling to detect potential *Phytopthera* species was also conducted. Tree-ring analysis indicates that beginning 1998-99, growth dropped significantly reflecting the onset of senescence and death in birch across the West Kootenay study area. High mortality occurred during the period 2000-2007, especially in 2003 (Figure 20). With a significant number of younger trees (41-60 years) succumbing, age-at-death does not appear to be a strong factor (Figure 21). Both 2003 and 2007 were record warm drought years.

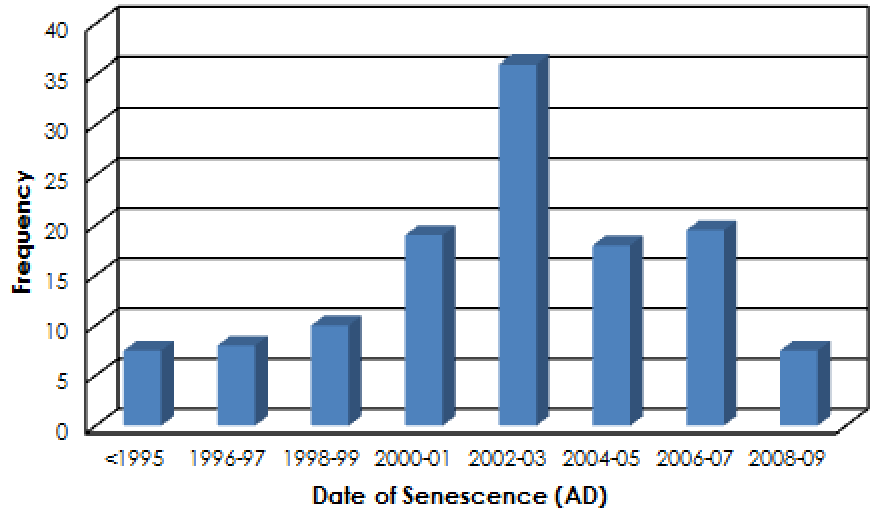


Figure 20. Death of paper birch.

From DNA barcoding, 35 fungal isolates were identified. No single species was common to all birch samples. However, the four most-common associates could potentially have a role in declining birch: *Fomes fomentarius, Cryptosporella tomentella, Armillaria ostoyae, and Cerrena unicolor.* No *Phytopthera* species were detected. A notable insect, bronze birch borer (*Agrilus anxius*) was found on about one-third of trees.

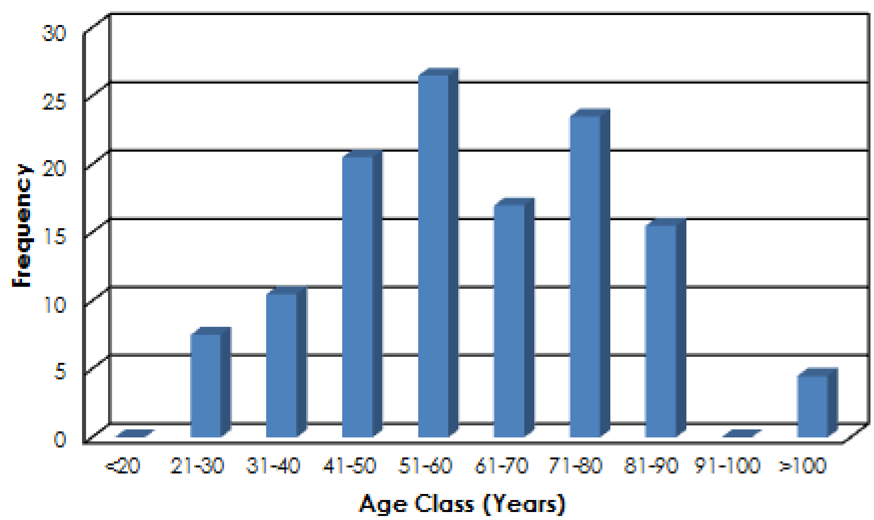


Figure 21. Age distribution of dead birch.

Forest 'dieback' and 'decline syndromes' are somewhat discrete events that are known to periodically impact individual tree species. They are typified by multiple agents of damage. A complex interaction of environmental stress combined with subsequent impacts of biotic agents is typical. For example, birch decline in Eastern Canada was associated with decreased moisture, higher soil temperatures, freezing of roots, insect defoliation, *Armillaria* and bronze birch borer. Our recent BAD event seems to share similarities with the eastern decline. Our tree-ring analysis indicates poor growth which is likely linked to dry conditions. Combined with record-high summer temperatures, tree stress has predisposed birch to multiple damaging agents. It's likely that whatever agents are endemic to a particular site, are able to overcome the natural defenses of stressed trees. Also of note, BC's southern interior and Idaho's northern panhandle are the southern-most extension of paper birch's range. Thus, being at the outer margins of their range renders them susceptible to climate-induced stress.

Copper sulphate trial against spruce beetle in Mackenzie District

Robert Hodgkinson Forest Entomologist, Omineca & NE Regions
Art Stock, Forest Entomologist, Kootenay/Boundary Region

Since the loss of the pesticide monosodium methane arsenate (MSMA) in 2008, the province has been searching for an adequate replacement to create "lethal trap trees" for use against spruce beetle and mountain pine beetle in inaccessible areas. A federal research permit was obtained from the *Pest Management Regulatory Agency* in 2015 to test liquid copper sulphate against spruce beetle and mountain pine beetle.

A total of 40 large diameter spruce trees were selected in the Mackenzie Community Forest in the Mackenzie District in early May and 30 were randomly treated on May 13th with one of the following dosages applied to axe-frilled phloem on each of 10 spruce: full-strength (25%), 1/2-strength (12.5%), or ¼-strength (6.3%), respectively. All trees were felled on May 27th and efficacy sampling occurred on Oct. 6-7th. Although the copper sulphate was translocated and an adequate beetle population attacked these trees, the full-strength dosage was not sufficient to kill attacking adults and prevent beetle reproduction.

Twenty lodgepole pine trees were selected on TFL 8 in the Selkirk Forest District, and randomly assigned to have a mountain pine beetle tree bait alone, or a bait plus an axe frill injected with full strength (25%) copper sulfate. The tree baits were applied on June 30th, copper sulfate treatments were applied on the 15th of July, and efficacy sampling was done on September 29th and 30th. There was evidence of copper sulfate translocation, however, treatment with copper sulfate did not appear to reduce female egg gallery length, or prevent development of larvae.

A decision will be made this winter on testing a higher dosage of copper sulphate or a different product in 2016.

