

An aerial photograph of a vast, mountainous landscape. In the foreground, a winding river flows through a dense, green forest. The middle ground shows rolling hills covered in lush green vegetation. In the background, rugged mountains rise under a clear blue sky with some light clouds. The overall scene is a beautiful representation of a natural environment.

2018 YUKON FOREST HEALTH REPORT


Yukon

TABLE OF CONTENTS

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Why We Have a Forest Health Program in Yukon	1
Yukon Forest Health Monitoring Strategy	1
Rotational Monitoring of Forest Health Zones	1
Aerial Surveys and Ground Truthing as the Primary Tools for Monitoring	2
Standards for Conducting Aerial Surveys.....	2
Identifying Yukon’s Major Forest Health Concerns	3
Summary of 2018 Forest Health Initiatives	6
Annual Forest Health Aerial and Ground Surveys	8
Weather and Biotic and Abiotic Disturbances	13
2018 Yukon Weather Summary.....	14
Summary of 2018 Biotic and Abiotic Disturbances	15
Biotic Disturbances.....	16
Forest Insects.....	16
Aspen Serpentine Leafminer (<i>Phyllocnistis populiella</i>).....	16
Large Aspen Tortrix (<i>Choristoneura conflictana</i>).....	18
Spruce Beetle (<i>Dendroctonus rufipennis</i>).....	23
Western Balsam Bark Beetle (<i>Dryocoetes confusus</i>).....	26
Willow Blotch Leafminer (<i>Micrurapteryx salicifoliella</i>).....	26
Forest Diseases.....	28
Pine Needle Cast (<i>Lophodermella concolor</i>).....	28
Spruce Needle Rust (<i>Chrysomyxa ledicola</i> , <i>Chrysomyxa ledi</i>).....	31
Abiotic Disturbances.....	32
Flooding and High Water Tables.....	32
Windthrow.....	32
Pest Complexes.....	35
Aspen Decline.....	35
Porcupine and Bark Beetles.....	38
Flooding Complex.....	41
Proactive Management of Mountain Pine Beetle	42
Monitoring Mountain Pine Beetle in 2018	43
Border Zone.....	43
British Columbia Observations.....	43
Using Bait Traps.....	46
Special Projects	47
Spruce Beetle Pheromone Trapping.....	47
Forest Health Extension	51
Other Noteworthy Disturbances in 2018	51
References	60

WHY WE HAVE A FOREST HEALTH PROGRAM IN YUKON

The Government of Yukon's Forest Management Branch (FMB) manages Yukon forests for sustainability and monitors and reports on forest health, a major component of forest management. The *Forest Resources Act* (FRA) supports forest health monitoring and recognizes that the long-term health of Yukon's forests must be maintained and protected for the benefit of Yukon people and future generations.

Under section 34-2 of the FRA, the Forest Management Branch director may develop research, monitoring plans and programs to:

- a) investigate the spread, effect and control of insects and pests as it relates to the protection of forest resources; and,
- b) support the advances in forest resource management.

This includes monitoring plans such the risk-based Yukon Forest Health Monitoring Strategy adopted by FMB in 2009

Yukon Forest Health Monitoring Strategy

The Yukon Forest Health Monitoring Strategy focuses on Yukon's forest stands that are most susceptible to the 10 forest health agents of greatest concern. Since its implementation in 2009, the strategy has met the three priorities described below each year.

The objectives of the Yukon Forest Health Monitoring Strategy are:

1. To provide a Yukon-wide overview of forest health issues;
2. To focus monitoring activities on high-risk forest health concerns across forested landscapes that are considered most valuable to Yukon residents; and
3. To monitor and assess forest health concerns and to determine and evaluate forest management responses.

The FRA regulations (sections 81 and 82) commit the director to provide a written report on the status of forest health in Yukon (the annual Forest Health Report) to the Minister of Energy, Mines and Resources (EMR).

Rotational Monitoring of Forest Health Zones

Yukon is divided into five forest health zones (FHZ) (Map 1). In these areas, monitoring focuses on forest stands that are most susceptible to the ten forest health agents of greatest concern. Each year since 2009, researchers have completed aerial surveys of one of the five zones, with FHZ 5 combined with another FHZ, given its small size.

This year marks the third year that FHZ 1 has been resurveyed, and the second year that FHZ 5 has been resurveyed. Given that baseline data has already been captured in each of the forest health zones, the mapping resolution from 2014 forward will be based on previous pest levels, FHZ size, and visibility. In 2018, a combination of grid and drainage flying was conducted, using a 12km grid.

Forest health reports are produced annually by FMB. These reports summarize the results of forest health monitoring and related activities, and drawn upon historical data to assess population trends. This historical data lies in both the FMB reports and Forest Insect and Disease Survey (FIDS) reports. In 2018 an additional source of historical FIDS spatial data has been made available and will be used for interpretation of population trends. This FIDS data generally represents point-source sampling for specific pests or that of permanent sample plots using a three-tree beating method to identify and quantify forest defoliators. This information will not only assist with assessing population trends but also help identify climate-induced changes to pest distribution.

AERIAL SURVEYS AND GROUND TRUTHING AS THE PRIMARY TOOLS FOR MONITORING

Aerial overview surveys and ground field checks are a relatively simple and low-cost method for effectively monitoring forest health over large areas (Ciesla, 2000; Mitton J.B. and M.C. Grant, 1980). Aerial overview surveys are also adequate for regional and provincial summaries and to meet national requirements for the Forest Health Network (BC Ministry of Forests, Lands and Mines and Canadian Forest Service, 2000).

As a result, aerial overview surveys are the primary tool for monitoring forest health in Yukon. The forest health aerial overview survey standards used by the BC Ministry of Forests, Lands and Natural Resource Operations are also used in Yukon, which ensures continuity across jurisdictions. Field checks are important for validating the data collected from the aerial surveys. Researchers check a portion of surveyed areas to confirm the identity and severity of the pest or disease disturbance.

Standards for Conducting Aerial Surveys

The following standards are used to conduct aerial surveys in Yukon:

- Use a Cessna 206 or equivalent high wing single engine airplane.
- Flying height of 800 m above ground level.
- Aerial surveyors use 1:100,000 scale maps.
- Two qualified aerial surveyors (one positioned on each side of plane).
- Each surveyor oversees a 4 km wide corridor (8 km gridlines) – in 2014 FMB modified this to a 6 km wide (12 km gridlines) corridor given that baseline data has been captured for each forest health zone.
 - In 2017, given the size of FHZ 4, the gridlines were increased to 14 km, or 7 km for each surveyor.
- Fly aerial surveys on clear days with sunny skies.
- Aerial surveyors map and record the severity and type of disturbance, such as:
 - Dead and dying trees caused by bark beetles.
 - Defoliation from insects and diseases such as budworm, leafminers or needle diseases.
 - Stressed or dead trees from climatic factors such as flood, drought or wind-throw.
 - Trees damaged by animals such as porcupines.

Aerial surveyors also use on-the-ground checks to confirm the type of disturbance recorded from the aerial surveys and digitize recorded mapping data to store in the Government of Yukon Geographic Information System.

IDENTIFYING YUKON'S MAJOR FOREST HEALTH CONCERNS



1a



1b



2a



2b



3a



3b

In 2009, FMB determined the top 10 concerns that pose the greatest risk (i.e. extensive mortality or defoliation) to Yukon forests – ones that can be effectively monitored as part of a risk-based forest health monitoring program. Eight are insects, one is a pathogen, and the last is an environmental effect called drought stress.

All these concerns can effectively be monitored with aerial surveys because their damage to trees is very visible.

The following is a rationale (based on Ott, 2008) for the identification of major forest health concerns that pose the greatest risks to Yukon forests:

1. Spruce bark beetle (*Dendroctonus rufipennis*)

This bark beetle is the most damaging forest pest of mature spruce (*Picea spp.*) forests in Yukon. A spruce bark beetle outbreak in southwest Yukon that began around 1990 has killed more than half of the mature spruce forest (primarily white spruce [*P. glauca*]) over approximately 400,000 hectares (ha).

1a Grey trees stand level damage, Spruce bark beetle Haines Junction, Yukon.

1b Adult spruce bark beetle.

2. Northern spruce engraver (*Ips perturbatus*)

The northern spruce engraver acts as both a secondary bark beetle that attacks trees infested with spruce bark beetle, as well as a primary pest that attacks and kills stressed spruce trees (primarily white spruce). The population of the northern spruce engraver beetle has increased in Yukon as a result of the increased availability of host trees associated with the spruce bark beetle outbreak in southwest Yukon. In 2008, infestations by the northern spruce engraver were at their greatest level since the beginning of forest health recording in Yukon. Spruce engraver beetle infestation was mapped in southwest Yukon at over 3,000 ha (Garbutt, 2013).

2a Single tree attack, Northern spruce engraver.

2b Young adults and larva, Northern spruce engraver.

3. Western balsam bark beetle (*Dryocoetes confusus*)

This beetle attacks subalpine fir (*Abies lasiocarpa*). Western balsam bark beetle moved north from BC. in the late 1980s and has become an active disturbance agent in mature subalpine fir stands in southern Yukon.

3a Single tree attack, Western balsam bark beetle, Watson Lake, Yukon.

3b Adults, Western balsam bark beetle.

4. Budworms (*Choristoneura spp.*)

The budworm guild, comprising of eastern spruce budworm, fir-spruce budworm, two-year cycle budworm and western black-headed budworm, cause similar defoliation damage to spruce, subalpine fir and larch (*Larix laricina*) forests in Yukon. In 2008, eastern spruce budworm damage was mapped across 1,000 ha in Yukon, primarily near Stewart Crossing. Historically, eastern spruce budworm damage has been mapped in the extreme southeast portion of Yukon (Garbutt, 2013).

4a Defoliation to tips of mature spruce trees, Spruce budworm, Stewart Crossing, Yukon.

4b Spruce budworm larva.

5. Larch sawfly (*Pristiphora erichsonii*)

This defoliator is the most damaging agent of larch in North America. In the mid and late 1990s, mature larch stands in southeast Yukon were heavily defoliated and experienced some mortality.

5 Larch sawfly larva.

6. Large aspen tortrix (*Choristoneura conflictana*)

This defoliator of trembling aspen (*Populus tremuloides*) periodically erupts into outbreaks that result in severe defoliation, branch dieback and, at times, extensive tree mortality. Outbreaks of large aspen tortrix have occurred in several places throughout Yukon, including Teslin Lake, Braeburn, Haines Junction, Pelly Crossing and Champagne.

6a Stand Level defoliation, Large aspen tortrix, Haines Junction, Yukon.

6b Adult moth, Large aspen tortrix.

7. Aspen serpentine leafminer (*Phyllocnistis populiella*)

This insect pest occurs throughout the Yukon range of trembling aspen and also defoliates balsam poplar (*Populus balsamifera*). Starting in the early 1990s, a massive outbreak of aspen serpentine leafminer extended from Alaska through Yukon, and into British Columbia.

7a Stand level damage, Aspen serpentine leafminer, Dawson City, Yukon.

7b Leaf mining, Aspen serpentine leafminer.



4a



4b



5



6a



6b



7a



7b



8a



8b



9a



9b



10

8. Pine needle cast (*Lophodermella concolor*)

This pathogen is the most common cause of premature needle loss of lodgepole pine (*Pinus contorta*) in Yukon (Garbutt, 2009). Pine stands in southeast Yukon are chronically infected and the disease is becoming increasingly common in central Yukon. In 2008, pine needle cast occurred from the British Columbia border to the Continental Divide, Yukon. The most northern observation of needle cast was observed in young pine stands in the Minto Flats-McCabe Creek area in the Yukon interior (Ott, 2008). The most severe damage in these pine stands covered 477 ha (Garbutt, 2014).

8a Stand level damage, from Pine needle cast, Minto, Yukon.

8b Damage to needles of young pine, Pine needle cast.

9. Mountain pine beetle (*Dendroctonus ponderosae*)

Though endemic to North America, this bark beetle is not present in Yukon. Most western pines in North America are suitable hosts, but lodgepole pine and ponderosa pine (*P. ponderosa*) are the most important host species (Logan and Powell, 2001). In western Canada, lodgepole pine is the primary host of this beetle (Campbell et al., 2007; Li et al., 2005).

Mountain pine beetle (MPB) is currently the most important forest health concern in western Canada. The current outbreak in BC is responsible for killing over 13 million ha of pine forests (Carroll, 2007). Cold-induced mortality is considered the most important factor controlling MPB dynamics (Régnière and Bentz 2007). A warming climate is expected to allow MPB to expand its range into higher elevations, eastward, and northward (Carroll et al., 2003; Régnière and Bentz 2007), potentially as far north as Yukon. Monitoring for MPB is a high priority because of its severe impact on pine forests during outbreaks and because of its confirmed proximity (80 km) to the Yukon border in 2011.

9a Mature pine tree attack, Mountain pine beetle, Rocky Mountain Trench, British Columbia.

9b Surviving larva at base of tree, Mountain pine beetle, Rocky Mountain Trench, British Columbia

10. Tree dieback due to drought stress

Trembling aspen tends to occupy the driest sites in Yukon. Because of this, dry site aspen stands are expected to be the first to exhibit dieback due to drought stress in a warming climate. In 2008, aspen stands exhibiting dieback were scattered along the North Klondike Highway between Whitehorse and Stewart Crossing. Most of these stands were on dry, rocky slopes and bluffs with south and west aspects, although some were located on level ground with well-drained gravel soil. Aspen stands experiencing dieback tended to be in an open canopy and were often stunted. Those on the rocky slopes and bluffs typically were adjacent to treeless steppe plant communities which are found on sites too dry for trees to grow (Ott, 2008).

10 Tree dieback of aspen due to drought stress, Mayo, Yukon.

SUMMARY OF 2018 FOREST HEALTH INITIATIVES

The following four initiatives were completed by FMB in 2018:

COMPONENT 1:

Annual Forest Health Aerial and Ground Surveys

In 2018, two separate aerial surveys were undertaken in order to map Yukon forest disturbances as described in the Yukon Forest Health Monitoring Strategy (Map 1):

- i. One-day survey to map FHZ 5 (Old Crow)
- ii. Five-and-a-half-day aerial survey to map FHZ 1 (Southwestern Yukon)

COMPONENT 2:

Proactive Management of Mountain Pine Beetle (MPB)

Yukon FMB continues to take a proactive approach to monitoring the northward expansion of the mountain pine beetle (MPB). A half-day aerial survey was undertaken to monitor the northward movement of the MPB along the Yukon/B.C. border near Watson Lake, as per the monitoring strategy.

The Five Year Mountain Pine Beetle Monitoring Strategy, implemented in 2013, describes and outlines monitoring activities for the next five years in Yukon. This plan will guide effective and efficient management for tracking the northern expansion of the MPB population.

COMPONENT 3:

Special Projects: Enhancing Knowledge Base to Inform Risk Management

Yukon FMB undertakes special projects to gain a better understanding of hazard, risk and host-pest interactions in Yukon Forests to help minimize the risk where possible. These surveys are often triggered by an abiotic event, such as extensive flooding, drought, wind events; or widespread presence of a biotic agent (pest or disease).

In 2018 one special project was initiated:

1. Spruce beetle pheromone trapping was undertaken in the Haines Junction area to 1) track the presence or absence of spruce beetle in Haines Junction Timber Harvest Planning areas; 2) better understand the timing of the spruce beetle flight period in the Haines Junction area; and 3) determine if spruce bark beetle populations are higher in some areas than others.

COMPONENT 4:

Extension – Community Engagement

FMB prepares and delivers presentations regarding forest health, either for special projects - (for example, the Mountain Pine Beetle Monitoring Strategy) or general information. These are conducted upon request or as required to communicate FMB programs.

FMB also responds to general forest health and pest incident reports from the public and from government agencies throughout Yukon. These reports are often incidental in nature. Pest incident reporting is covered under the section titled Other Noteworthy Disturbances in 2018, contained in this forest health report.

In addition to pest incidents reported by the public in 2018, FMB also followed up on an aerial observation of 'red trees' reported by a helicopter pilot near Little Salmon Lake in Forest Health Zone 2.

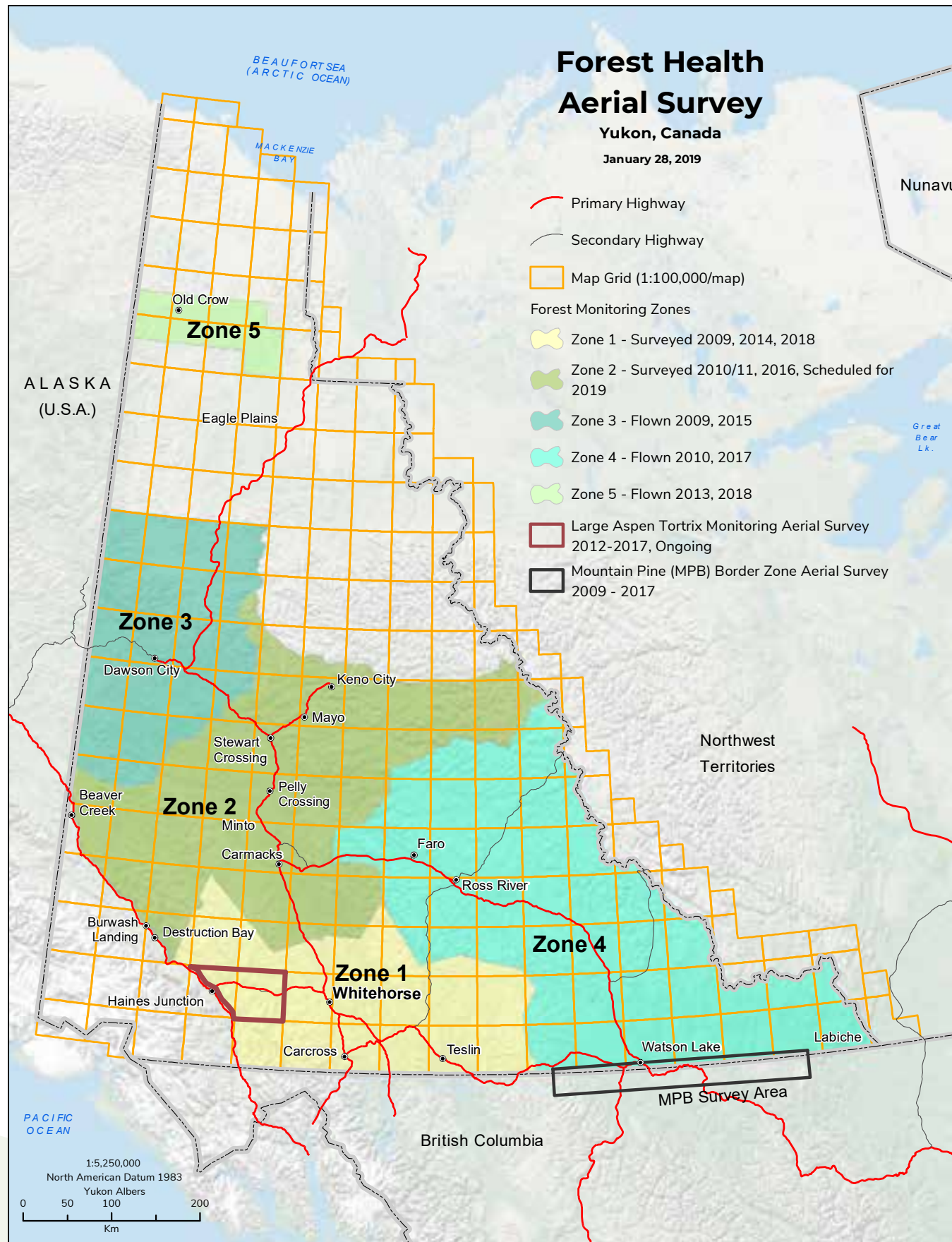


PHOTO 1 Two-person aerial survey crew with Cessna 206.

ANNUAL FOREST HEALTH AERIAL AND GROUND SURVEYS

In 2018 forest health surveys were directed at biotic and abiotic disturbances in FHZ1 and FHZ5. A five- and-a-half-day aerial survey of the forested area within FHZ 1, and a one-day survey in FHZ 5 was undertaken using an extended Cessna 206 fixed-wing aircraft (Photo 1, Map 2).

FHZ 1 is bounded by the BC border to the south, extending north to the Nisling River in the west and the Salmon River in the east, and eastward to continental divide in the Cassiar Mountains (Map 2). Its most northerly point is 61° N 56' N and falls entirely in the Boreal Cordillera ecozone (Photo 2-4). The forests consist mostly of homogenous or mixed stands of lodgepole pine, white and black spruce, and trembling aspen. It includes the communities of Haines Junction, Whitehorse, Carcross, and Teslin.

FHZ 5 is the most northerly forest health zone (67° 45' N) and includes a section of the Porcupine River drainage basin. This area provides material resources for the Village of Old Crow, including timber and firewood. The zone falls entirely within the Taiga Cordillera ecozone with the majority located north of the Arctic Circle. The forested areas are comprised of discontinuous but vigorous stands of white spruce and scattered larch along rivers. There are also continuous stands of stunted black spruce overlaying permafrost mixed in with discontinuous pockets of aspen along the upland sites.

FHZ 1 was flown using a combination of grid and drainage flying, with grid lines occurring 12 km apart allowing each surveyor to map six km on either side of the plane (Map 3). Major drainages were flown in FHZ 5 (Map 3).



PHOTO 2 Predominantly lodgepole pine forests with some trembling aspen and spruce intermixed with agricultural land; west of Whitehorse in Ibx Valley.



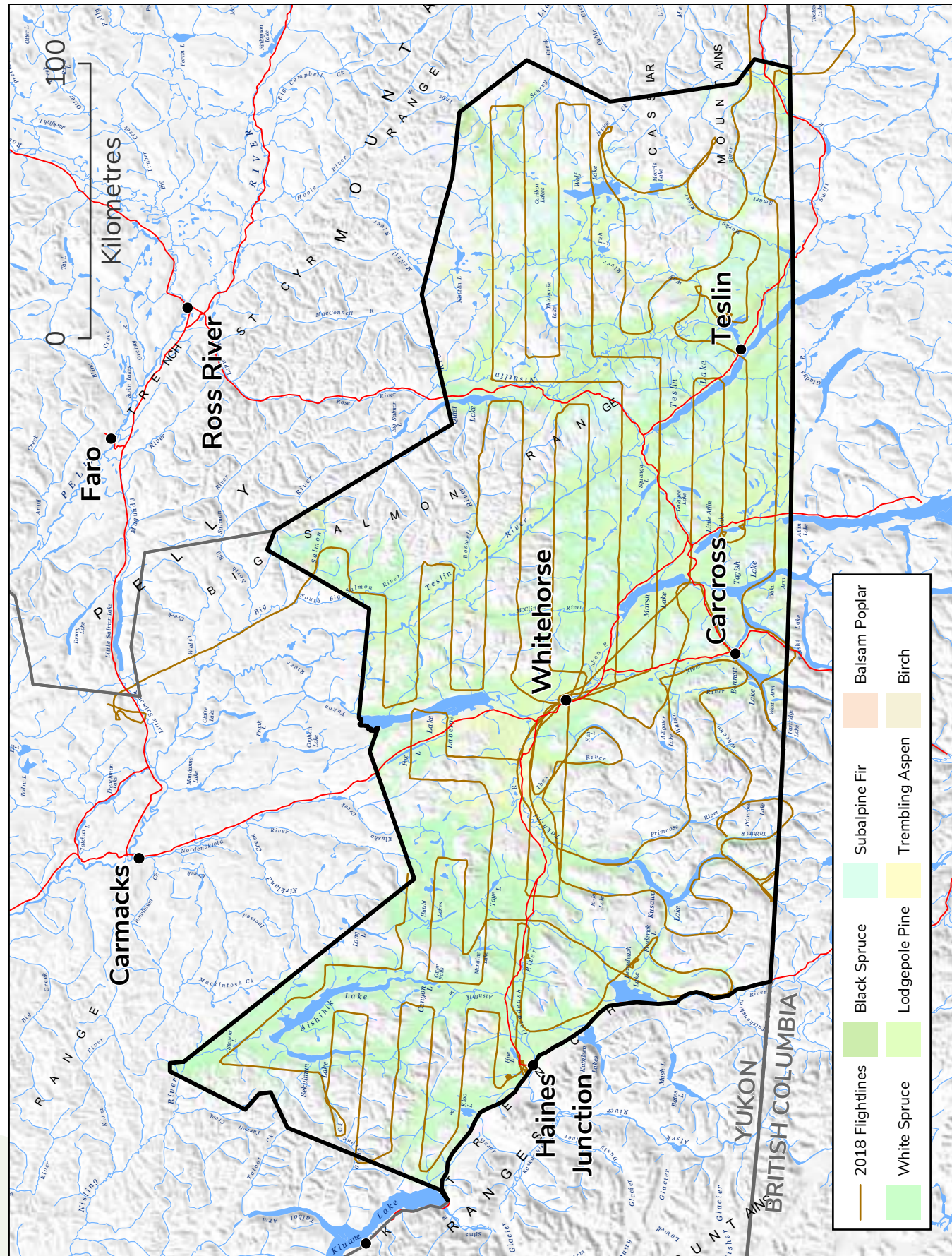
PHOTO 4 Lodgepole pine and spruce forests along the Wolf River, NE of Teslin.



PHOTO 3 Mixed forest types looking west towards Kluane National Park.



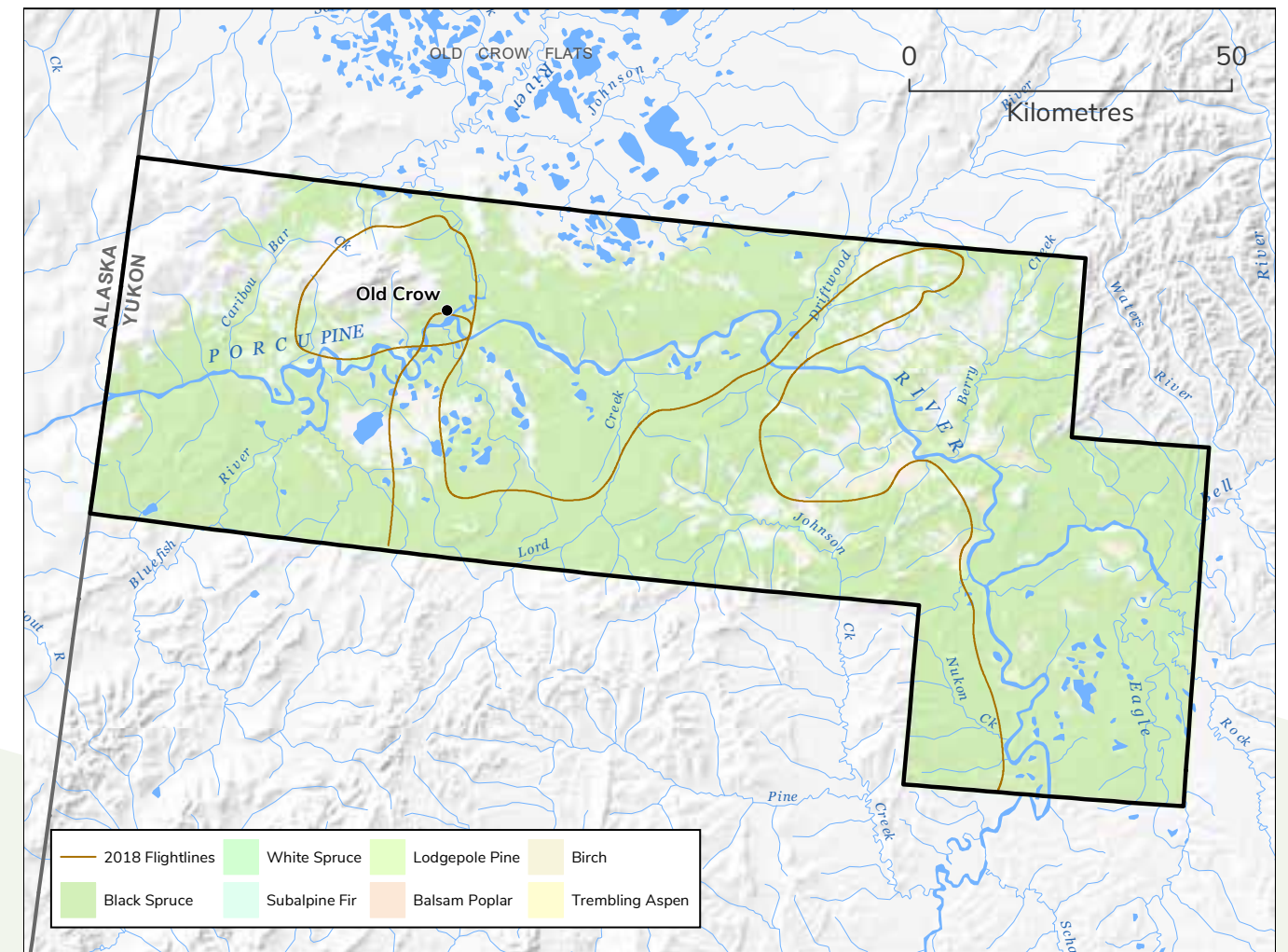
PHOTO 5 Landscape of spruce forests, Porcupine River and lakes and creeks near Old Crow.



11 MAP 2 Aerial survey flight lines in 2018 over Forest Health Zone 1.



PHOTO 6 White spruce forests along riparian zone of Driftwood Creek, south of Old Crow.



MAP 3 Aerial survey flight lines in 2018 over Forest Health Zone 5.

WEATHER AND BIOTIC AND ABIOTIC DISTURBANCES

Weather influences forest pests by affecting their development, survival, reproduction, and spread and establishment rates, as well as altering tree phenology (life cycle events) and susceptibility. Indirectly weather influences the levels of natural enemies and hence the incidence, severity, and frequency of pest outbreaks. Weather itself can also cause abiotic damage such as flooding, wildfire, red belt, etc. Given climate change it is important to view annual pest conditions in the context of weather to help reduce the uncertainty associated with the effects of climate change on forest pests. The following provides a summary of weather in Yukon in 2018 based on 21 weather stations throughout Yukon.

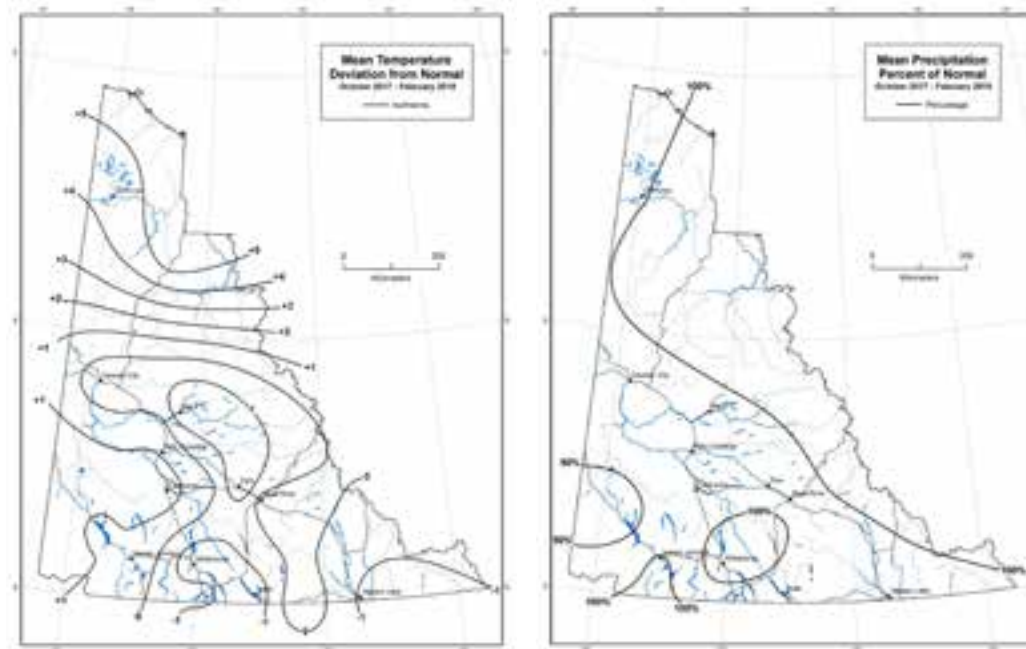


FIGURE 1 Temperature (left) and precipitation (right) anomalies, Oct 2017 to Feb 2018.

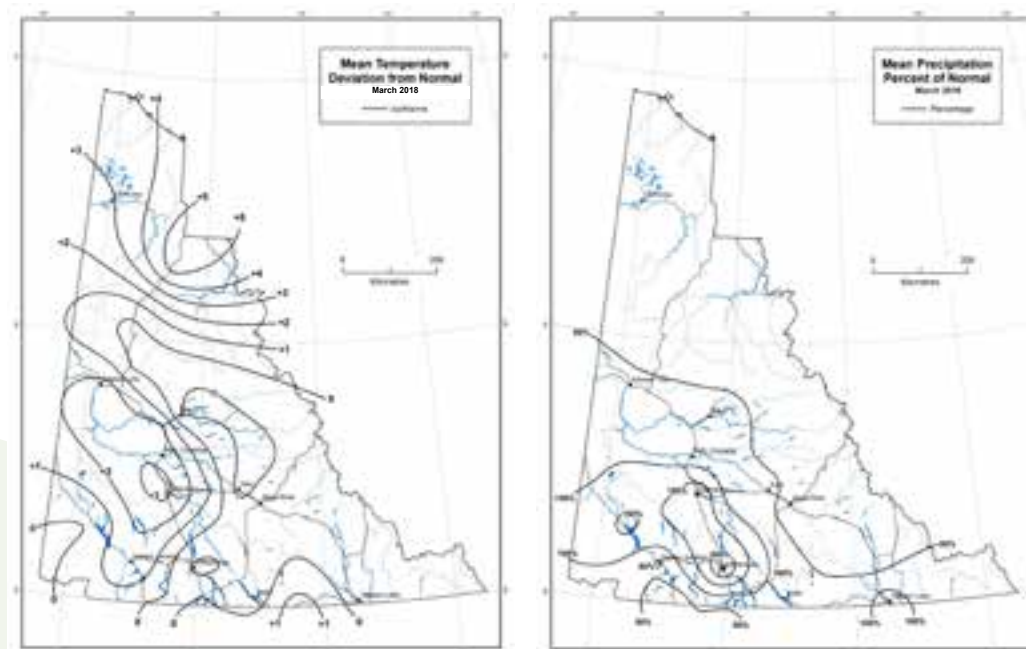


FIGURE 2 Temperature and precipitation anomalies, March 2018.

2018 YUKON WEATHER SUMMARY

- November 2017-March 2018 was slightly cooler than normal for most of the Yukon due mostly to a cold February.
- The notable exception was the northern Yukon (4-5 degrees warmer than normal over the period) based on stations at Eagle Plains and Old Crow.
- Precipitation during the snow season (November – March) was slightly below normal except at Burwash and Whitehorse airports.
- April - August 2018 was overall warmer and drier than normal, driven primarily by a very warm and dry July across Yukon.
- Regional trends were also evident throughout the summer, with southern Yukon remaining warmer and drier than normal through late August, while central and northern Yukon received well above normal rainfall and ranged from slightly below to near-normal temperatures.