Effects of the Pacific Decadal Oscillation on Yellow-cedar growth and mortality

Lori Daniels, Associate Professor, UBC Forestry
Jenny Liu, Bachelor of Natural Resource Conservation student, UBC Forestry
Stefan Zeglen, Forest Pathologist, South and West Coast Regions

Since the end of the Little Ice Age in the 1880s, yellow-cedar (*Chamaecyparis nootkatensis*) has been in decline along the coast of southeastern Alaska and northern British Columbia. Current evidence points to fine root freezing damage as the cause, with warming temperatures reducing insulating snow packs and causing earlier snowmelt. The Pacific Decadal Oscillation (PDO) is a cyclic ocean-atmosphere climate regime that may be exacerbating this process in its positive (warm) phase. In this study, we sampled a population of living and dead yellow-cedars near Prince Rupert, British Columbia to determine: 1) if different phases of the Pacific Decadal Oscillation affected radial growth response to temperature and precipitation, 2) if trees that were alive when sampled (2009) had a different PDO signature than dead sampled trees and 3) if the rate of tree deaths differed between phases of the PDO.

Cross dated ring-width chronologies from living and dead (when sampled in 2009) yellow-cedar were correlated with site-specific modelled climate data to quantify growth responses and mortality. Ring widths of yellow-cedar were sensitive to both growing season and winter climatic conditions. Climate-growth relations differed between trees that died versus survivors and these relations shifted between the negative (1946-1976) and positive (1977-2007) phases of the PDO. In contrast to survivors, the ring widths of trees that died were significantly negatively correlated with January and February temperatures and mortality was greater than expected during the positive PDO. Combined, these findings corroborate the hypothesis that warm winters with reduced snowpack limits yellow-cedar growth and contributes to tree death. It also provides preliminary evidence that multidecadal climatic variation associated with the PDO has accelerated yellow-cedar decline. Future research replicating this work is needed to verify the PDO effects on yellow-cedar growth and mortality. Improved understanding of spatio-temporal effects of climatic variation is needed to guide adaptive management of yellow-cedar in coastal British Columbia.

Field test of commercially available Douglas-fir beetle funnel trap lures, June 2014, Kootenay/Boundary Region

Art Stock, Forest Entomologist, Kootenay/Boundary Region

Kootenay/Boundary Region is using baited funnel traps in both Selkirk and Rocky Mountain Resource Districts to help manage Douglas-fir beetle populations. To optimise trapping efficacy, it is important to use the best available lures. There were two commercially available lures in 2014, one from Contech Ltd, and one from Synergy Semiochemicals Ltd. In order to assess which of the two lures was most effective, a three treatment nine replicate randomised complete block experiment was established at 3 km on the Limpid Creek Forest Service Road in the Pend d'Oreille River area of the Arrow TSA, where there was an active Douglas-fir beetle population. The treatments were:

Trap set for testing Douglas-fir beetle funnel trap lures, Limpid Creek FSR, June-July 2014, Kootenay/Boundary Region, south-east British Columbia.

1. Contech Douglas-fir beetle funnel trap lure (40 cm ethanol releasing at 28 mg per day, racemic frontalin at 2.6 mg per day, and racemic MCOL at 1.4 mg per day, all release rates at 20 C, all components at ≥99% purity)

2. Contech Douglas-fir beetle funnel trap lure as in (1), but which had been stored in a "domestic" freezer from 2009, so it was about 6 years old.
3. Synergy "enhanced" Douglas-fir beetle funnel trap lure (racemic frontalin, ≥95% pure releasing at 2-3 mg/day, racemic seudenol ≥97% pure 1-2 mg/day, Douglas-fir terpene blend ~100 - 200 mg/day, low release ethanol 95% pure 10-20 mg/day, all release rates at 20°C).

Cost per new lure was $7.75 for Contech, and $10.79 for Synergy, therefore the Synergy lure was 28% more expensive than the Contech lure. Traps were set up on 5th June, 2014, with approximately 20 m spacing. Treatments were re-randomised within replicates on 26th June and 3rd July. Traps were taken down on 3rd July, 2014. Data were analysed with a 2-factor analysis of variance (Systat 1998).

A total of 203,069 beetles were trapped in the 27 traps over the 4 week collection period. The Synergy lure was significantly better than the other 2 lures ($p < .001$), and the fresh Contech lure was significantly better than the Contech lure that had been stored in the freezer for 6 years (Table 7). The Synergy lure caught 60 percent of the total catch over the 4 week test, the fresh Contech lure caught 25 percent, and the 6-year old Contech lure caught 15 percent (Table 8).

Results indicated that the Synergy lure, although more expensive, was superior to the current Contech lure for mass-trapping of Douglas-fir beetle. Also, the performance of 6-year old Contech lure suggested that such long storage of any bark beetle funnel trap lure will marginalise the lure utility. How fast the deterioration actually occurs would be useful to know.

Thanks to Nazca Consulting Ltd. for meticulous field work on this project.

	Date			
	12 June	19 June	26 June	03 July
Trap lure	Catch per trap (mean ± S.E.)*			
Contech 2009	137 ± 24a	40 ± 12a	112 ± 56a	64 ± 20a
Contech new	279 ± 67b	59 ± 7b	163 ± 35b	75 ± 41b
Synergy	778 ± 93c	76 ±14c	459 ± 27c	188 ± 27c

* Means within columns, followed by a different letter are significantly different, $p < .001$.

Table 7. Average Douglas-fir beetle catch per baited funnel trap using 3 different lures, Limpid Creek FSR, June-July 2014, Kootenay/Boundary Region, south-east British Columbia.

	Date				
	12 June	19 June	26 June	03 July	Season Total Percent
Lure	Percent of total catch				
Contech 2009	6.0	1.8	4.4	2.8	15.0
Contech new	12.3	2.6	6.4	3.3	24.7
Synergy	30.6	3.4	18.0	8.3	60.3
Weekly Total	48.9	7.8	28.8	14.5	100.0

Table 8. Douglas-fir beetle catch in baited funnel traps, as percent of total catch, for 3 different lures, Limpid Creek FSR, June-July 2014, Kootenay/Boundary Region, south-east British Columbia.

Ice storm damage around Hope, BC

Lucy Stad Stewardship Forester, Chilliwack District

In early January 2015 a major ice storm hit the area around Hope, BC and caused significant damage to deciduous stands below 500 meters along the Fraser River, Coquihalla and Silverhope drainages. The majority of the damage was on non-commercial deciduous trees although top breakage was noted on some coniferous stands near Hope. Damage in a few young coniferous plantations was also recorded.

Ice storm, Hope BC

Kevin Buxton, Forest Health Specialist in Kamloops, developed an aerial survey methodology for snow and/or ice damage using methods previously used in the United States. During a helicopter flight, we simplified the rating system and used a combination of geo referenced maps in the Avenza program on iPads and paper copy maps to record the damage.

Damage occurred mainly to red alder (*Alnus rubra*) and bigleaf maple (*Acer macrophyllum*) where branches were stripped off and in harder hit areas, up to the top third of some trees were broken. Damage in a few coniferous plantations consisted of trees pressed toward the ground. These will be monitored to determine if rehabilitation work is needed or possible.

Since the majority of the damage was in non-commercial stands, the information will be compiled and recorded for future reference.

Lodgepole pine dwarf mistletoe sanitation trial established

David Rusch Forest Pathologist, Cariboo & Thompson/Okanagan Regions

A trial was set up to test the effect of lodgepole pine dwarf mistletoe (DMP) sanitation height on the subsequent spread and impact of lodgepole pine dwarf mistletoe on a site in the IDFdk4. Twelve 60 x 60 m square plots were randomly assigned to 0.3m, 1m, and, 2m sanitation treatments, and a no sanitation control treatment (3 reps per treatment). Circular plots (0.1 ha) were set up in each of the treatment blocks and then trees over the assigned sanitation height were marked and their diameter at breast height (dbh), height, distance and bearing from plot center recorded. The sites were then treated and planted. Using the pre-treatment plot centers, 0.05 and 0.1 ha circular plots were established after planting. Each plot was divided into 12 equal sectors. Within the smaller plot the trees were tagged and the sector, distance from plot center, dbh, height, and origin (planted or residual) were recorded. In the outer, larger plot only the location of infected dwarf mistletoe residuals was recorded. Due to lack of time and money, only two of the three replicates were measured in 2015. The third replicate will be measured and tagged in the spring of 2016. The preliminary results are shown in tables 9 and 10.

Rep	Treatment	Plot	Post treatment Stocking Prior to Plant in spring 2015 (stems/ha)	Planted and still alive in Aug 2015 (stems/ha)	Stocking after plant (stems/ha)	Damaged trees (stems/ha)	Damaged trees (%)
1	0.3 m	2	2420	1460	3880	460	11.9
2	0.3 m	3	1440	1340	2780	200	7.2
3	0.3 m	12					
mean	0.3 m		1930	1400	3330	330	9.5
1	1 m	4					
2	1 m	7	380	1560	1940	100	5.2
3	1 m	8	2960	1520	4480	600	13.4
mean	1 m		1670	1540	3210	350	9.3
1	2 m	1	5080	1980	7060	540	7.6
2	2 m	5					
3	2 m	6	2100	1400	3500	720	20.6
mean	2 m		3590	1690	5280	630	14.1
1	no sanitation	9	4420	1440	5860	920	15.7
2	no sanitation	10	7140	1360	8500	900	10.6
3	no sanitation	11					
mean	no sanitation		5780	1400	7180	910	13.1

Table 9. Pre and post planting stocking and damaged trees

Rep	Treatment	Plot	DMP residuals to remove pre-treatment fall 2014 (stems/ha)	DMP reduction (%)	DMP infected stocking pre-treatment[1] (stems/ha)	DMP infected[2] stems inner plot[3] (stems/ha)	DMP inner plot (%)	DMP infected stems outer plot[4] (stems/ha)	mean height all trees inner plot (cm)	mean height DMP infected stems outer plot (cm)
1	0.3 m	2	730	74	990	220	5.7	40	26	52
2	0.3 m	3	310	89	350	0	0.0	40	21	80
3	0.3 m	12[5]	220							
mean	0.3 m		420	81	670	110	2.8	40	24	66
1	1 m	4[4]	260							
2	1 m	7	150	60	250	40	2.1	60	24	84
3	1 m	8	220	55	400	80	1.8	100	35	60
mean	1 m		210	58	325	60	1.9	80	30	72
1	2 m	1	80	10	840	440	6.2	320	38	107
2	2 m	5[4]	50							
3	2 m	6	130	12	1070	420	12.0	520	41	96
mean	2 m		87	11	955	430	9.1	420	40	102
1	no sanitation	9	0	0	1560	1140	19.5	420	69	130
2	no sanitation	10	0	0	560	200	2.4	360	58	164
3	no sanitation	11[4]	0							
mean	no sanitation		0	0	1060	670	10.9	390	63	147

[1] assumes all residuals over treatment height were removed otherwise some double counting
[2] only trees with dwarf mistletoe shoots were considered infected
[3] inner plot was 12.62m radius (0.05 ha)
[4] outer plot was 17.85m radius plot with 12.62 m radius donut hole in the center (net area 0.05 ha). Only DMP residuals measured in outer plot.
[5] plots 4, 5, 11, & 12 have yet to be measured post planting

Table 10. Dwarf mistletoe levels pre and post sanitation and post planting mean tree heights

Planting density was similar in all treatments. The table shows increased stocking, damage, height, and infected dwarf mistletoe with less sanitation with the exception of the 0.3 m and 1 m sanitation treatments. Both the 0.3m and 1m treatment had similar dwarf mistletoe levels, stocking, and tree damage levels. Some of this lack of difference in the 0.3m and 1m treatment may have been due to the low initial stocking in plot 7, higher mean dwarf mistletoe levels in the 0.3m treatment, and failure to remove all trees over 0.3m in the 0.3m treatment. This trial will be re-measured periodically to see how long infected residuals remain over topping and to study the effect of sanitation height on any long term growth impacts from lodgepole pine dwarf mistletoe.

Sphaerulina musiva (Septoria musiva) disease of *Populus*

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

The detection and monitoring phase for *Sphaerulina musiva* on native and hybrid poplar (*Populus* spp.) continues as well as a new project on sanitizing poplar cuttings. Poplar cuttings are the means by which hybrid plantations are established and also a mode of transfer for *Sphaerulina* spores. By sanitizing cuttings the movement and introduction of the disease into new locations should be mitigated.

To date the disease has been confirmed in the lower Fraser Valley occurring mostly in hybrid poplar plantations and on adjacent wild growing black cottonwood. Hybrid poplar has been planted on private property for farm credits (providing tax incentives for legitimate farming). During 2013, 21 hybrid plantations were sampled and of those, 16 tested positive for *S. musiva*. These results suggest that the emergence of *S. musiva* in BC is related to the planting of susceptible hybrid poplars.

The movement of *S. musiva* on cuttings was further confirmed, operationally, during a September visit to a carbon capture project near Armstrong BC. Here the owner had propagated hybrid poplar by raising susceptible poplar stock in stool beds and then cuttings were taken and planted at three different sites. In one case the resulting 5 year old plantation was determined to be heavily infected with *S. musiva*. This was a new location for the disease outside of the Fraser Valley.

The owner was instructed to discontinue the further movement and planting of susceptible hybrid poplars. In the interim a sanitation project has been initiated between the University of British Columbia, FLNRO and the private land owner. The expected outcome for spring 2016 is that a protocol for sanitizing cuttings can be established, which would allow for future movement and plantings of disease-free poplar cuttings. Another objective is to use information to assess the risk of *S. musiva* expanding outside of plantations and threatening native *P. trichocarpa* in the Pacific Northwest.