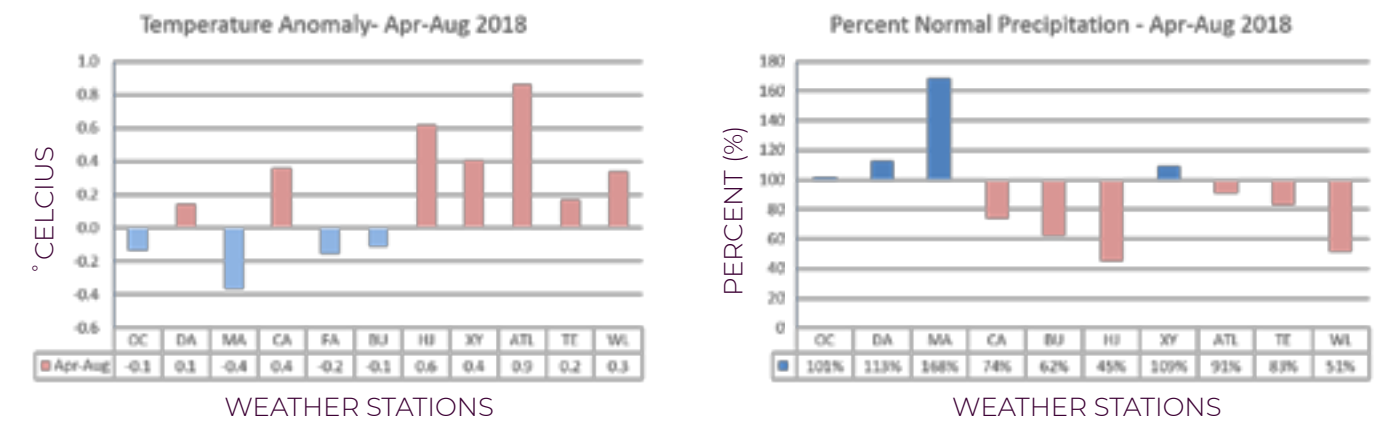


FIGURE 3 Temperature and precipitation anomalies, Apr-Aug 2018.¹

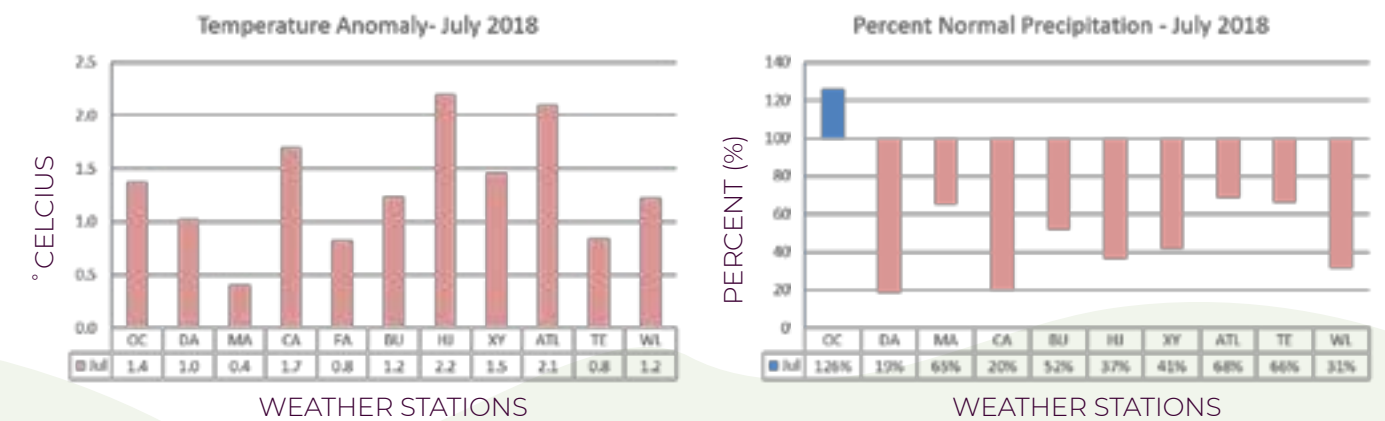


FIGURE 4 Temperature and precipitation anomalies, July 2018.¹

¹ OC = Old Crow CA = Carmacks HJ = Haines Junction TE = Teslin
 DA = Dason FA = Faro XY = Whitehorse WL = Watson Lake
 MA = Mayo BU = Burwash ATL = Atlin

SUMMARY OF 2018 BIOTIC AND ABIOTIC DISTURBANCES

Given that FHZ 1 south was surveyed in 2009 and 2014 it is possible to assess trends over time by comparing pest activity in these years (Table 1). Similarly for large aspen tortrix aerial surveys have been conducted annually since 2015 between Whitehorse and Haines Junction (Table 1).

Aerial surveys were conducted in FHZ 5 in 2013 and again in 2018. In both years no forest health disturbances were noted.

TABLE 1 Summary forest health disturbances in FHZ 1 in 2009, 2014, and 2018, and a portion of FHZ 2 in 2018. Note: Some stands had a combination of pests – the most dominant pest is noted first.

DISTURBANCE TYPE	ZONE 1			ZONE 2
	2009 (ha)	2014 (ha)	2018 (ha)	2018 (ha)
Biotic				
Aspen Serpentine Leafminer	111,720	400	3,257	-
Large Aspen Tortrix	-	6,120	2,292	-
Large Aspen Tortrix/Aspen Decline	-	-	140	-
Spruce Beetle	3,130	2	1,196	-
Western Balsam Bark Beetle	1,465	2,760	1,816	-
Willow Blotch Leafminer	65	-	246	-
Pine Needle Cast	-	-	780	17
Spruce Needle Rust	-	-	45	90
Abiotic				
Flooding and High Water	640	608	346	-
Windthrow	40	10	38	-
Pest Complexes				
Aspen Decline	-	-	2,102	-
Porcupine/lodgepole pine beetle/lps	180	815	1,466	-
Flooding Complex	-	-	55	-
Porcupine	1	18	-	-
Lightning	1	-	-	-
Bear	-	46	-	-

BIOTIC DISTURBANCES FOREST INSECTS

Aspen Serpentine Leafminer (*Phyllocnistis populiella*)

The aspen serpentine leafminer is a defoliator of trembling aspen (*Populus tremuloides*) and is common throughout the host range in Yukon. The leafminer's activities were first recorded in the early 1950s along the Alaska Highway. At endemic levels, single leaf infestation is common but whole tree infestation occurs during outbreaks. Current outbreaks in Alaska and Yukon have impacted hundreds of thousands of hectares of mature and immature aspen. Ten to 20 years of unprecedentedly severe leafminer defoliation has occurred in stands of aspen along the Silver Trail between Mayo and Stewart Crossing.

While the leafminer rarely causes tree mortality, tell-tale signs of silvery foliage and reduced growth can be seen along most of the highways in Yukon. In general, trees infested by serpentine leafminer will only die if already stressed by factors such as past infestation by large-aspen tortrix. Indeed,

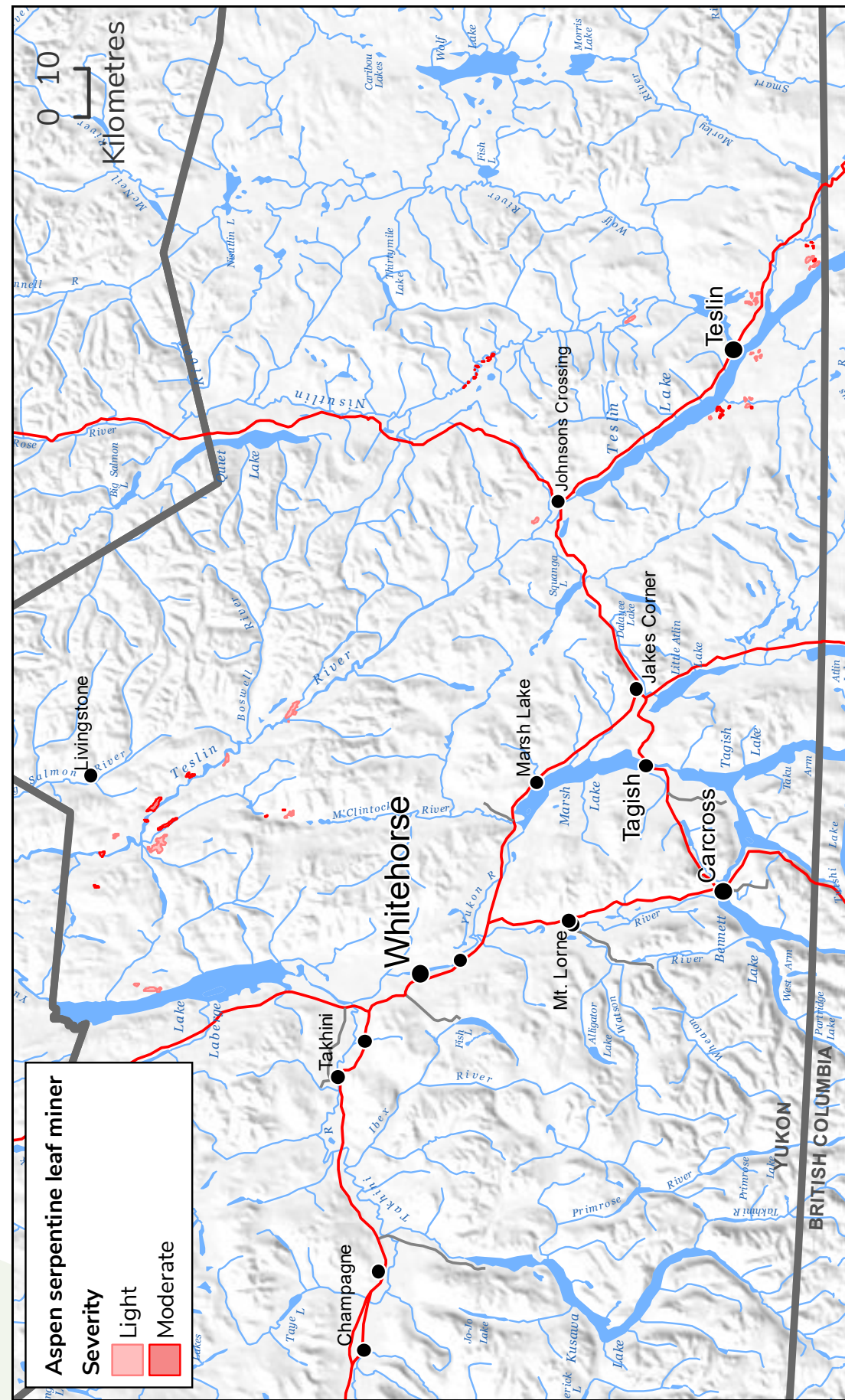
these biotic complexes are contributing factors to aspen decline noted in Yukon.

In Yukon this leafminer has been present every year for the last two decades with variation in annual levels, severity and extent. In 2018 the area infested increased to 3,257 ha, up from 400 ha in 2014, but down significantly from the 111,720 ha recorded in 2009. This increase in area from 2014 may be partially attributable to the collapse of the large aspen tortrix outbreak and corresponding availability of host material. Two thirds of the defoliation in 2018 was classified as light, and the remainder was classified as moderate defoliation.

The majority of the defoliation occurred in trembling aspen stands in the Teslin River drainage, including Teslin Lake (Map 4). It was also mapped on the east side of Lake Laberge, and along Nisutlin River (Map 4, Photo 7).



PHOTO 7 Light to moderate aspen serpentine leafminer near Nisutlin River, NE of Teslin.



MAP 4 Aspen serpentine leaf miner defoliation in FHZ1 in 2018.

Large Aspen Tortrix (*Choristoneura conflictana*)

Native to North America, the large aspen tortrix is found throughout the trembling aspen's range. Before 1990 and the onset of the spruce bark beetle infestation in the southwest Yukon, it was the single most common cause of insect-based disturbance in Yukon forests. In FHZ 1 the last outbreak was prior to 1990, and occurred near Haines Junction in stands just north of town rather than in the town itself. In FHZ 2 and FHZ 3 the last recorded outbreak occurred from 1975 to 1981, in aspen stands between McQuesten and Dawson City.

This insect completes its life cycle in a single year. During that time, larvae pass through five developmental stages, known as instars, before reaching maturity. At the end of each instar, larvae shed their skins and re-emerge as the next larger stage. Small second instar larvae emerge from the tents they have spun for winter quarters in late May or early June. They then feed on the emerging buds and leaves of the aspen trees. In some instances, initial feeding damages the buds to the extent that they fail to flush. At the third instar stage of larval development, they roll the leaves and continue until they complete larval development. Pupation occurs normally at the leaf edge in late June. Adults emerge after about ten days and mate. Then, females lay eggs in small masses on the upper surfaces of leaves. Eggs hatch in early August. After hatching, early instar larvae feed on leaf surfaces until late August. Then at the second instar stage, they hide in the bark crevices. Here they spin webs

(*hibernacula*) for overwinter shelter and enter a hibernation stage known as diapause. At this stage, the water in their cells is replaced with glycol (antifreeze) which allows them to withstand winter temperatures as cold as -27°C.

The life history of this insect places it in direct competition with the aspen serpentine leafminer, such that in years when aspen serpentine leafminer populations are low, large aspen tortrix feeding is more significant.

The outbreak in FHZ 1 began in 2012, and in 2015 in FHZ 2 and FHZ 3. In FHZ 4 sporadic defoliation has been noted from Francis Lake to Ross River, and Little Salmon Lake, but there have not been any recorded landscape-level events.

In **FHZ 1** aerial surveys have been conducted for large aspen tortrix in the Whitehorse/Haines Junction corridor since the outbreak began in 2012. These surveys indicate that populations peaked in 2015, with a notable decrease in 2016, and a smaller decrease in 2017 (Figure 1). In 2018 populations in this area increased to 1,060 ha (includes 140 ha of a combination of defoliation/ aspen decline), up from 452 ha in 2017. Interestingly all defoliation occurred in stands not previously defoliated by large aspen tortrix (Map 5). This represents an expansion of the infestation rather than intensification in previously defoliated stands.

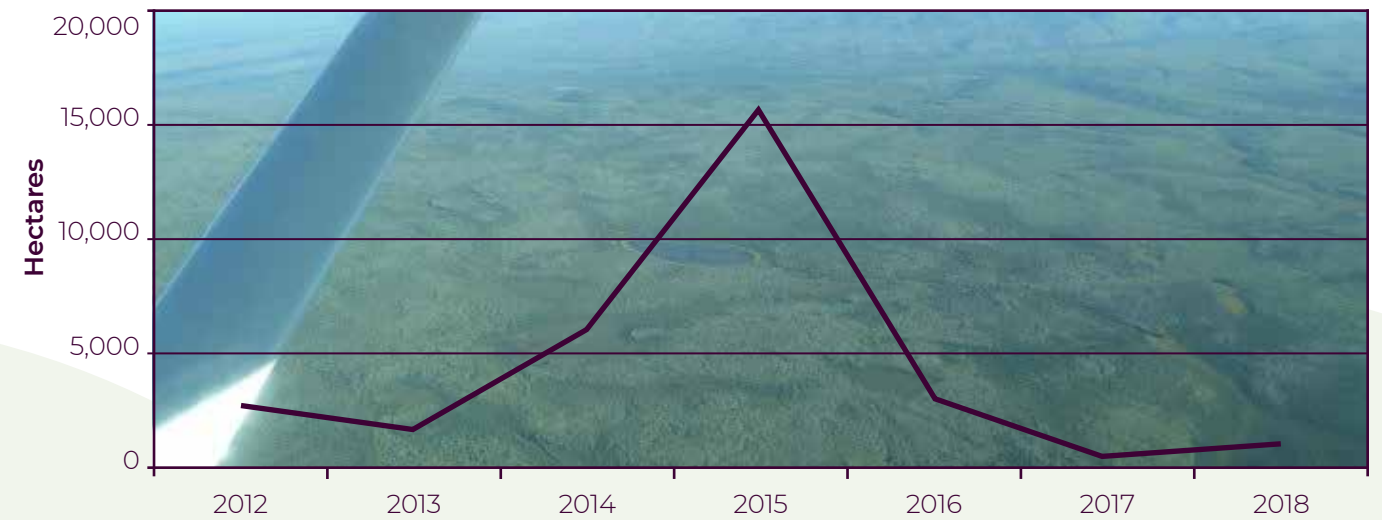


FIGURE 5 Area (hectares) defoliated by large aspen tortrix in the Whitehorse/Haines Junction corridor of FHZ 1 from 2012-2018.

Elsewhere in **FHZ 1** defoliation was also noted in areas with no history of defoliation; south of Whitehorse to the British Columbia border and east to Morley Lake (Map 6), and north to Fox Lake (Map 7). Although there is no history of landscape-level defoliation events in these areas, forest insect and disease survey records indicate large numbers of larvae (722) near Johnson's Crossing in 1993, and Fox Lake in 1989 (200).



PHOTO 8 Light to moderate large aspen tortrix defoliation (light pinkish of the aspen) near Four Mile Lake SW of Teslin close to BC border. Note the light pinkish hue of the aspen as well as the presence of aspen serpentine leafminer.



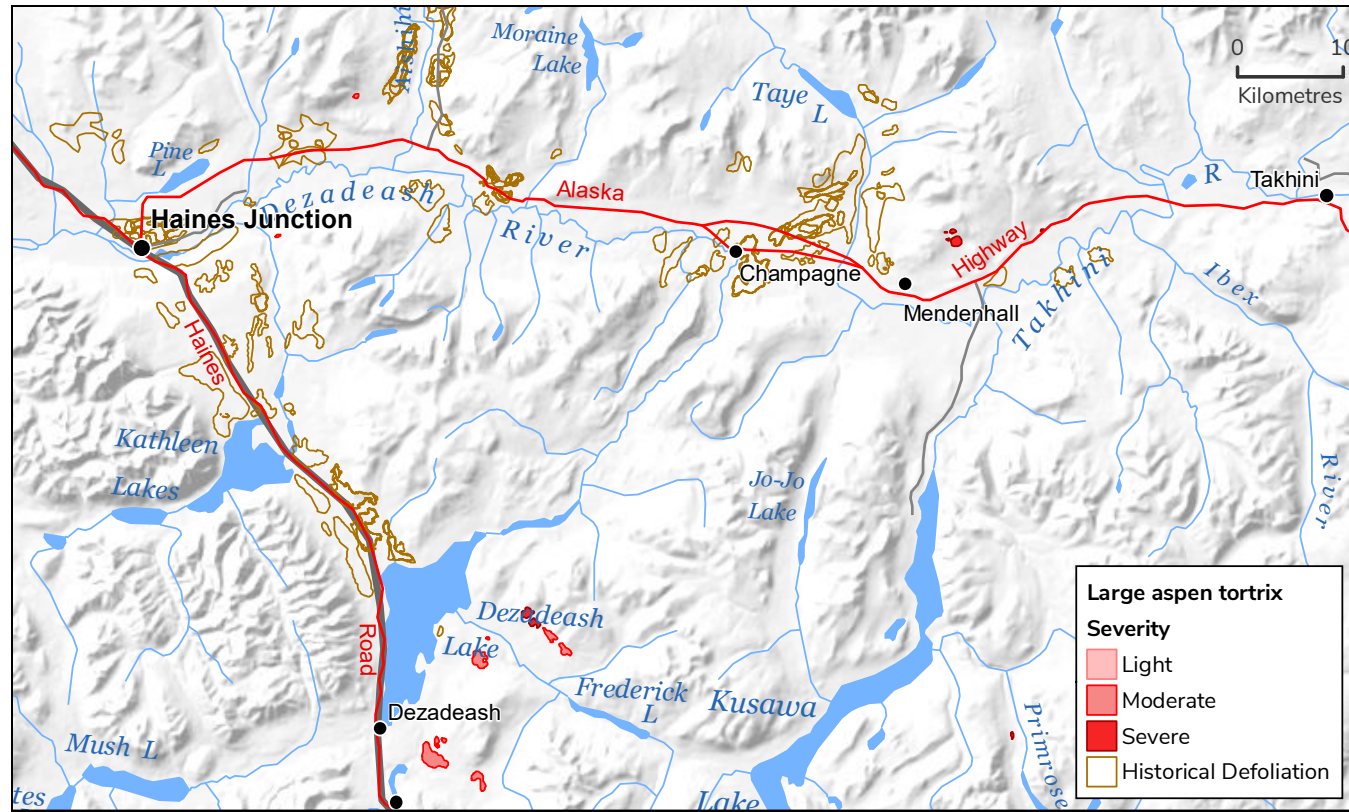
PHOTO 10 Moderate large aspen tortrix defoliation SE of Dezadeash Lake near Frederick Creek. Note the light pinkish hue of the aspen.