Stump removal experimental trials: some preliminary findings

Michael Murray Forest Pathologist, Kootenay/Boundary Region

In natural forests, where *Armillaria* root disease is endemic, it plays an important role through its ability to weaken or kill trees, and contribute to stand structure, forest succession, decomposition, and nutrient cycling processes. However, in managed plantations, great volume losses can occur. Until recently, the effectiveness of *Armillaria* control in limiting root disease had been under-studied. Although some evaluative trials were established in the 1980s, results have been limited. This is because *Armillaria*-induced mortality within a plantation tends to peak between 12-20 years old, thus requiring considerable time for relevant findings to emerge.

Mushrooms indicating Armillaria root disease

Since the 1980s, the Southern Interior and adjacent northwestern USA have accumulated the greatest collection of root disease research sites in the world. These are typically divided spatially into separate treatments (stumps removed and stumps retained). At several sites, an additional treatment relies on the application of a potential biocontrol (*Hypholoma fasiculare*) on stumps. The most commonly measured responses are tree mortality, growth (height and diameter) and forest health, especially root disease.

During 2011-2013, thirteen trials were re-surveyed in the Kootenay/Boundary and Thompson/Okanagan regions. Ages of trials range from 10-32 years (avg. = 19). This dataset is composed of repeated measures on nearly 30,000 trees. Resulting analysis models included age as a continuous (=regression) covariate.

- Where stumps were removed, the number of *Armillaria*-infected trees was found to be about half of non-stumped treatments.
- Trees had greater diameters and height on stumped treatments.
- The greatest difference between treatments occurred in moist interior cedar-hemlock (ICH) habitats.
- Within the ICH moist group, basal area is estimated to be 63% higher at 31 years of age with stump removal.

Thus, preliminary results suggest stump removal leads to a lower incidence of *Armillaria* coupled with greater tree growth. Although these are desired goals from a timber production perspective, the environmental impacts and operational costs of stumping should also be factored in. Further analysis will continue, including a cost-benefit study.

Swiss needle cast monitoring update in the Chilliwack Natural Resource District

Lucy Stad *Stewardship Forester, Chilliwack District*

In 2012, we began monitoring the impact of Swiss needle cast (*Phaeocryptopus gaeumannii*) (SNC) on young Douglas-fir stands in the Chilliwack District. Varying levels of infestation have been recorded in all major drainages except in the northeast portion of the district around Boston Bar where only heavily stressed stands showed signs of light attack.

We are entering the third year of a multiyear project where monitoring lines are established in forty young Douglas-fir stands. Trees 6 to 12 years old are tagged and will be resurveyed every two years to determine the amount of needle loss over time. Years of needle retention are recorded for the fifth and sixth whorls of branches measured from the top of the tree. The goal is to determine the degree to which tree growth and survival are affected by the defoliation. Since SNC thrives when cool, wet spring weather occurs, we want to track the level of infestation over time.

Healthy Douglas-fir will retain their needles for up to 4 years. Surveys have shown that trees affected by SNC have one to three years of needle retention. Although some mortality was identified in the surveyed stands, none could be positively attributed to Swiss needle cast. Two years or less of needle retention has been found in surveyed stands west of Harrison Lake, the Chilliwack River Valley, along the east side of Harrison Lake and in drainages accessed from Highway 9 between Hope and Agassiz.

It will take further monitoring work to quantify potential impacts on the affected stands. In 2016, we plan to re-measure the monitoring lines established in 2014 in the western half of the district.

The ecology of decay in large cavity development

Harry Kope, *Provincial Forest Pathologist, Resource Practices Branch*

The project is a multi-discipline partnership with Ministry of Environment as the lead investigator and additional support from UBC, UC Berkley, private contractors and FLNRO. The FLNRO provides mycological support.

The project goals are to identify and quantify the factors influencing the rate and nature of decay and development of large wildlife cavities in standing trees, and use this information to develop effective management and mitigation approaches to help conserve this critical forest resource.

The objectives of the project are to characterize the community composition and distribution of primary fungal decay agents in den trees and compare findings with known host pathogens and decay agents for the tree species involved.

The project has focused on fisher (*Martes pennant*) dens in aspen and balsam poplar and some work on black bear (*Ursa americanus*) dens in western redcedar and yellow-cedar trees. Detailed sample collection has been exclusively on aspen and balsam poplar trees where discs cut from a stem at specific distances (between 30 and 150 cm) above and below a den cavity, as well, drill and core samples were taken from 'precursor' trees. 'Precursor' trees are not currently used as dens because they lack some characteristic needed for a safe and dry den, but the mammologist on the team indicated that they had the kind of opening on the stem and were in an area of the forest that would in the future, become denning trees. The cut discs were then subsampled from multiple locations (decayed wood, undecayed wood) for fungal material, and these collected samples were processed at both UBC and UC Berkley. The results although very varied, did identify decay fungi expected (*Phellinus sp*., *Cryptosphaeria sp, Sistotrema sp., Oxyporus sp., Hericium sp., etc)* and other unexpected fungi at the height of the cavities (*Armillaria sp*.). Subsequent year(s) of sampling will focus again on precursor trees to establish a microbial pattern, which can give insights to decay fungi in putative den cavities.

Using digital photography and Lidar height class data to identify root rot centers at Gavin Lake

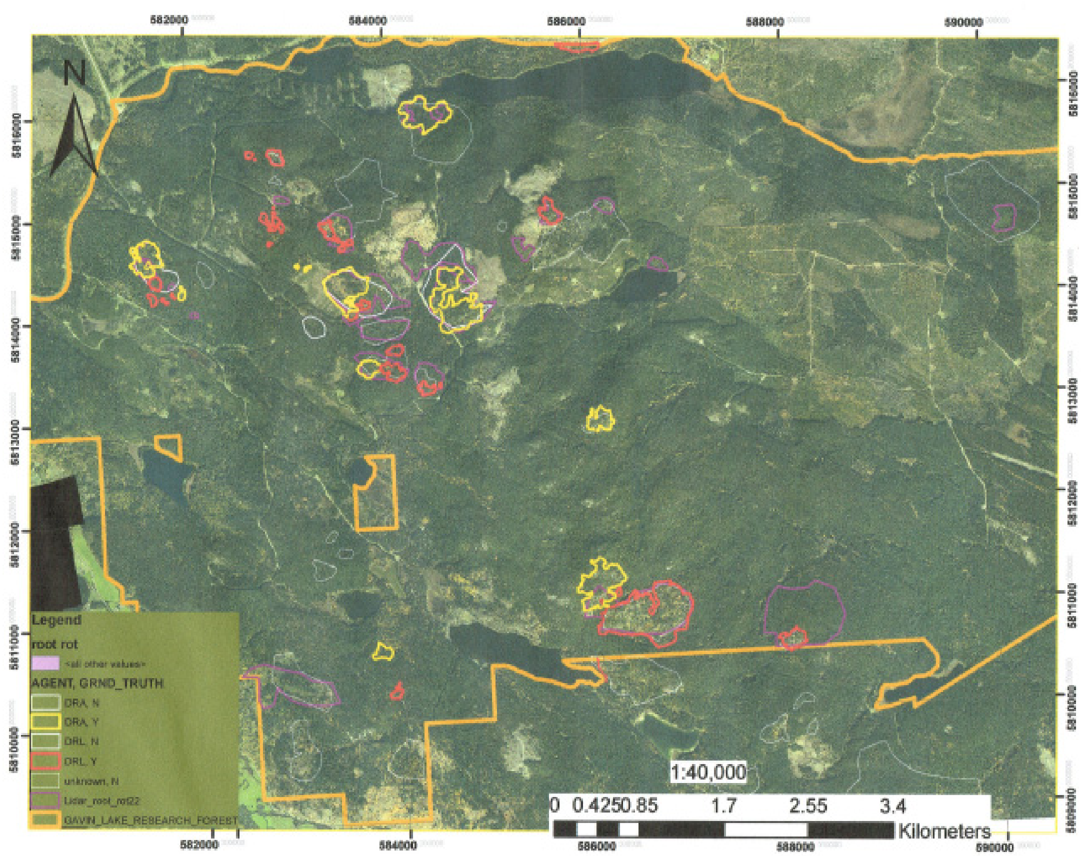
David Rusch *Forest Pathologist, Cariboo & Thompson/Okanagan Regions*

Root rot centers were identified in the Gavin Lake UBC Research Forest using imagery and Lidar height class data as well as information provided by the Research Forest. Twenty-three root rot polygons were identified from imagery and 15 were identified from Lidar height class data. These areas were then visited on the ground and root rot centers that were encountered were traversed and mapped and given a root rot severity rating. The centers were given an overall severity rating of between 0 and 10, where 0 represents no canopy loss and 10 represents 100% canopy loss.

A total of 42 root rot centers were identified on the ground. Seventy-one percent of the centers were laminated root rot and 29% were Armillaria centers but because the laminated root rot centers were about a third of the size of Armillaria centers (2.0 ha vs. 6.4 ha) the percentage of area infected by each root rot was almost identical. In a few instances Laminated and Armillaria polygons were adjacent to each other but they rarely overlapped. The lowest Armillaria severity rating was 3 and the lowest Laminated root rot severity rating was 7. This reflects the fact that a couple of the Armillaria centers had only scattered mortality. These Armillaria centers were much more difficult to map than centers with high severity ratings and were not detected from imagery. Both Armillaria and Laminated root rot showed a strong preference for south and southwest facing slopes. Eighty –four percent of root rot centers were south or southwest facing. Only 7% of root rot centers had north, northeast or east aspects. Most of the root rot centers (93%) were in the SBSdw1 and the remainder (7%) were in the ICHmk3. This probably reflects the fact that much of the ICHmk3 at Gavin Lake has a northeastern aspect.

Just over half (57%) of the ground proofed root rot centers overlapped with areas that were pre-identified from orthophotos or Lidar, 39% were not detected prior to ground truthing, and 5% were previously identified by the research forest but were not detected from orthophoto or Lidar height class data. Some of the orthophoto and Lidar identified root rot areas were much larger than the ground proofed areas that they overlapped with. Some of the most common causes for misidentification based on orthophotos and Lidar were deciduous patches, mountain pine beetle impacted areas, and partial harvest areas.

Inventory data was collected from inventory polygons that overlapped with root rot polygons. Live volume, crown class, age class, height class, percentage of Douglas-fir leading polygons, and polygons with a deciduous component in the inventory label were compared for inventory polygons with less than 50% of the area occupied by root rot and inventory polygons with more than 50% of the area occupied by root rot. Unfortunately, due to the small size of the average root rot center (3.1 ha) relative to the average inventory polygon size (17.4 ha) there were very few polygons with >50% root rot (seven Armillaria inventory polygons and four laminated inventory polygons out of a total of 100 overlapping inventory polygons) which made comparisons difficult. As expected inventory polygons with more than 50% root rot showed lower volumes (but only small reductions in crown, age, and height class) than inventory polygons with less than 50% of the area occupied by root rot. Root rot polygons were predominantly Douglas-fir leading as expected (77%) but the percentage of root rot polygons with a deciduous component was somewhat lower than expected. Only 55% of root rot polygons with more than 50% of the area in root rot had a deciduous component in their inventory label.



Gavin Lake Root Rot project

Forest Health Meetings/Workshops/Presentations

Adapting forest resource management to a changing climate

Jodi Axelson, Forest Entomologist, Cariboo Region

Venue: Field based workshop at the UBC Alex Fraser Research Forest, Williams Lake, BC October 7-8, 2015.

Abstract:
In the Cariboo region, 15% of the forested land-base is dominated by Douglas-fir, and 45% of the total area located in the Interior Douglas-fir (IDF) biogeoclimatic zone. The two most damaging insects of the IDF in the Cariboo region are the western spruce budworm and Douglas -fir beetle. The western spruce budworm has been at outbreak levels across the region for nearly two decades. In 2015 around 5,000 hectares was mapped in the aerial overview survey, which is the lowest level since 1999. Douglas-fir beetle populations have been steadily increasing since 2009/10 wildfire years and are now at outbreak levels across portions of the Cariboo region. One impact of climate change is increased temperature, which can influence Douglas-fir beetle populations directly through lower overwinter mortality, earlier emergence and longer flight periods, and possibly bivoltism (two generations a year instead of typical one generation); and indirectly through drought stress that impairs the ability of the host to resist mass attack. For western spruce budworm the impact of climate change is less certain as this insect's success is closely linked to the phenology of its host. If there is a decoupling in insect-host phenology, as has been demonstrated to have happened on Vancouver Island, then outbreak intensity could decrease in the future. Managing for these outbreaks requires the consideration of landscape to stand-level resistance and resilience. Resistance is the ability of a forest ecosystem to remain unchanged when challenged by disturbances, while resilience is the capacity of a system to absorb disturbance(s) and reorganize and change while still retaining essentially the same function, structure, identity, and feedbacks.

BC report at the National Pest Forum

Tim Ebata, Forest Health Officer, Resource Practices Branch

Venue: National Pest Forum, Shaw Centre, Ottawa, ON. December 1-3, 2015

Abstract:
The highlights from BC's 2015 AOS program were presented at the annual meeting of provincial and federal forest health representatives. The presentation highlighted the continuing decline of the mountain pine beetle, the Douglas-fir beetle and spruce beetle outbreaks, the decline in defoliator activity and gypsy moth eradication program results. Also highlighted were several special projects and studies carried out by regional and provincial forest health specialists including a review of potential forest health impacts resulting from recent droughts, an update on the *Septoria musiva* problem in hybrid poplar plantations, a quick summary of pest impact study results, and the recent announcement by the Forest Genetics Council's strategic plan performance measure of increasing use of seed with a genetic gain for pest resistance to 50% of select seed sown by 2035.