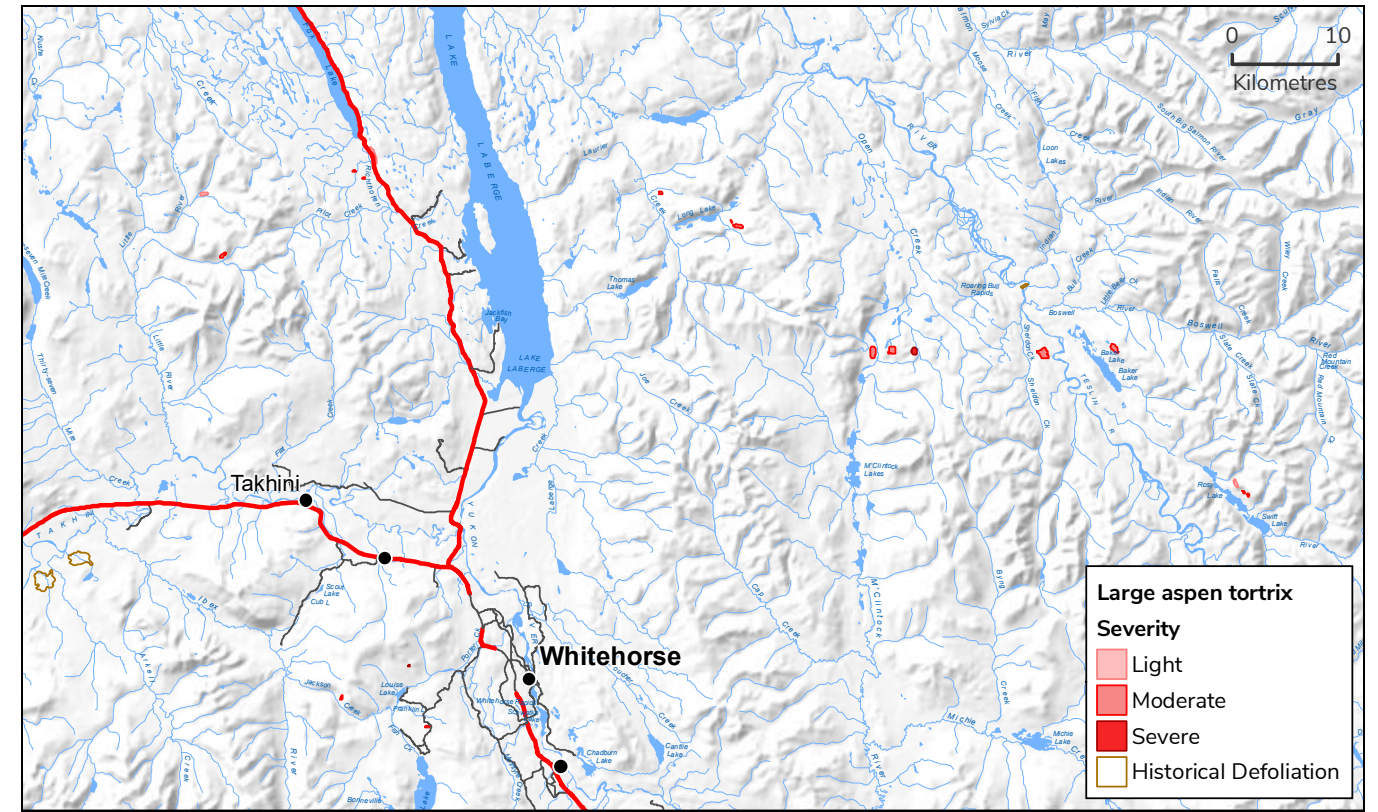
PHOTO 9 Moderate large aspen tortrix defoliation near Spawn Lake, just north of the BC border. Note the light pinkish hue of the aspen.



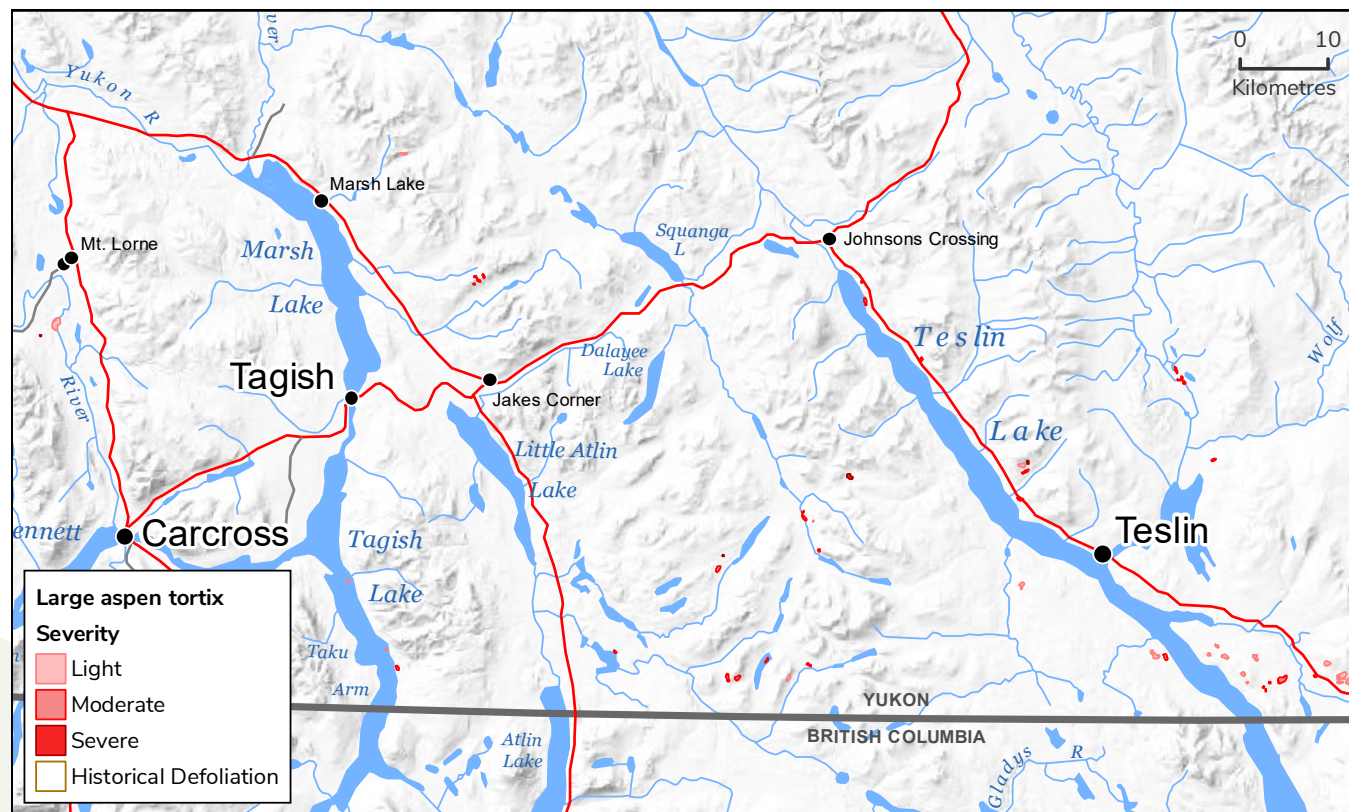
PHOTO 11 Scattered patches of moderate large aspen tortrix defoliation north of Kluhini River near Dezadeash Lake. Note the light pinkish hue of the aspen.



MAP 5 Large aspen tortrix defoliation west of Whitehorse in 2018.



MAP 7 Large aspen tortrix defoliation north of Whitehorse in 2018, in an area with no recorded history of defoliation.



21 MAP 6 Large aspen tortrix defoliation south of Whitehorse in 2018, in an area with no recorded history of defoliation.



PHOTO 12 Light to moderate large aspen defoliation west of Pelly Crossing.

Spruce Beetle (*Dendroctonus rufipennis*)

The spruce beetle is a natural disturbance agent throughout the geographical range of spruce (*Picea spp.*) in North America. At endemic levels, spruce beetle normally infest downed trees, logging debris, decked timber, dying or stressed trees and only occasionally cause tree mortality. During periods of outbreak, beetles will attack and kill live trees causing widespread mortality. In Yukon, spruce beetle is the most damaging agent of mature spruce forests. The earliest recorded outbreak occurred in the late 1930s and early 1940s around Dezadeash Lake when 50,000 ha were infested with the beetle. It is thought that logging during the building of the Haines Road contributed to this outbreak. In the mid-1970s a smaller (100 ha) outbreak occurred during the construction of the Aishihik Power Project. Both of these outbreaks were likely caused or exacerbated by human activities as trees were felled and left during construction, providing ideal breeding habitat for beetle populations.

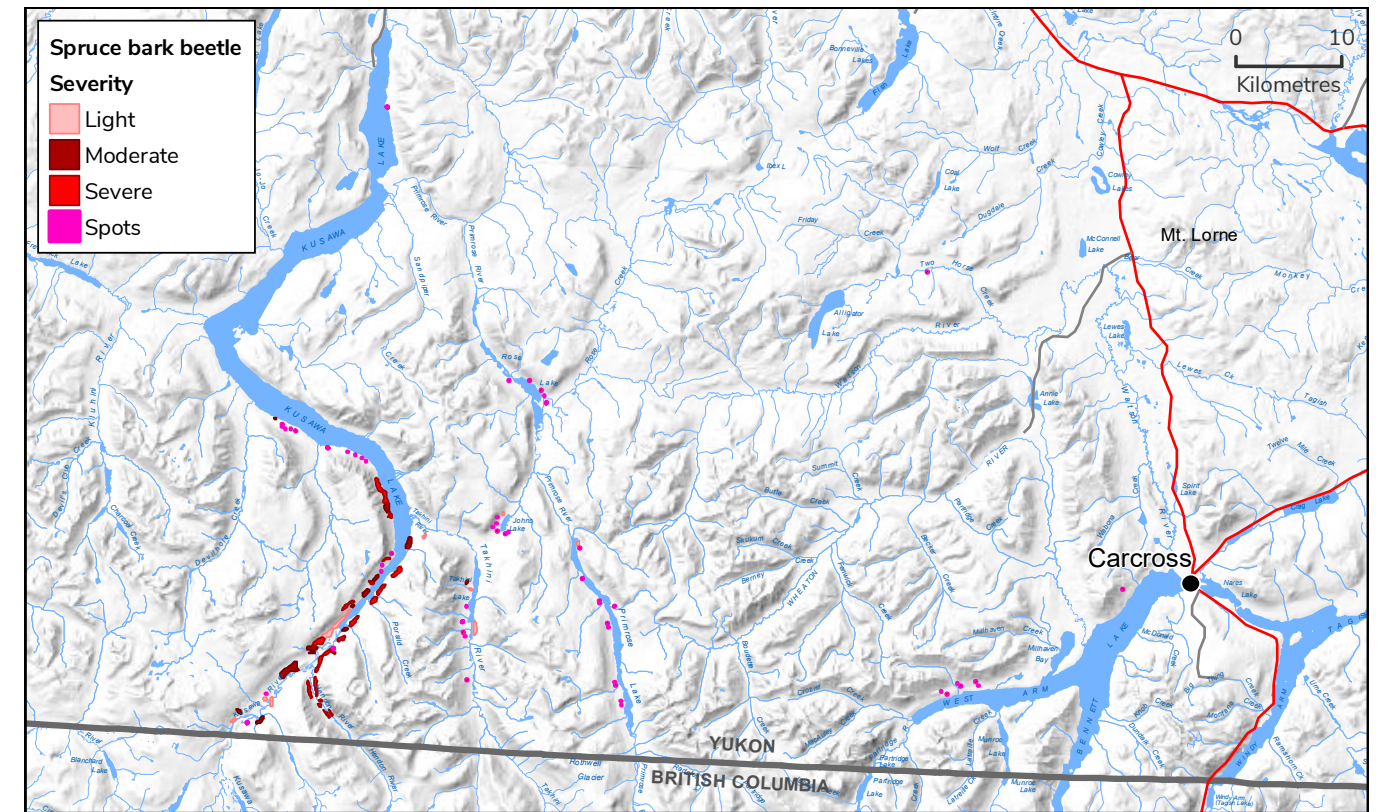
The most recent spruce beetle outbreak started in Kluane National Park and Reserve around 1990. The outbreak was first observed in 1994, by which time the beetle had already caused over 32,000 ha of mortality. The beetle then moved into public and First Nations forest lands north and south of Haines Junction in the Shakwak Trench. Over the next 15 years, the beetle continued to kill large tracts of spruce within and west of Kluane National Park. During the outbreak more than half of the mature spruce had been killed over approximately 400,000 ha.

One of the main differences between the recent and historic outbreaks was the mode of initiation. In the past, outbreaks were associated with certain stand-level, abiotic disturbances such as windthrow, fire or right-of-way clearing. The recent outbreak is unique in that climate moderation was the initiation factor. These climatic conditions also favoured increased beetle fecundity. Over the same period, warmer winters resulted in reduced brood mortality.

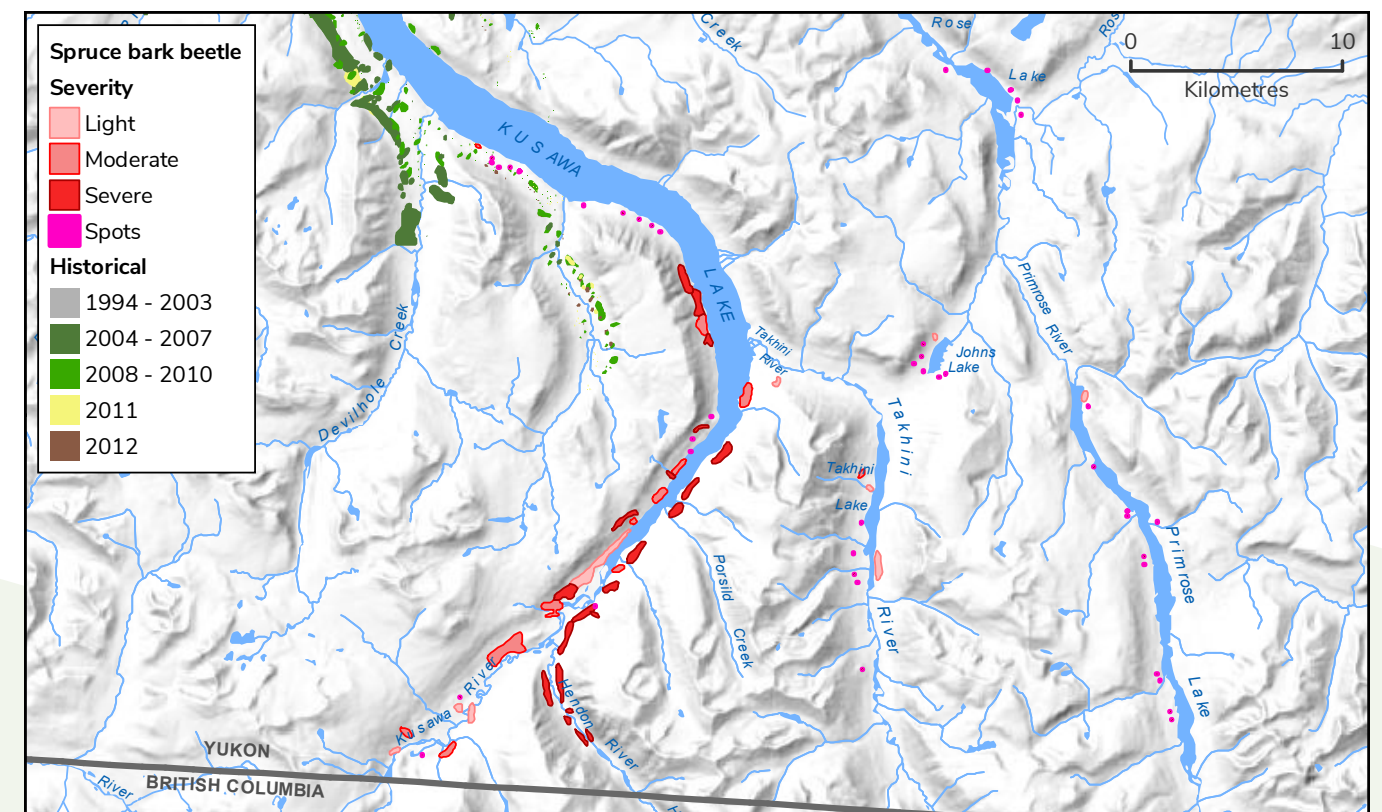
In 2018 spruce beetle was recorded over 1,196 ha in FHZ 1, the majority of which was found near the south end of Kusawa Lake and eastern drainages including Two Horse Creek, West Arm of Teslin Lake, and Primrose and Rose Lakes (Map 8). Elsewhere scattered spots of between one and 10 trees were recorded east of Whitehorse near Nisutlin River, Johnson's Crossing, and Munson Lake.

The origin of the infestation at the south end of Kusawa is uncertain, as ground surveys are not possible given terrain. Based on the ratio of faders (new attack) to reds (previous year's attack) to greys (>two-year-old attack) it is estimated that this disturbance has been active for three to four years. At the end of the last outbreak populations were persisting, albeit at very low levels, in the Devilhole Creek/Kusawa Lake area (Map 9). At that time ground assessments found very low survival and fecundity rates. In 2012, the last year this area was mapped, populations were very low with only light polygons (<10% infested) mapped. This marked a significant reduction in severity from the outbreak years and thus signaled the decline of the local populations. Based upon the proximity of the last known infestation and the current levels it is possible that spruce beetle found an endemic niche, with populations persisting in stressed trees and expanding into the homogeneous spruce forests at the south end of Kusawa Lake, Takhini River and Primrose Lake (Map 9). Assuming a two-year life cycle adult beetles emerged from the grey trees in 2018 and will emerge from red trees in spring of 2019 to attack healthy spruce trees.

Yukon FMB will continue to monitor this area annually, weather permitting, as part of its proactive approach to forest health management.



MAP 8 Location of the majority of the spruce beetle infestation mapped in 2018, including polygons and spots. Note spots have been enlarged for visibility as they are only 0.25 to 0.5 hectares in size.



MAP 9 Current spruce beetle infestation in relation to the location of spruce beetle at the end of the last outbreak.



PHOTO 13 Scattered red and grey attack on the west side of south Kusawa Lake.



PHOTO 14 Scattered new, red, and grey attack at the very south end of Kusawa Lake.

Western Balsam Bark Beetle (*Dryocoetes confusus*)

The western balsam bark beetle is a woody tissue feeder of subalpine fir. It is found throughout the host range in Yukon and, over the past two decades, light to moderate infestations have been observed in the southern part of the territory. The beetle works in concert with a symbiotic fungal pathogen to overcome tree defense mechanisms. At endemic levels, the beetles prefer trees weakened by age or climatic stress (e.g., drought, wind damage or snow-damage), but during outbreaks healthy trees are susceptible to attack. Endemic beetle populations can cause single tree mortality; however, outbreak populations can cause extensive group tree or stand-level mortality over successive years of attack.

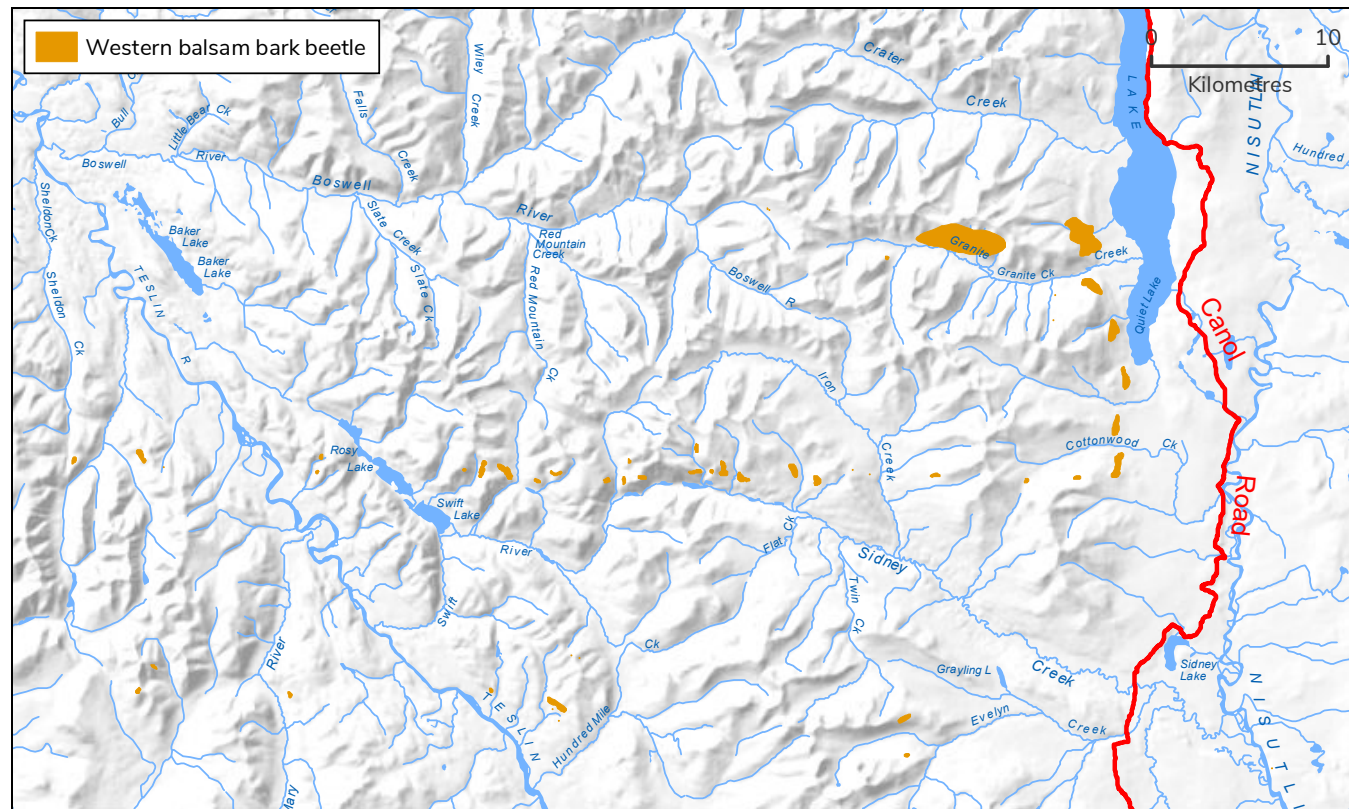
Over the last 20 years, the western balsam bark beetle has advanced north from British Columbia into southern Yukon. Surveys from the mid-1980s to the early 1990s recorded the beetle's northerly spread across the 60th parallel. With the change in climatic conditions, extensive amounts of mature and semi-mature trees, and successive years of attack, the balsam bark beetle has become an active stand-level disturbance agent in southern Yukon. Surveys indicate that the most affected areas have been high elevation stands with concentrated subalpine fir components. In the mid-1990s, hundreds of hectares of light (<10%), current-year mortality were mapped in the LaBiche River area in southeast Yukon.

Years of successive attacks have removed a large proportion of the subalpine fir overstory. In 2007, an extensive area of light, current-year mortality was mapped in the hills south and west of Teslin Lake. Light scattered mortality has also been seen on both sides of Tagish Lake (Windy Arm), south of Carcross. Similarly in 2017 significant increases were noted in southeast Yukon, where previously mapped spot infestations expanded into trace polygon infestations. This persistence and expansion of western balsam bark beetle confirms that climate suitability has improved such that this bark beetle is now established in Yukon forests.

In 2018 populations decreased to 1,816 hectares from 2,760 hectares in 2014. The largest decrease occurred in stands near the Nisutlin River and Wolf Lake, where in 2014 large trace polygons were mapped with only a few spots remaining in 2018. The majority occurred between Quiet Lake and Teslin River (Map 10, Photo 15), with two large polygons near Quiet Lake accounting for 45% of the area infested (Map 10). The remainder were a combination of spot and trace (<1% infested) polygons.

Willow Blotch Leafminer (*Micrurapteryx salicifoliella*)

This common leaf miner was first recorded in Yukon in 2007 adjacent to the Stewart River at Stewart Crossing. In 2018 this defoliator caused severe defoliation to 246 ha of willow along the Dezadeash River, near Champagne.



MAP 10 Trace western balsam bark polygons near Quiet Lake, accounting for 45% of the total area infested in FHZ 1 in 2018.



PHOTO 15 Scattered and progressive mortality of western balsam bark beetle in mature sub-alpine fir stands near Quiet Lake.

FOREST DISEASES

Pine Needle Cast (*Lophodermella concolor*)

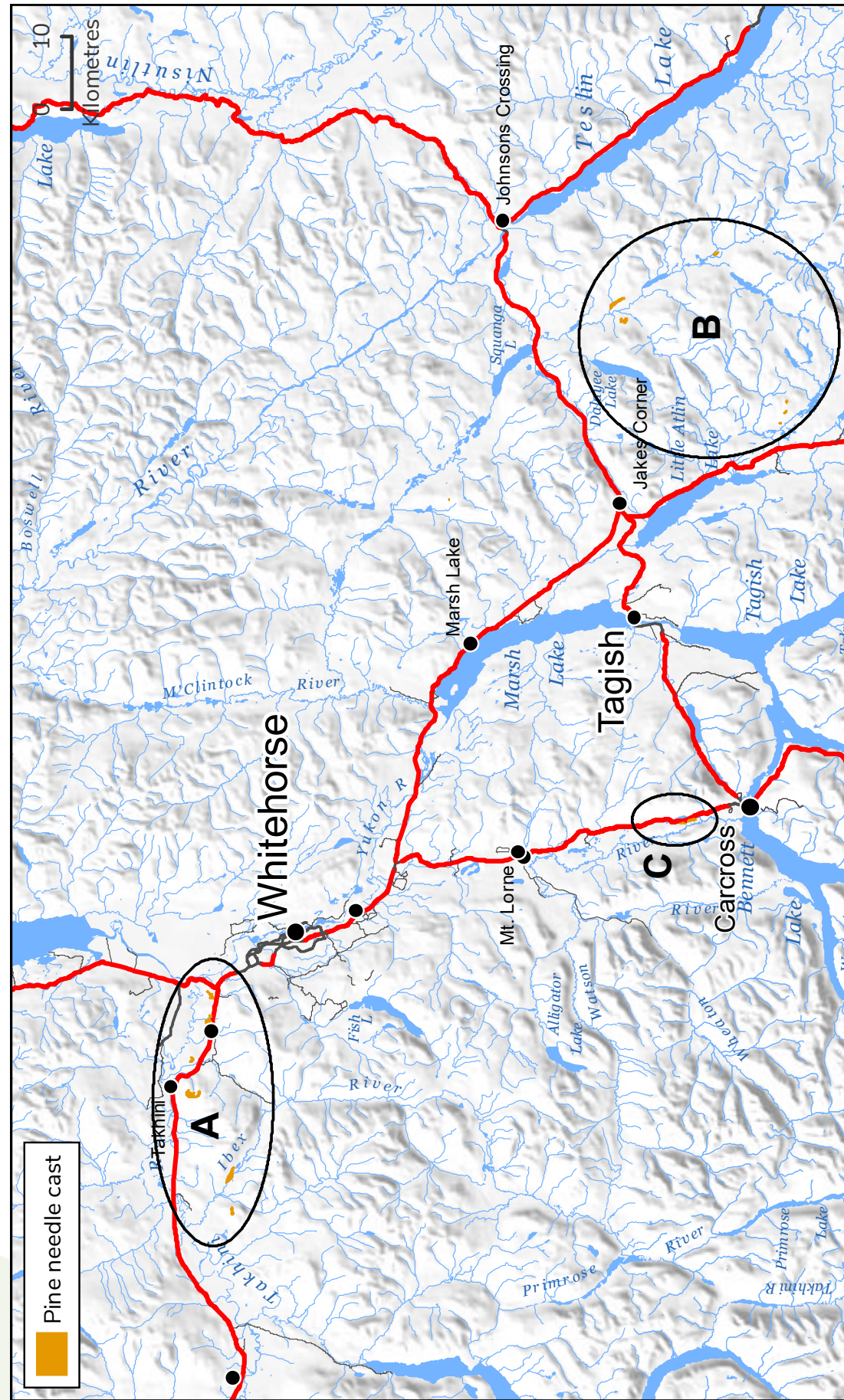
Pine needle cast is a fungal disease of two-needle pines. In Yukon, it occurs throughout the range of the host species, lodgepole pine. The disease is prevalent in the southeast and is increasingly common in central Yukon. In 2008, severe infections were found in young pine that regenerated following the Minto Fire. This was the northernmost incidence of the disease yet found in Yukon. Crown dieback, branch kill, defoliation and tree mortality (rarely) occur as a result of infection. Pine needle cast can infect all age classes of pine. Outbreaks of pine needle cast tend to be more severe following successive wet summers when conditions have been optimal for spore production, dispersal and infection. The disease spores are transferred during periods of wet weather from the year-old needles to the newly flushed needles at the branch tips. Pine needles infected the previous year turn red in early summer as needle necrosis takes place (Photo 16). These one-year-old needles are then shed later in the year, making it challenging to identify from the air later in the summer. Hence annual infected area figures likely underrepresent the actual area given these conditions. Successive years of severe infection results in only the current years needles remaining on the tree. This phenomena is commonly referred to as "lion's tailing".



In FHZ 1 this foliar disease caused discoloration/defoliation to 780 ha of young lodgepole pine along the Takhini and Ibex rivers near Whitehorse (Map 11A, Photo 17), near Snafu and Teenah lakes near Jakes Corner (Map 11B), and near Spirit Lake north of Carcross (Map 11C).

In FHZ 2 a public report of discolored stands between Pelly Crossing and Little Salmon Lake triggered an aerial survey of the area. Severe discoloration of young pine stands was noted and suspected to be a combination of pine needle cast and winter damage. Similar damage was also observed while ferrying from Whitehorse to Old Crow. This discoloration occurred SW of Stewart Crossing in an area where needle cast has been recorded in 2011 and 2012 (Photo 18).

PHOTO 16 Lodgepole pine needles infected with pine needle cast in early summer.



MAP 11 Location of pine needle cast defoliation in 2018 in FHZ 1. A: along Takhini and Ibez rivers near Whitehorse, B: near Snafu and Teenah lakes near Jakes Corner, C: near Spirit Lake north of Carcross.



PHOTO 17 Moderate discoloration of young lodgepole pine by pine needle cast, just west of Whitehorse.



PHOTO 18 Severe discoloration of young lodgepole pine suspected to be a combination of pine needle cast and winter damage, SW of Stewart Crossing in FHZ 2.

Spruce Needle Rust (*Chrysomyxa ledicola*, *Chrysomyxa ledi*)

Small-spored spruce Labrador tea rust (*Chrysomyxa ledi*) and large-spored spruce Labrador tea rust (*Chrysomyxa ledicola*) are fungal diseases affecting the current year's needles of white spruce. The range of spruce needle rust coincides with the ranges of the aecial (primary) host, white spruce and the telial (secondary) hosts, Labrador tea (*Ledum palustre* and *L. groenlandicum*) and leatherleaf (*Chamaedaphne calyculata*). These complex rust fungi are heteroecious, meaning that they require the presence of both spruce and Labrador tea to complete the disease cycle. Because both species of Labrador tea only occur in moist conifer woods and peatlands, disease incidence is limited to these areas. Spruce needle rust rarely cause tree mortality and symptoms manifest as defoliation of current needles resulting in twig and branch dieback. In 2008,

localized patches were observed along the Long Lake Road near Whitehorse and near the Morley River along the Alaska Highway. In general, wet and cool weather is conducive for spore formation and spore dispersal from Labrador tea, as well as infection of new spruce needles (Photo 19).

In FHZ 1 spruce needle rust, *Chrysomyxa ledicola*, caused discoloration to this year's growth over 45 ha in three locations; near Haines Junction, Champagne, and near Boswell River east of Whitehorse.

Based on follow up aerial surveys to a public report of discolored trees near Little Salmon Lake in **FHZ 2**, 90 hectares of spruce needle rust discoloration were also recorded (Photo 20).



PHOTO 19 Current year's growth infected with spruce needle rust.



PHOTO 20 Yellow-orange discoloration of white spruce NW of Little Salmon Lake.

ABIOTIC DISTURBANCES

Flooding and High Water Tables

Flooding affects trees by reducing the supply of oxygen to the soils and roots, sediment accumulation which can lead to poor soil aeration, exposure to toxic compounds that accumulate in waterlogged soils, and in some cases physical damage to the roots or sudden exposure to the elements (Anon, 2008).

In FHZ 1 flooding was widespread, recorded in over 50 locations totaling 346 ha. The majority occurred in spruce stands (Photo 21) but lodgepole pine was also affected in a few areas (Photo 22). Notably, damage occurred not only along creeks and rivers but also inland from lakes where forests adjacent to lakes were damaged (Map 12, Photo 23). This could be due to flooding or high water tables. The largest area recorded was on the west side of Little Atlin Lake where 55 ha of lowland spruce was affected from high water levels or high water tables. From a distance the damage resembled that of spruce beetle but the signature was slightly different in that the edges were too abrupt and the trees all died at the same time. This type of abiotic event however could predispose trees to attack by spruce beetle or northern spruce engraver beetle (see pest complex section).

Windthrow

In FHZ 1 38 ha of spruce windthrow was mapped in three separate locations; Nayton Creek east of Haines Junction, near the Takhini River southwest of Champagne, and near Munntiger Lake north of Champagne.