Dothistroma needle blight, weather and possible climatic triggers for the disease's recent emergence

Alex Woods, *Forest Pathologist, Skeena Region*

Venue:
WIFDWC, Newport Oregon, September 24th, 2015 and National Pest Forum, December 2nd, 2015.

Abstract:
Dothistroma needle blight (DNB), caused by the two fungi *Dothistroma septosporum* and *D. pini*, is a major disease of pines with a worldwide distribution. DNB has been reported from more than 63 countries, infecting over 82 different species of pine and several other non-pine species (Barnes et al. 2014). DNB infects needles of all ages, causing pre-mature leaf mortality and reduced photosynthetic capacity (Bradshaw 2004). Dothistroma spreads primarily by means of splash-dispersed asexual conidia (Gibson et al. 1964) which may be released and germinate any time temperatures are above 5 degrees C and moisture is available (Sinclair et al. 1987).

Recognition of increases in the severity of disease in areas where DNB has long been established and notable range expansions (e.g., Drenkhan and Hanso 2009) have resulted in the creation of the International Dothistroma Alliance (IDA) in 2006 and the subsequent EU COST Action FP1102 DIAROD (Determining Invasiveness and Risk of Dothistroma), that now includes members from 35 countries. The report is a product of collaboration fostered by DIAROD and its aim was to assess the relationship between DNB, weather factors and climate to better understand possible underlying causes of this recent intensification in disease. A substantial body of literature shows that the life cycles of the fungi are closely related to weather factors such as precipitation and temperature (Gadgil 1967, Peterson 1973). Total accumulations of summer rainfall of more than 100 mm/month are consistently associated with DNB outbreaks (Murray and Batko 1962, Dubin 1967, Peterson 1973, Marks and Hepworth 1986) but the distribution of precipitation events is perhaps more important (Gadgil 1977). Increasing trends in summer precipitation, particularly in the Northern Hemisphere, have been linked to increased DNB activity in both Europe and North America (Brown et al 2003, Woods et al 2005). Optimal daytime temperatures for DNB are 18-20p C while optimal minimums are 10-12p C (Gadgil 1974). When these temperatures are combined with favourable amounts of precipitation DNB can quickly take advantage.

Given the rapid response of DNB to favourable weather conditions it seems plausible that changes in disease behaviour could be due to changes in climate. If a climate fingerprint was to be found linking a forest pathogen to global climate variability one of the best candidates would be DNB given its global distribution (Barnes et al. 2014), known rapid response to favourable weather conditions (Peterson 1973) and worldwide recognition as a major disease of pines over the past six decades (Bradshaw 2004). The recurrent El Niño-Southern oscillation (ENSO) phenomenon influences patterns of temperature and precipitation in many regions of the world, often resulting in warmer and wetter conditions than normal (Zebiak et al. 2014). We found that since the 1950s, four of the past five strong El Niño events appear to have coincided with reports of increased DNB activity on an intercontinental scale.

This presentation reported on a publication of the same name (see publication section for authors and reference).

Gypsy Moth Aerial Spray Communications Issues

Tim Ebata, *Forest Health Officer, Resource Practices Branch*

Venue:
National Pest Forum, Shaw Centre, Ottawa, ON. December 1-3, 2015

Abstract:
Aerial spray applications over heavily populated urban areas are highly controversial and pose many communications challenges. The Surrey and Delta aerial spray program conducted from April 15 to May 12th, 2015 was no exception. This presentation described the numerous communications issues faced by provincial forest health staff in delivery of this important eradication program.

The manner in which the public keeps informed about important local issues has changed dramatically over the past decade with far less reliance on mainstream print, television and radio and, surprisingly, only being partially replaced by the internet and social media. The significance of this change was demonstrated clearly during the start of the first aerial application on April 15th when virtually no one in the treatment area appeared to be aware of the operation despite all of the efforts provincial officials used to communicate through the media options specified by the provincial pesticide use permit conditions.

Lessons learned from the project were:

1. In addition to the use of mainstream media, the internet and social media, "old school" household flyer drops should be employed earlier and more frequently.
2. Use of highway road signs was an effective means of communicating to commuters.
3. Social media was difficult to use as it requires near immediate responses to counter incorrect information.
4. More resources need to be dedicated for public information.

Ground spray operations for gypsy moth program

B.C.'s Climate Change Adaptation Strategy

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

Venue:
National Pest Forum, Shaw Centre, Ottawa, ON. December 1-3, 2015

Abstract:
As part of a panel highlighting different examples of forest health impacts being affected by climate change, my presentation described the initiatives the BC provincial government has invested in to adapt to the effects of climate change. I presented an overview of the high level strategies that guide adaptation efforts (i.e., BC's 2008 Climate Action Plan), and then to specific Ministry and regional action and adaptation plans, and further down to specific examples of "on the ground" activities designed to mitigate the predicted negative impacts of climate change. These specific activities included maintaining forest health monitoring – particularly of the impacts of extreme weather events, initiating assisted migration trials, expanding the use of western larch into new habitats (both moving into northern latitudes and higher elevations), and evaluating the forest health risks inherent to pushing species beyond their natural range.

A key component of the FLNR adaptation strategy, led by the Competitiveness and Innovation Branch, is training of as many operational staff as possible on basic climate change prediction tools, vulnerability assessments, adaptation options and tools and at the same time receiving input on possible operational barriers and challenges to implementation. To date, over 470 district and regional staff have attended the 12 training sessions over the last 3 years. The FLNR's has now established an excellent foundation of climate change adaptation skills throughout the organization.

Dryocoetes confusus, shaping subalpine fir forests

<u>Lorraine Maclauchlan</u>, Forest Entomologist, Thompson/Okanagan Region

Venue:
Entomological Society of BC Symposium, Kamloops, BC, October 17th, 2015.

Abstract:
The western balsam bark beetle is considered the most destructive mortality agent in subalpine-fir ecosystems, yet the actual impact of this beetle is not well quantified. Results from two long-term studies highlight the significant and on-going impact by western balsam bark beetle in high elevation forests of southern British Columbia. The wet, cold Engelmann Spruce-Subalpine Fir ecosystem (ESSFwc), is the most predominant ecosystem in southern BC containing subalpine fir, suffering moderate levels of attack by western balsam bark beetle, on average 0.8% trees killed annually. The very dry cold Engelmann Spruce Subalpine Fir (ESSFxc) ecosystem sustained the highest levels of mortality; averaging 1.6% trees killed annually (47% average in-stand mortality by 2014). Therefore it is reasonable to conclude that with continued and increasing climatic stresses in the ESSFwc, this ecosystem will likely experience higher and more severe levels of attack in the coming decades. The preponderance of red attack in the 2014 assessment compared to the first assessment in 1997 suggests that mortality is occurring at higher rates now than two decades ago.

Forest Insects: response to changing hosts and habitat

Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region

Venue:
Climate action planning workshop, Kamloops, BC, October 15th, 2015.

Abstract:
What has been learned from the recent mountain pine beetle outbreak? Future impacts to our forests could come as cumulative effects of numerous insect pests or low level impacts over a number of years. There could be another large outbreak of bark beetles, even mountain pine beetle in discrete settings, but over the next decade managers should be focusing on managing for resilient forests and increasing monitoring and risk-rating efforts. This presentation considered three main points:

1. Host condition
2. Insect population dynamics
3. Climate triggers (for hosts and for insects)

Tree species, ecosystem, present and future condition (e.g. age, stressors, singe or mixed species stand) should be considered in light of climate change and trigger events that may promote insect outbreaks or population declines. When thinking about future or potential insect outbreaks you must be able to evaluate host and stand conditions to make reasonable predictions, formulate prescriptions and take action.

There are numerous ways in which insects may respond to changing climate and host conditions. Some bark beetles may shorten their life cycles from two years to one year, or have multiple reproductive flights per year. Other insects such as the spruce weevil could expand their range significantly, both north and to higher elevations. Other factors to consider are whether an insect has facultative or obligatory diapause and what life stage overwinters, to mention a few. Changing and unpredictable weather events could create abundant host resource in the form of blowdown, ice breakage or stressed trees. Events and insect population dynamics and possible actions that can be taken to mitigate impacts were discussed.

Helicopter-GPS spruce beetle tour

Robert Hodgkinson, Forest Entomologist, Omineca & Northeast Regions

Venue:
Prince George and Mackenzie Districts, BC, October 30th, 2015.

Abstract:
An aerial overview helicopter tour was conducted in the Prince George and Mackenzie Districts, specifically including infestations south of Parsnip River, North of Chuchinka F.S. Road, around upper Bill's Creek, southwest of Wooyadilinka Creek, west of Tutu Creek and the Mugaha and Tony Creek drainages northeast of Mackenzie. MFLNRO staff from branch and the Omineca Region were aboard.

Spruce beetle flight participants left to right: Kelly Izzard, Timber Supply Analyst, Victoria; Diane Nicholls, Deputy Chief Forester, Victoria; Albert Nussbaum, Director, Forest Analysis and Inventory Branch, Victoria, Robert Hodgkinson, Regional Forest Entomologist, Omineca & N.E. Regions, Mike Byl, Authorizations Forester, Mackenzie District and Jacek Bankowski, Stewardship Officer, Prince George District.

IDF: a conundrum of issues

Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region

Venue:
South Area Dry Belt Fir Initiative Workshop, Kamloops, BC, November 3rd – 4th, 2015.

Abstract:
Insects are one of the key drivers in dry Interior Douglas-fir (IDF) ecosystems. Three of the dominant insects are Douglas-fir beetle, western spruce budworm and Douglas-fir tussock moth. Climate change will almost certainly result in more frequent, widespread, and intense Douglas-fir beetle outbreaks because of wind and snow damage causing an abundance of high quality host resource. Western spruce budworm has been at chronically high levels in the Thompson/ Okanagan Region for the past 30 years but we are currently experiencing a low point in the outbreak cycle. Each geographic outbreak region has its own periodicity and dynamics, but currently all areas are at a low level. The five lowest recorded years for budworm defoliation since the 1970's are 1970, 1971, 1995, 1999 and 2015. In both the early 1970's and mid- to late 1990's, budworm populations increased within a few years and area defoliated increased exponentially. The IDFxh and IDFdk are both highly susceptible and will continue to under-perform unless attention is put to density management, species and stocking selection but all forest structures are susceptible when budworm is in outbreak therefore additional treatment with *B.t.k.* will be necessary.

Douglas-fir tussock moth is a pest of very hot, dry, low elevation Douglas-fir forests. Outbreaks occur at intervals of 8 years on average in the Kamloops and Okanagan area (range 2- 17 yrs), and about 13 year intervals in the Simil-kameen. Outbreaks have been progressively occur-ring at higher elevations (increasing 100-200 meters per outbreak period) and each successive outbreak occurs predominantly in forests adjacent to but not within forests previously infested with tussock moth. To manage tussock moth, we should promote low density mixtures of Douglas-fir and Ponderosa pine. Future considerations: more attention should be put on detection and monitoring for all forest health issues in the IDF.

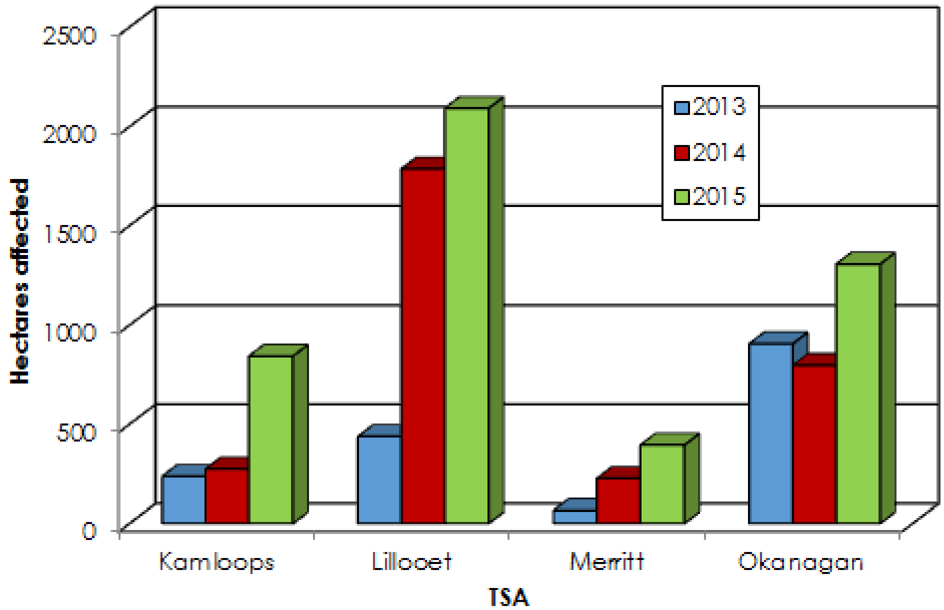


Figure 22. Hectares affected by Douglas-fir beetle in the Thompson/ Okanagan Region 2013-2015.

Spruce beetle ground survey detection courses

Robert Hodgkinson, Forest Entomologist, Omineca & Northeast Regions

Venue:
Prince George, BC, September 23-24th / October 27th and Mackenzie, BC, October 18th, 2015.

Abstract:
Attendees included: 50 consultants, 19 FLNRO staff (of which 11 were BCTS personnel) & 3 licensees.

The course outline was:

- 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 course consisted of a half-day in the classroom, a half-day in the field, and an optional 1 hour exam.