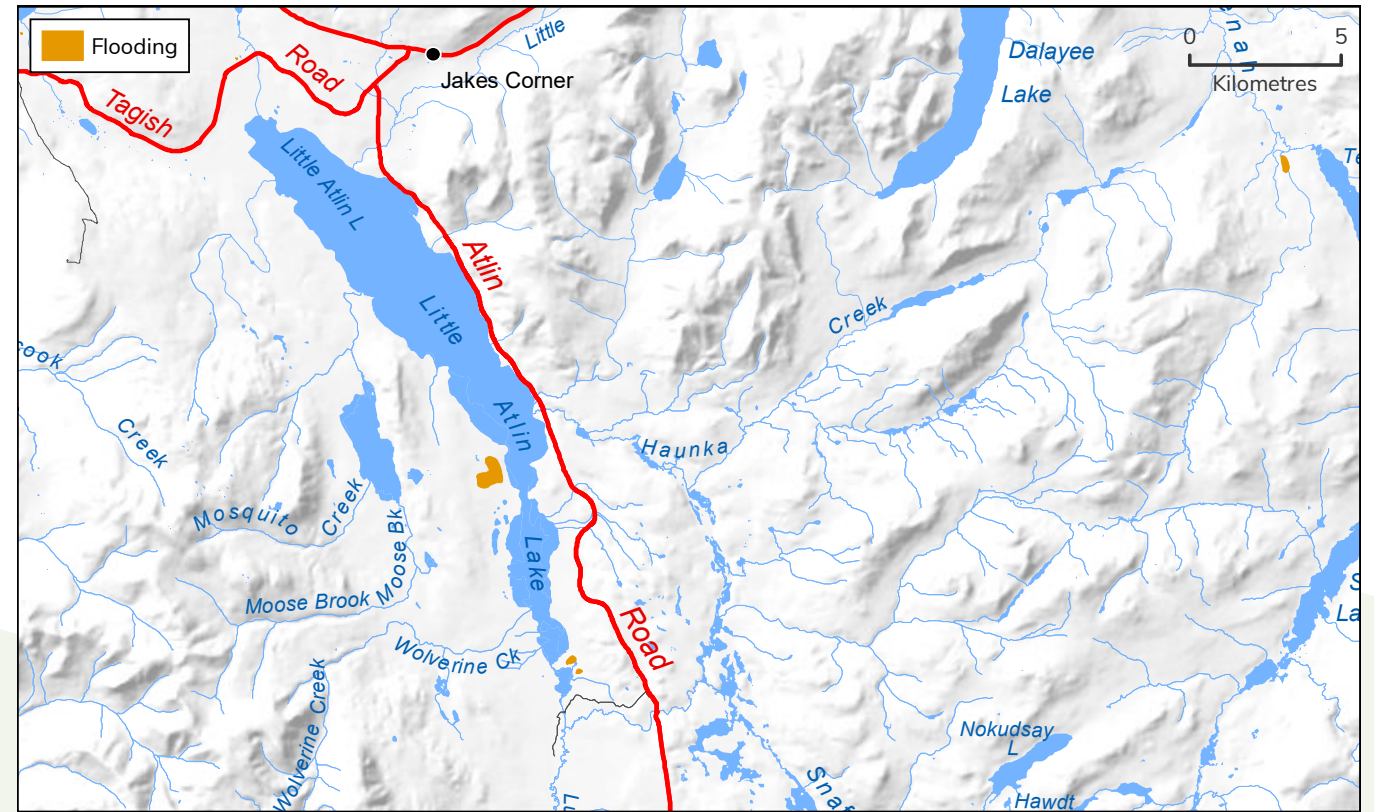
PHOTO 21 Flooding of mature white spruce along Wolf Lake.



PHOTO 23 High water tables or flooding damage to lowland white spruce stands at Little Atlin Lake.



33 **PHOTO 22** Flooding of mature lodgepole pine stands adjacent to Flat Creek, NW of Whitehorse.



MAP 12 Lowland white spruce stands, as depicted by contours, affected by high water tables or levels from Little Atlin Lake (bottom polygons pictured in Photo 23).

PEST COMPLEXES

Aspen Decline

In the most simplistic terms decline or dieback refers to mortality or damage to forests due to unknown causes, including a possible combination of biotic and abiotic factors. Symptoms include thin crowns, top dieback, stem mortality, and stem breakage (Photo 24). In Western Canada decline has been observed on a number of tree species including yellow cedar, birch, aspen, and cottonwood. According to Canadian Forest Service forest insect and disease historical records for the Yukon (which date back to 1952), aspen dieback was first detected in 1987 near Swift River. Since then dieback has been recorded intermittently on a variety of tree species, including cottonwood and trembling aspen. In 2016 158,367 ha exhibited symptoms of aspen decline in FHZ 2. In 2017 damage was mapped over 4,618 ha in the highway corridor between Mendenhall and Dezadeash Lake, up from 2,130 in 2016. The vast majority in 2016 was in combination with defoliator activity. In 2015 5,621 ha were affected in FHZ 3, some of which had visible snow and ice damage. Decline was also observed aerially in 2009 (2,488 ha), 2010 (11 ha), and 2011 (529 ha). Ground assessments of

aspen mortality in 2008 between Whitehorse and Stewart Crossing found that site and stand conditions also played a role. Open grown and/or sites with poor water retention had a high incidence of pests, such as poplar borers (*Saperda calcarata*), which contributed to decline of the stands. Similar relationships were found in 2016 in ground assessments of symptomatic stands between Dawson City and Whitehorse. In the Northwest Territories aspen decline has been linked to high water tables from melting permafrost.

In the United States and Canada widespread dieback and mortality of trembling aspen occurred between 2000 and 2010. Research in both countries has found that drought was a major predisposing and contributing factor, along with multi-year defoliation by forest tent caterpillar, and to a lesser extent stem damage by fungi or insects (Worrall et al, 2013). Frost, particularly late spring frost, was also found to be a contributing factor on some sites in Utah. Based on these findings a retrospective spatial analysis



PHOTO 25 Scattered pockets of aspen decline in stands previously defoliated by large aspen tortrix near Quill Creek, south of Haines Junction.

was conducted to determine if such was the case for Yukon trembling aspen stands. Results of the analysis indicated a strong relationship between cumulative defoliation severity and aspen decline symptoms, thereby confirming the findings in Alberta and United States.

As the climate warms the likelihood of ongoing decline is possible given the potential for increased frequency of drought events, and warmer springs which could result in early spring flush followed by late spring frosts. Changing climate will also lead to changes in biotic factor regimes including changes to pest distribution, severity, and frequency which could also contribute to aspen decline. Establishing permanent sample plots to facilitate ongoing monitoring of these forests using protocol developed by Canadian Forest Service for examining climate impacts on the productivity and health of aspen (CIPHA) will help elucidate the factors involved, and the extent of and changes in, damage levels.

Given recent and historical observations of decline and the potential for continued and possible expansion of decline, Yukon FMB is conducting work to gain a better understanding of contributing factors. This included the retrospective spatial analysis of defoliation events and ground reconnaissance to identify potential causal agents.

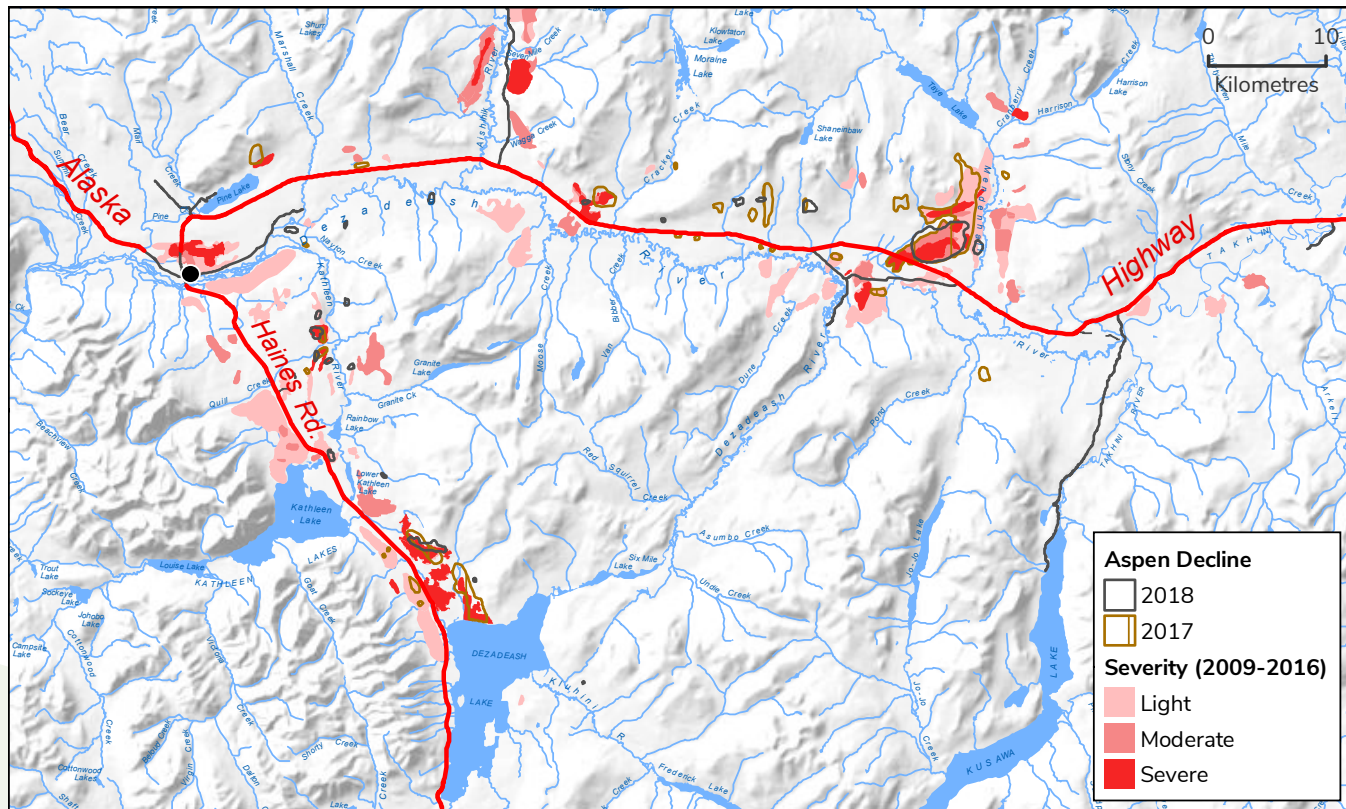
In FHZ 1 aspen decline occurred over 2,102 ha, 1,953 ha of which was in the highway corridor between Mendenhall and Dezadeash Lake where 4,618 ha of damage was mapped in 2017. Areas with decline tended to be in areas where large aspen tortrix defoliation had occurred (Map 13, Photo 25). This decrease in area with decline symptoms confirms the association with defoliation events; stands showing signs of recovery post-large aspen tortrix outbreak. It is important to bear in mind that decline can occur in absence of defoliation, as noted in **FHZ 3**, where aspen stands without a history of large aspen tortrix continue to show decline symptoms (Photo 26).



PHOTO 24 Symptoms of aspen decline: thin crowns, top dieback, stem mortality, and stem breakage.



PHOTO 26 Ongoing aspen decline in stands near Dawson City, in FHZ 3.



MAP 13 Location of aspen decline mapped in 2017 and 2018 relative to cumulative severity of large aspen tortrix defoliation from 2000-2016, in the Alaska Highway Corridor between Mendenhall to Haines Junction.

Porcupine and Bark Beetles

Porcupines feed on the nutrient-rich inner bark of all species of coniferous and deciduous trees, but they prefer pine. This feeding generally takes place in the winter, when their favoured foods are scarce, but can occur throughout the year. Some of the trees are girdled by the feeding and subsequently die, or are predisposed such that secondary bark beetles such as lodgepole pine beetle (*Dendroctonus murrayane*) or pine engraver beetle (*Ips pini*) attack and further weaken or kill the trees. Rocky slopes tend to be favoured by porcupines due to the abundance of potential denning sites. Areas such as these allow for the relatively large populations that are required to cause the degree of damage observed this year.

In 2014 ground checks were conducted on pockets of lodgepole pine that had a signature similar to mountain pine beetle (Photo 27). Several ground checks revealed mortality or damage due

to porcupine solely (Photo 28), porcupine and lodgepole pine beetle (Photo 29), and in some cases, pine engraver beetle. Hence similar damage is now deemed affected by this pest complex.

In 2018 porcupine/bark beetle damage on lodgepole pine was mapped over 1,466 ha in FHZ 1, up from 815 ha in 2014. While the majority were spots of one to 10 trees, there were many polygons mapped as having trace, light, or moderate infestations. These accounted for most of the affected area (Table 2). The most concentrated and largest area was between Whitehorse and Lake Laberge where 591 ha of trace damage was recorded, including an area 356 ha in size. Damage was observed throughout most of FHZ 1, with the exception of southwest Yukon, west of Champagne, and north of Lake Laberge (Map 15). The geographic extent of the damage was also larger than in 2014 (Map 15).

TABLE 2 Summary of porcupine/bark beetle infestation by severity, area affected, and number of spots or polygons in FHZ 1 in 2018.

SEVERITY	AREA (HECTARES)	# OF SPOTS OR POLYGONS
Very Severe (spot; 1-10 trees)	55	191
Trace (<1% infested)	1,289	63
Light (1-10% infested)	100	10
Moderate (11-30% infested)	21	5



PHOTO 27 Stand-level signature of porcupine/bark beetle pest complex.



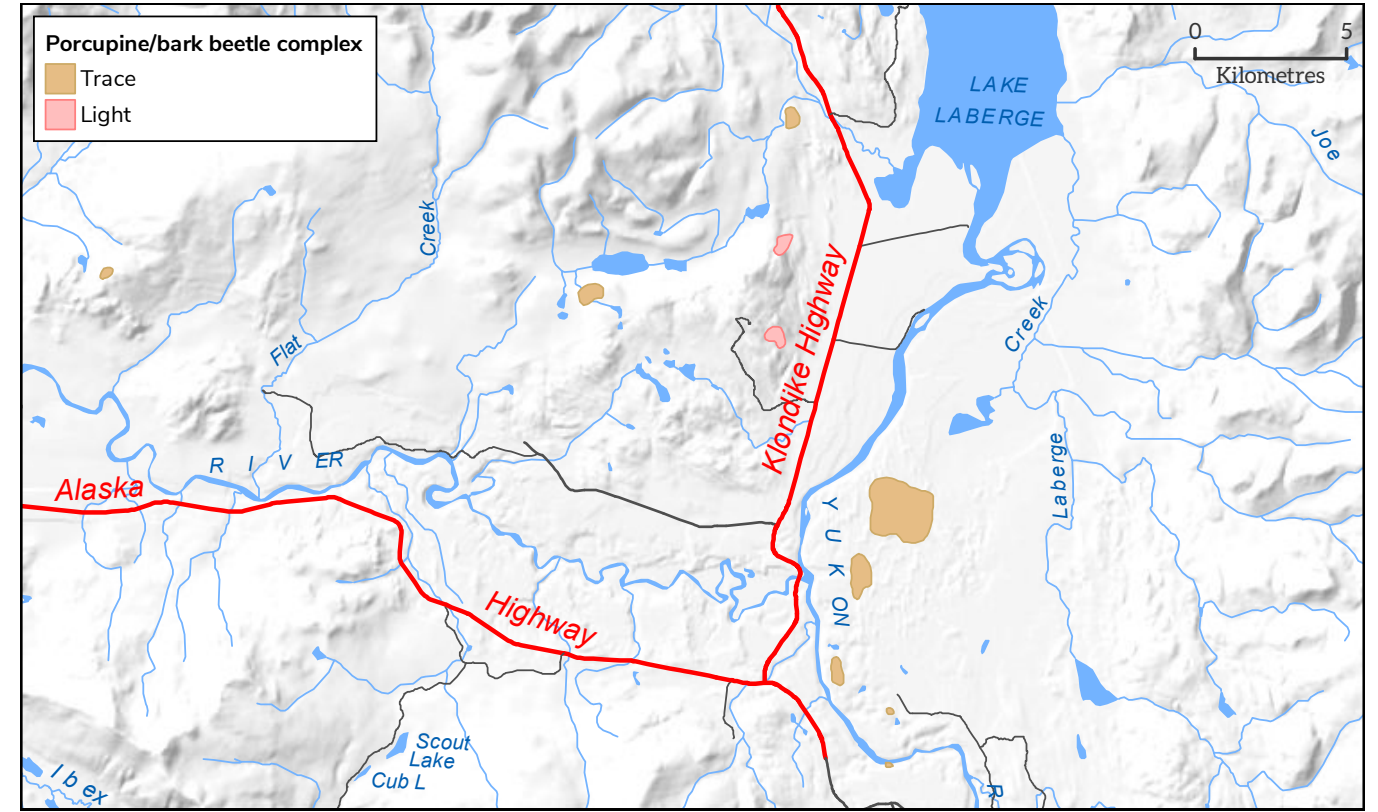
PHOTO 28 Top-kill due to porcupine feeding on main stem of lodgepole pine.



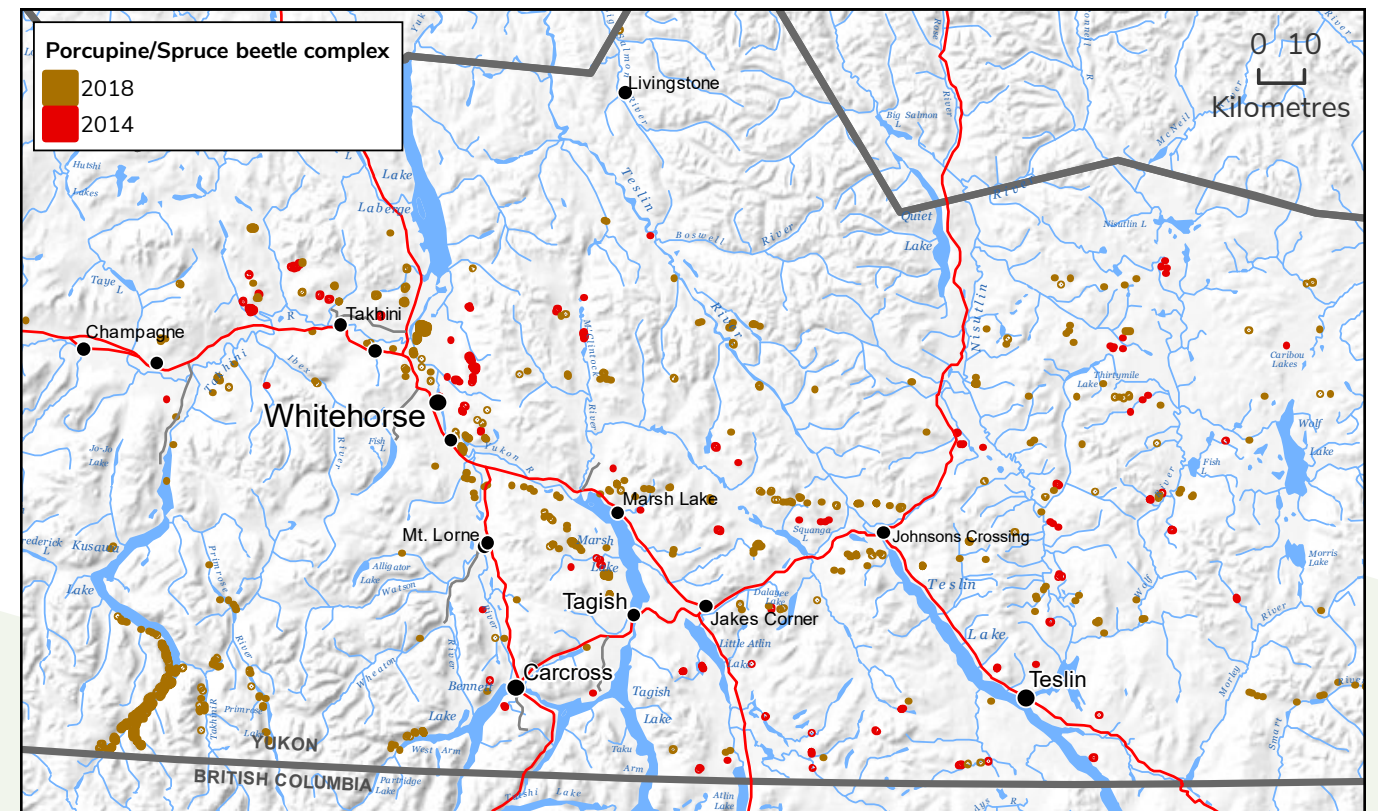
PHOTO 29 Lodgepole pine beetle pitch tubes and boring dust at base of tree damaged by porcupine.

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Moderate (11-30% infested)	21	5



MAP 14 Area with largest concentration of porcupine/bark beetle complex damage, between Whitehorse and Lake Laberge.



MAP 15 Extent of porcupine/bark beetle pest complex in relation to 2014 incidence. (Note: spots have been enlarged for visibility.)

Flooding Complex

As noted in the abiotic section of the report, flooding and high water tables were widespread in both spruce and lodgepole pine stands in 2018. Tree mortality caused solely from flooding is dependent upon the tree species affected, and the longevity and severity of the flooding event. If trees survive they may be predisposed to secondary biotic factors, such as bark beetles and wood borers, which could in turn lead to tree mortality. These include spruce beetle, engraver beetles (*Ips pini* and *Ips pertubatus*), and wood borers (*Monochamus* spp.).

As endemic spruce beetle populations favor predisposed trees a ground check was conducted to assess potential spruce beetle risk in a 55 ha flooded white spruce stand near Little Atlin Lake (Photo 23, Photo 30). Ground checks revealed a number of pests including spruce beetle, northern spruce engraver beetle, wood borers, and ambrosia beetle (Photo 31). As the majority of trees were likely dying prior to attack it is felt that this site will act more as a sink than a source for bark beetles. However given the amount of host material, FMB will conduct aerial surveys in this area next year in conjunction with the proactive management efforts that will be undertaken in the Kusawa Lake area.



PHOTO 28 Dead and dying white spruce in stand flooded in spring/early summer of 2018, near Little Atlin Lake.



PHOTO 31 Evidence of bark beetle and wood borers. **A** – spruce beetle larvae (note anal shields), **B** – (northern spruce engraver beetle (note: clean adult gallery i.e. no frass), **C** – wood borer gallery, **D** – pinhole damage by ambrosia beetle.

PROACTIVE MANAGEMENT OF MOUNTAIN PINE BEETLE

Concerned about the northward expansion of the Mountain Pine Beetle (MPB), the Government of Yukon has developed a risk analysis and subsequent monitoring strategy to track the northern movement of this bark beetle. Below is a history of response to MPB:

- A National Risk Assessment of the threat of MPB to Canada's boreal and eastern pine forests was completed in 2007 by the Canadian Forest Service.
- In 2009, the Forest Management Branch (FMB) implemented the Yukon Forest Health Strategy that is in line with the National Forest Pest Strategy (NFPS).
- From 2009 until the present, both FMB and BC's Ministry of Forests, Lands and Natural Resource Operations have been conducting aerial surveys.
- Since 2009 FMB has been setting and monitoring MPB bait traps in southern Yukon to detect presence of MPB. (To date no presence of MPB has been detected.)
- The Government of Yukon Interdepartmental Mountain Pine Beetle Committee, formed in 2011, provided direction and developed strategies to monitor and manage MPB in the future.
- In 2012 the MPB committee completed a Yukon-specific pest risk analysis: *Mountain Pine Beetle Pest Risk Analysis for Yukon Lodgepole Pine Forests*.
- From this risk analysis, a five year MPB monitoring plan and strategy was developed and implemented in 2013: *Mountain Pine Beetle Monitoring Plan for Yukon Lodgepole Pine Forests 2013 - 2018* (Refer to Forest Health Report 2013 (Garbutt 2013), Appendix 2).

The Mountain Pine Beetle (MPB) is a native North American bark beetle that is distributed throughout most of the range of lodgepole pine in British Columbia. Historically climate has impeded its expansion northward, not host, and until the current outbreak was only recorded south of 56°N. The MPB is currently the single biggest forest health concern in western Canada. The current MPB outbreak is responsible for killing over 13 million ha of pine forest in BC alone.

The MPB is one of ten forest health agents that pose the greatest risk to Yukon forests. It can be effectively monitored as part of a risk-based forest health monitoring program. As such, FMB has taken a proactive approach to managing the threat posed by the northward expansion of the MPB from British Columbia. Although the MPB has not expanded into Yukon yet, it moved quickly northwards within the Rocky Mountain Trench in northern BC, during the peak of the BC outbreak. This represents a potential pathway of MPB into Yukon given the availability of susceptible host and lack of geographic barriers.

Climate plays an important role in the population of MPB. One of the most important factors in controlling the northern movement of MPB is cold weather and an inner bark temperature of -40°C for at least one week. Mild winter weather allows overwintering MPB populations to thrive and the outbreak to continue. Unseasonably warm, dry springs and summers have likely also played an important role in the expansion of the beetle, possibly allowing for earlier emergence and mating in the spring and summer (Mitton and Ferrenberg, 2013).

MONITORING MOUNTAIN PINE BEETLE IN 2018

This marks the ninth consecutive year that the threat of MPB invasion of Yukon forests was addressed by aerial surveys in mid-August (Map 1). In 2010 when aerial surveys were initiated, MPB populations and subsequent pine mortality within the Rocky Mountain Trench (RMT) of British Columbia were very high (within 150 km of Yukon border). Given the beetle pressure and risk associated with active MPB populations in the RMT, aerial surveys were expanded in 2014 to assess the ongoing risk in two areas; a 30 by 300 km border zone straddling the Yukon/B.C. border, as well as the Rocky Mountain Trench on the British Columbia side. The border zone stretches from the Rancheria River in the west to nearly as far east as the Northwest Territories border, and encompasses areas with lodgepole pine as the dominant species.

Since that time severe winter cold has killed beetle broods within the trees. That, combined with declining populations in northern BC, has arrested significant northward movement of MPB populations. Hence in 2015, aerial surveys in the RMT were discontinued following two years of insignificant northward movement of MPB in the RMT.

Border Zone

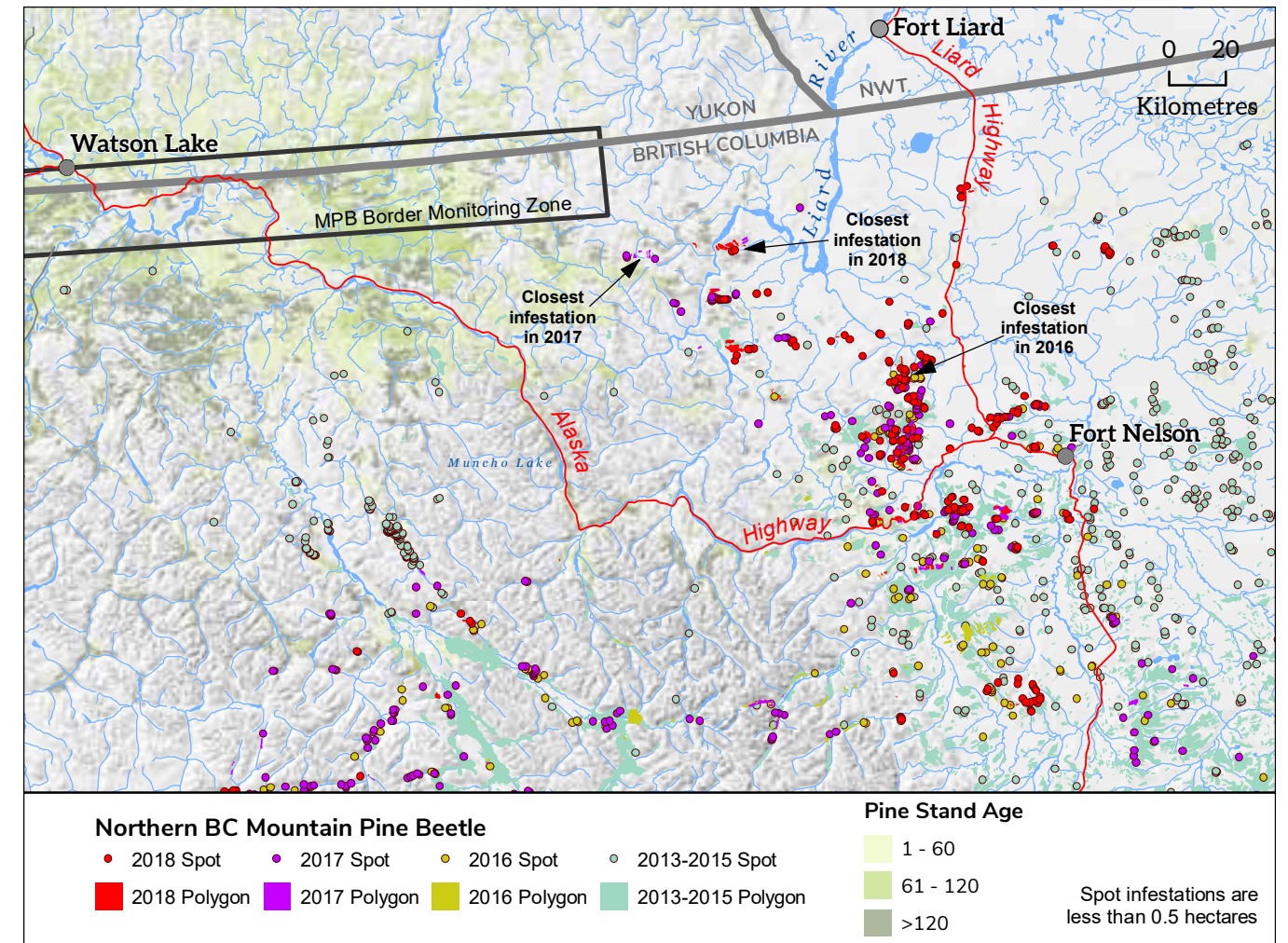
In 2018 wildfires in close proximity and within the MPB monitoring zone hampered monitoring efforts. As a result only a portion was monitored with no mountain pine beetle detected. Similar to previous years scattered single red lodgepole pines were observed in this area, suggesting attack by either the lodgepole pine beetle (*Dendroctonus murrayanae*), pine engraver beetle (*Ips pini*), and possibly porcupine. The beetles are indigenous to Yukon and generally attack old or weakened trees, as such they pose no significant threat to forest health. A typical attack from MPB usually involves small groups of trees rather than one single tree. However, given the uncertainty of behavior of MPB in novel habitats (i.e. pine habitats that have not had a history of MPB infestation) these spots will continue to be aerielly monitored as per the monitoring plan. If these spots expand to small groups of affected pine trees, ground truthing may be required to confirm whether the attacks are caused by mountain pine beetle. Currently, MPB is not present in the Yukon.

British Columbia Observations

B.C.'s Ministry of Forests, Lands and Natural Resource Operations also conduct aerial surveys in northern BC. These surveys have found that since 2013 populations in the northern Rocky Mountain Trench have retreated with only a few spots noted from 2015-2018. East of the RMT populations have receded somewhat with no new populations north of the Liard River. In 2017 a number of trace polygons had been mapped between Grayling and Scatter rivers west of Liard River. While 2018 aerial survey results suggest that these populations failed to establish, there are likely established populations - e.g. mapped two years in a row, in older pine stands east of the major bend in the Liard River (Map 17). These trace populations, totaling 234 ha, are within 40 km of the border (similar to 2017) and are found in a fragmented mature pine landscape near the Scatter and Torpid rivers. The closest (unconfirmed) spots are in the same

area, whereas in 2017 they were within 30 km of the border, in 2016 within 100 kilometers, and in 2015 within 30 km. This ebb and flow is typical of populations trying to establish in a less suitable climate and fragmented landscapes.

The boundaries of the monitoring zone in southern Yukon are based on the suitability of the landscape for MPB in terms of hazard and connectivity of lodgepole pine stands. The spots and polygons noted by BC are within 32 km of the most SE edge of the monitoring zone, within a more heterogeneous landscape. It is anticipated that westward migration will likely be halted or significantly slowed by the vast young pine stands that resulted from the 1982 "Egg Fire" that burned over 100,000 ha of mature pine (Map 16). These young stands will act as sinks rather than sources, given the smaller diameter and thin bark. Given



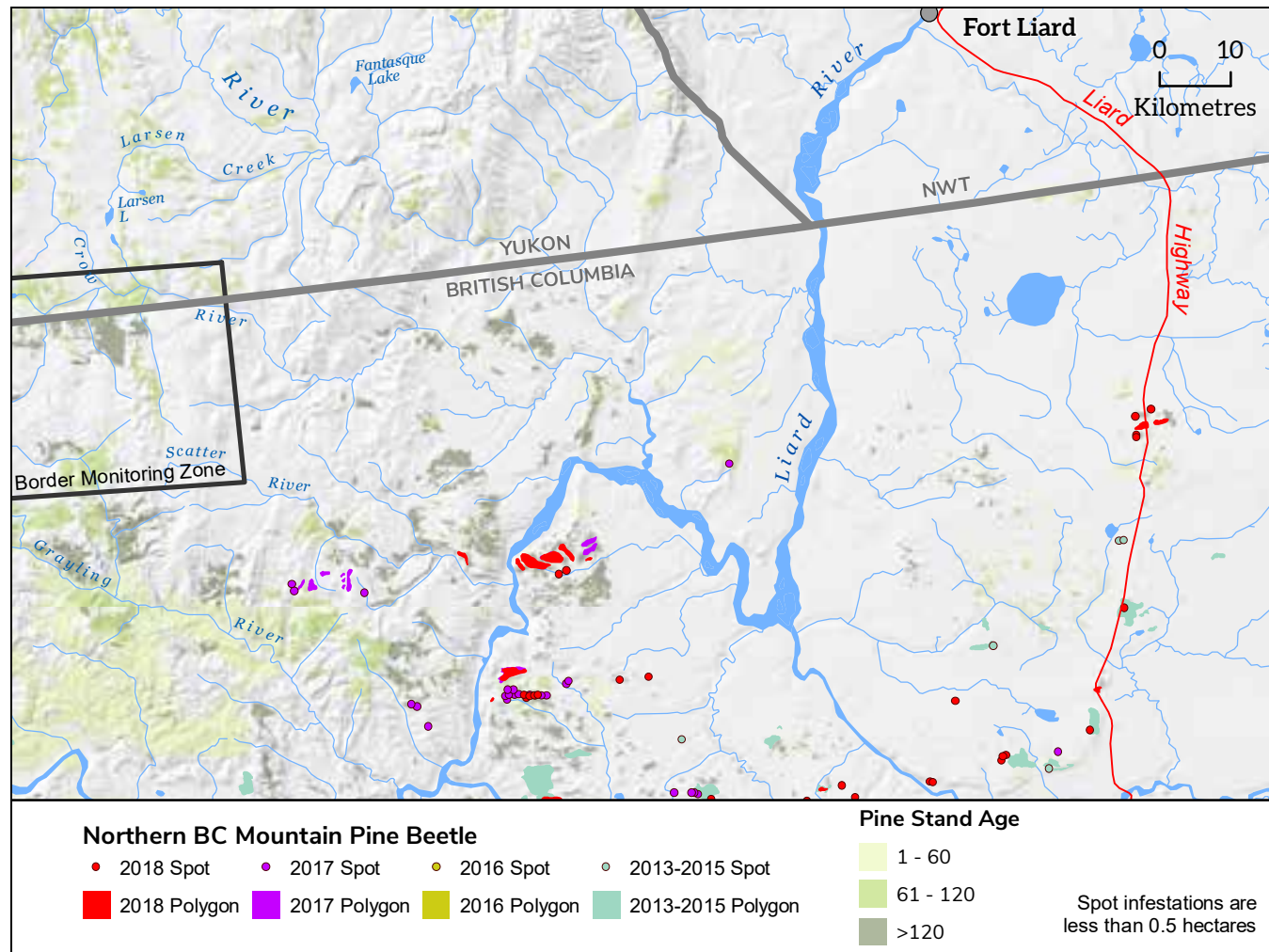
MAP 16 Mountain pine beetle in northern BC, including the Rocky Mountain Trench, from 2013-2018, and border zone monitoring area. Note based on preliminary BC data.

the uncertainty regarding fragmented habitats, Yukon FMB will continue to monitor the border zone in 2019, and conduct aerial assessments of the 'unconfirmed' MPB areas as necessary.

During the northward advance, MPB has encountered what has come to be referred as "naïve" pine. These are pine stands that have no prior experience with MPB and thus have none of the genetic defenses of southern pine trees that co-evolved with the MPB. Preliminary research indicates that "naïve" pine trees may have lower resistance and greater MPB production capacity. However the beetle remains susceptible to extended cold periods of -40°C, which cause high levels of brood mortality, especially if they occur in early or late winter. This has already been witnessed in the RMT, reinforcing the lethal effect of harsh cold winters on beetle populations. This aspect will

likely continue to influence the beetle's success or failure as it moves farther north.

If favorable weather occurs for a few years in a row, populations could increase (Bleiker, 2012, personal communication). MPB is an opportunistic species and a large pool of susceptible hosts is present. A possible future scenario could result in small remnant populations surviving and crossing the BC/Yukon border into southeast Yukon and killing scattered individual trees or small groups of trees. According to the MPB risk analysis conducted for Yukon, this could occur within the next 12 to 15 years.



MAP 17 2017 and 2018 MPB detections in northern BC in relation to host distribution and age and Yukon FMB's MPB monitoring zone.