Suitable management practices when stumping for root disease control

Harry Kope, Provincial Forest Pathologist, Resource Practices Branch

Venue:
SISCO (Southern Interior Silviculture Committee), Salmon Arm, BC, September 14 to 16, 2015.

Abstract:
Root disease management as stump and large root removal, is a classical disease control method used in forests and many horticultural crops. A comparative analysis of different root disease control methods of infested forest sites (chemical, biological, integrated Silvicultural systems) shows that stump removal, although expensive, is the most effective method of control and eradication of root disease.

But what is an effective treatment? Also, what defines partial or incomplete stumping? And, is there a maximum stump size/diameter that cannot be stumped? And further, what is the area of risk around unstumped stumps? Does burning stumps work? And moreover, how is stumping to be done in variable retention areas?

Contractors and licensees have posed these questions to district staff, while in some cases actively altering their stumping practices based on their observations and experience. This was flagged as an issue in the Thompson/Okanagan Region, and subsequently a SISCO field tour was organized with the purpose of describing the biological and economic benefits of stumping from pre-harvest through harvest, and finally to the future growth and yield of a stand.

Forest Health Publications

Axelson, J., Smith, D., Daniels, L. and Alfaro, R. 2015. Multi century reconstruction of western spruce budworm outbreaks in central British Columbia, Canada. Forest Ecology and Management, 335: 235-248. doi: 10.1016/j.foreco.2014.10.002

Axelson, J.N. 2016. The effects of western spruce budworm (*Choristoneura occidentalis*) defoliation on Douglas-fir (*Pseudotsuga menziesii*): disturbance dynamics from the landscape to the cellular level. Ph.D. Dissertation. University of Victoria, Department of Geography.

Bowser, M.L. and A.J. Woods. 2016. Forest insect and pathogen epidemics in the Northwest Boreal Region. 2016. *FAO Forestry Paper*, in press.

Herath, P., Beauseigle, S., Dhillon, B., Ojeda, D.I., Bilodeau, G., Isabel, N., Gros-Louis[3], M-C., Kope, H., Zeglen, S., Hamelin, R. C., Feau, N. 2016. Anthropogenic signature in the incidence and distribution of an emerging pathogen of poplars. *Biological Invasions,* in press.

Hodgkinson, R.S., Stock, A.J. and Lindgren, B.S. 2015. Reducing spruce beetle *Dendroctonus rufipennis* (Kirby) (Coleoptera: Curculionidae) emergence for hibernation in central British Columbia by felling infested trees. *Journal of Agricultural and Forest Entomology* 17:439–444.

Kope, H.H.. 2016. Cedar Leaf Blight. *Compendium of Conifer Diseases*, 2nd Edition, *APS Press* (Ed. K. Lewis, G. Chastagner E. Hansen).

Maclauchlan, L.E., Brooks, J.E. and White, K.J. 2015. Impacts and susceptibility of young pine stands to the mountain pine beetle, *Dendroctonus ponderosae*, in British Columbia. *Journal of Ecosystems & Management* Vol. 15, No. 1: in press.

Maclauchlan, L. 2016. Quantification of *Dryocoetes confuses*-caused mortality in subalpine fir forests of southern British Columbia. Forest Ecology and Management 359 (2016) 210-220.

Murray, M. and P. Palacios (compilers) 2015. Proceedings of the 62nd annual western international forest disease work conference. 8-12 September 2014; Cedar City, UT. WIFDWC. 157 p.

Woods, A.J. and S.J. Frankel. 2016. Climate change and abiotic forest disturbances. *APS Compendium of Conifer Diseases*, in press, (Editor Everett Hansen).

Woods A.J., Martín-García J., Bulman L., Vasconcelos M.W., Boberg J., La Porta N., Peredo H., Vergara G., Ahumada R., Brown A. and J.J. Diez. 2016. Dothistroma needle blight, weather and possible climatic triggers for the disease's recent emergence. *Journal of Forest Pathology*, in press.

Spruce beetle mortality in Mackenzie TSA

Squirrel feeding on western gall rust infections

ACKNOWLEDGEMENTS:

Many thanks to the contributors to this document:

Data and project information:

Resource Practices Branch -	Harry Kope, Provincial Forest Pathologist
Kootenay/Boundary Region -	Art Stock, Forest Entomologist Michael Murray, Forest Pathologist
Thompson/Okanagan Region -	Lorraine Maclauchlan, Forest Entomologist Kevin Buxton, Forest Health Specialist
Cariboo Region -	Jodi Axelson, Forest Entomologist David Rusch, Forest Pathologist
Ominica & Northeast Regions -	Robert Hodgkinson, Forest Entomologist Jewel Yurkewich, Forest Pathologist
Skeena Region -	Ken White, Forest Entomologist Alex Woods, Forest Pathologist
Coast Regions -	Stefan Zeglen, Forest Pathologist
University of British Columbia-	Tom Sullivan, Agroecology Professor
Consultants -	Alta Vista Management BA Blackwell & Associates Ltd. Industrial Forestry Service Ltd. JCH Forest Pest Management Nazca Consulting Pro-Tech Forest Resources Ltd. TimberWright Contracting

Aircraft carriers for overview surveys:

- AC Airways
- Alpine Lakes Air
- Babin Air
- Cariboo Air Ltd.
- Glacier Air
- Guardian Aerospace Holdings Inc.
- Inland Air Charters Ltd.
- Kootenay Lake Aviation
- Lakes District Air Services
- Lawrence Aviation Ltd.
- Trek Aerial Services

Photographs:

- Aaron Bigsby (west coast drought)
- Aline Lachapelle (flood, slides)
- Art Stock (balsam fir tip blight, Douglas-fir beetle funnel traps)
- Bob Green (balsam woolly adelgid)
- David Rusch (root rot project)
- Don Wright (pine needle sheathminer close-up)
- Janice Hodge (hail)
- Joan Westfall (various remaining)
- Jodi Axelson (gypsy moth spray)
- Joe Cortese (Cariboo drought)
- Ken White (aspen leaf miner moth)
- Kevin Buxton (larch needle blight, aerial pine needle sheathminer, western balsam bark beetle Kamloops TSA)
- Lorraine Maclauchlan (western spruce budworm spray and larvae, white pine blister rust, cedar flagging, western gall rust)
- Michael Murray (birch decline, Armillaria root disease)
- Mike Byl (helicopter spruce beetle tour)
- Nick Reynolds (yellow-cedar decline)
- Richard Kean (apple ermine moth larvae)
- Robert Hodgkinson (western balsam bark beetle Omineca Region, mountain pine beetle Robson Valley TSA, spruce beetle Mackenzie TSA)
- Scott Denkers (ice storm)
- Sean McLean (hare)

Maps:

- Duncan Richards - HR.GISolutions

BRITISH COLUMBIA
Ministry of Forests, Lands and Natural Resource Operations

BRITISH COLUMBIA

Ministry of Forests, Lands and Natural Resource Operations