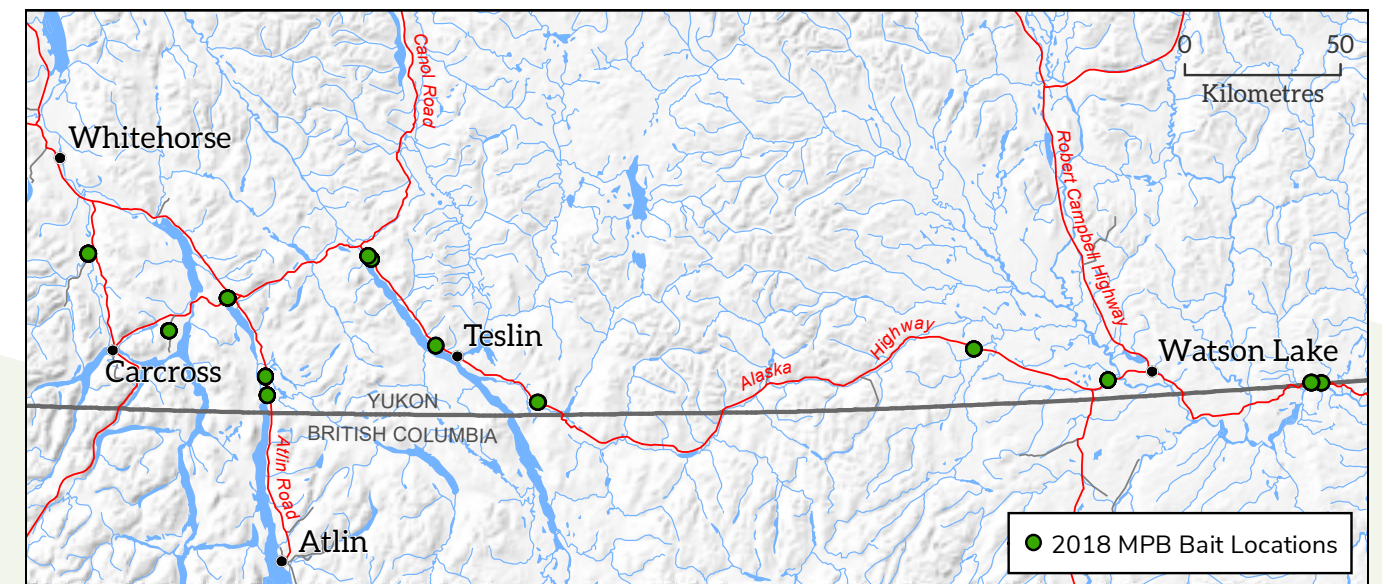
PHOTO 32 Pheromone placed on the north side of the tree.

Using Bait Traps

Since 2009, FMB has been setting up and monitoring 15 pheromone bait tree stations in southern Yukon and northern B.C. to detect the presence of MPB (Map 18, Photo 32-33). These pheromone baits do not attract MPB over long distances, but will draw them to the baits if they are already in the area. They also do not attract other species of bark beetles. No presence of MPB was found in 2018.



PHOTO 33 MPB bait tree.



MAP 18 Mountain pine beetle monitoring bait trap locations in southern Yukon and BC, conducted by Yukon FMB.

SPECIAL PROJECTS

One special project was undertaken in 2018 to better understand pest disturbances and inform risk management.

Spruce Beetle Pheromone Trapping

Rationale for monitoring plots

In the summer of 2018, spruce beetle (*Dendroctonus rufipennis*) monitoring plots were established in the Haines Junction, Yukon area. The objective of the monitoring plots was to collect information on spruce beetle populations.

Background – Spruce Beetle life history and 1990-2000s attack

The spruce beetle is a natural forest insect disturbance throughout the range of spruce (*Picea spp.*) in North America. In Yukon, spruce beetle has been the most damaging agent of mature spruce forests. The most recent major spruce beetle outbreak in Yukon was located in the southwest (Kluane region) and started in the early 1990s. The outbreak lasted well over a decade, peaking in 2004. This spruce beetle infestation has been the largest, most severe and long-lasting infestation in Canada, affecting 400,000 ha of white spruce (*Picea glauca*) forest.

During the outbreak aerial surveys were conducted annually from 1994 to 2012 to monitor activity and map white spruce mortality. During the peak of the infestation in 2004 nearly 100,000 ha of newly attacked spruce forest were detected. After 2004 the area of newly infested forest steadily declined to only 263 ha of light infestation in 2012. Aerial surveys (specific to spruce beetles in southwest Yukon) ceased in 2013 because the infestation had come to an end (Yukon Forest Health Report, 2013).

While populations are currently at endemic levels in southwest Yukon monitoring high hazard spruce forests is viewed as a best practice. This proactive measure will act as an early warning system should conditions favorable to population growth occur.

Spruce beetles have a dynamic and multi-phase life cycle which typically takes one to three years to complete. The majority of the life cycle is spent under the bark, however there is a window of time (flight period) when the adults emerge from trees and search for new host material (new live trees) to mate, excavate galleries, and lay eggs. During the outbreak, the primary tool for monitoring spruce beetles was the annual aerial surveys. Between 2005 and 2007, additional ground-based monitoring was conducted using a series of pheromone-baited Lindgren® funnel traps to determine flight period and the spatial variation in population levels. This work indicated that the flight period occurred from May to the beginning of August.

In the summer of 2018 the Forest Management Branch implemented a similar ground-based monitoring plots with the following objectives:

1. To track the presence or absence of spruce beetle in Haines Junction Timber Harvest Planning areas;
2. To better understand the timing of the spruce beetle flight period in the Haines Junction area; and,
3. To determine if spruce beetle populations are higher in some areas than others.

Description of monitoring plots & duration

Lindgren® funnel traps were used to monitor spruce beetles (*Dendroctonus rufipennis*) through the spring and summer of 2018. Lindgren® funnel traps are specifically designed for monitoring and sampling insect populations (BC FLNRO 2016). Ten funnel traps were erected across eight locations surrounding Haines Junction. Traps were established in locations where a 30 meter buffer existed between traps and live spruce trees in order to reduce the risk of attacks on live spruce trees. Traps were set on stand-alone metal posts, and chemical lures were attached to the traps to attract spruce bark beetles. Two different chemicals (lures) were used to attract spruce bark beetles to the traps; Englemann spruce terpene blend, and frontalin, both developed by Synergy Semiochemicals Corporation, Burnaby, BC. The Englemann spruce terpene blend has a similar chemical composition as the natural volatile organic compounds released by spruce trees that is responsible for attracting spruce beetles to living spruce trees. Frontalin is a chemical communication agent common to many insect species and acts as an aggregation pheromone that spruce beetles will emit to signal others to aggregate at that location (attack a specific tree).

Findings

Traps were established during the first two weeks of May, and were checked on a weekly basis for 12 weeks (Photo 34-36). During the peak of the flight period (June 18-26, 2018), traps were checked twice per week. Trap catches indicated that spruce beetle flight began during the last week of May and continued to increase thereafter, with peak activity observed in the end of June (June 18th - June 26th). After June 26th, trap catches decreased, and by the beginning of August the flight period had ended. After several weeks of little-to-no spruce beetles observed in the pheromone traps, the traps were taken down for the season. Overall there was a small number of spruce beetles caught, with 147 spruce beetles collected and recorded for all traps over the collection period.

There was considerable variation in the number of spruce beetles collected between traps (Table 3). At the low end, Trap 3 collected a total of three beetles over the entire season, at the high end, Trap 8 collected 36 beetles over the entire season. Based on trap catches it appears that spruce beetle populations are highest in the Pine Canyon and Mackintosh East areas, which are currently active commercial harvest areas. There are several harvesting considerations and best management practices that can be used to reduce spruce beetle risk, including timing harvesting operations outside the flight period (informed by Lindgren trap monitoring plots), minimizing large (>20 cm) logging debris left on site, minimizing stump heights, and not stacking infested firewood next to healthy trees.

The Lindgren® funnel traps collected many other insect species over the summer, including other bark beetles, moths, flies, bees, etc. Northern spruce engraver beetle (*Ips perturbatus*) was commonly found in the traps. Northern spruce engraver is a secondary bark beetle that attacks stressed or predisposed trees, including those already infested with spruce beetle. The northern spruce engraver population appeared to be lower than the spruce beetle population. Across all traps for the entire collection period, 43 northern spruce engraver beetles were collected.

The 2018 pheromone trap catches are considerably lower than the results from the 2005-2007 pheromone trapping undertaken during the decline of the last outbreak. However, at that time a flight pattern was also noted whereby trap catches were higher in the odd year.

Summary and Considerations for Next Year

The 2018 spruce beetle monitoring plots provided further insight into the adult flight period in southeast Yukon. Given the biennial flight pattern observed in the previous infestation and the potential effects of climate change on flight periods, it is recommended that the monitoring plots be adopted as an annual proactive measure to inform best management practices, such as timing of harvesting and milling operations.



PHOTO 34 Lindgren© funnel trap # 10 (Pine Canyon)

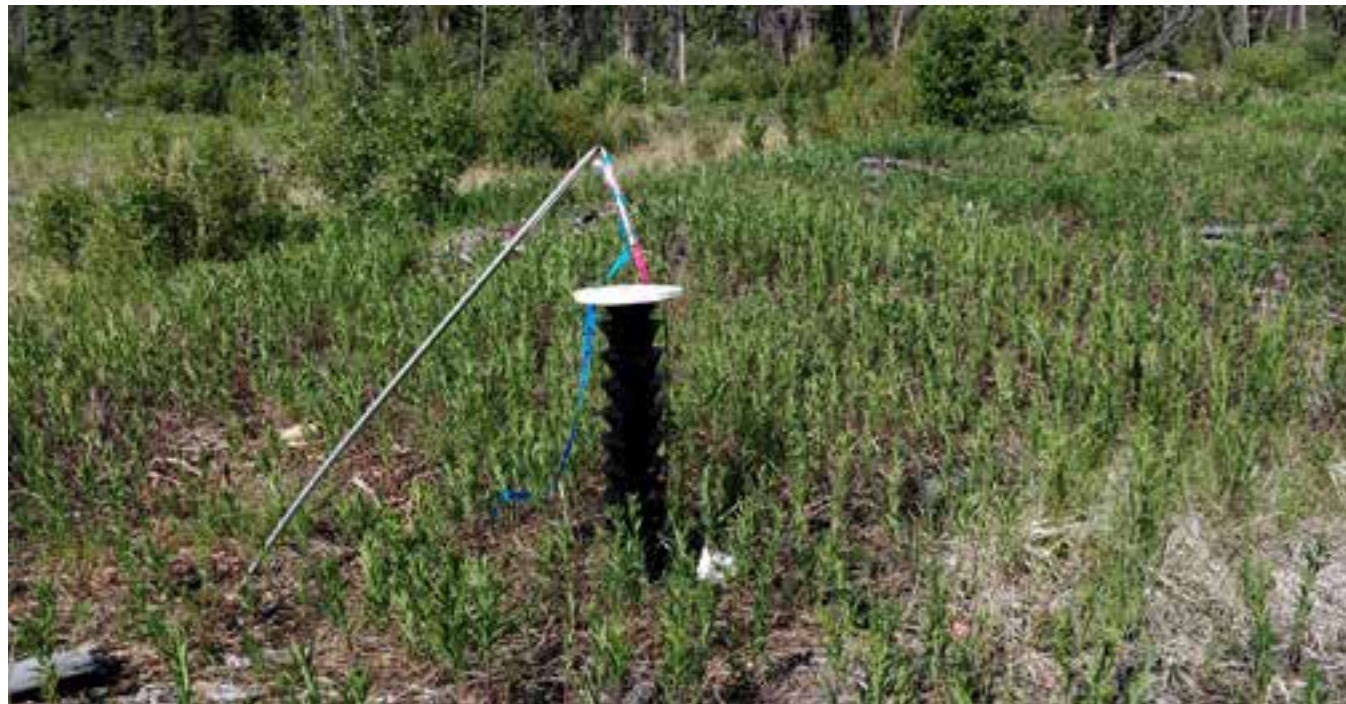


PHOTO 35 Lindgren© funnel trap # 5 (Quill Creek). Occasionally there were issues with the traps (e.g. bent posts, traps blown off posts), these issues were recorded along with any insects in the trap, and the traps were repaired and continually monitored.

TABLE 3 Location information and total number of spruce beetles collected for each Lindgren© funnel trap established near Haines Junction in spring/summer 2018.

TRAP NUMBER	LOCATION (TIMBER HARVEST PLANNING AREA)	NUMBER OF SPRUCE BEETLE COLLECTED
1	Pine Canyon	6
2	Pine Canyon	20
3	HJ Community Fuel Abatement	3
4	HJ Community Fuel Abatement	8
5	Quill Creek	4
6	Bear Creek	4
7	Pine Canyon	6
8	Mackintosh East	36
9	Pine Canyon	25
10	Pine Canyon	35

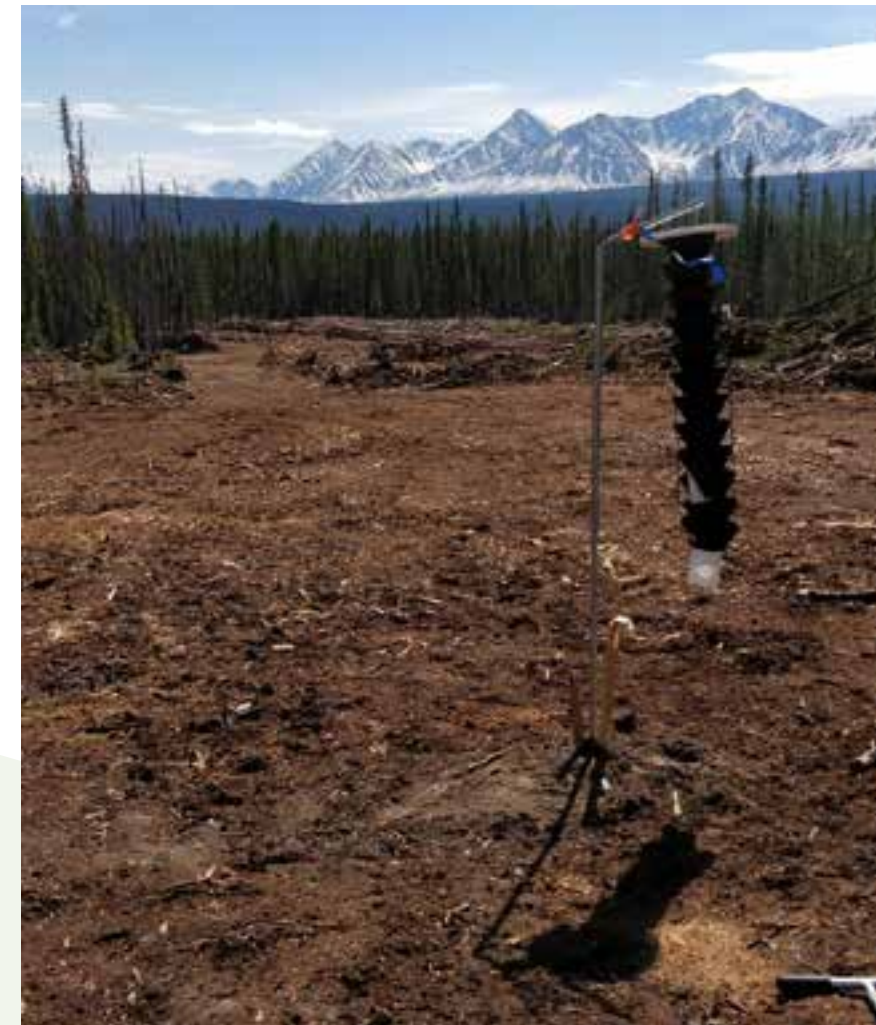


PHOTO 36 Lindgren© funnel trap # 9 (Pine Canyon)

FOREST HEALTH EXTENSION

Forest Management Branch made presentations to various stakeholders in 2018 to familiarize them with the work and priorities of Yukon's forest health program.

OTHER NOTEWORTHY DISTURBANCES IN 2018

As part of the forest health program FMB assists both the public and other government agencies to identify forest pests (Table 4 – Table 8). This section includes pests/damage that may or may not occur within the Forest Health Monitoring Zone being monitored in any given year.

TABLE 4 Summary of forest insects associated with pest incident reports in 2018.

INSECT NAME	HOST	SETTING	LOCATION	PICTURES
Northern spruce engraver beetle, <i>Ips perturbatus</i>	White spruce	Mature white spruce forest	Haines Junction area	Photo 37
Pitch twig moth, <i>Petrova spp.</i>	Lodgepole pine	Young pine forest along roadside	Nahanni road	Photo 38
Aphids	Trembling aspen, Balsam poplar	Mixed poplar, aspen, spruce along urban greenbelt	Whitehorse area	Photo 39
Roundheaded woodborers, <i>Monochamus spp</i>	White spruce	Mature spruce forest	Watson Lake area	Photo 40
Black army cutworm, <i>Actebia fennica</i>	Lodgepole pine	Mature pine, spruce forest	Takhini River road	Photo 41



51 **PHOTO 37** Northern spruce engraver beetle in the Haines Junction Area.



PHOTO 38 Pitch twig moth along Nahanni Road.



PHOTO 39 Aphids on trembling aspen and cottonwood, Whitehorse.



PHOTO 40 Roundheaded woodborers on windthrown white spruce tree, Watson Lake.



PHOTO 41 Black army cutworm, Takhini River road.

TABLE 5 Summary of forest diseases associated with pest incident reports in 2018.

DISEASE NAME	HOST	SETTING	LOCATION	PICTURES
Spruce needle rust, <i>Chrysomyxa</i> spp.	White spruce	Mature spruce forest	Mayo Area	Photo 42
Spruce broom rust, <i>Chrysomyxa arctostaphyli</i>	White spruce	Mixed spruce, aspen along urban greenbelt	Whitehorse area	Photo 43
Powdery mildew	Willow	Willow along Yukon river	Whitehorse area	Photo 44
Cytospora canker, <i>Valsa sordida</i>	Trembling aspen	Young mixed aspen, spruce forest	South of Teye Lake, Haines Junction area	Photo 45
Atropellis stem canker, <i>Atropellis piniphila</i>	Lodgepole pine	Mature pine, forest	Annie Lake road area	Photo 46



53 PHOTO 42 Spruce needle rust, Mayo.



PHOTO 43 Spruce broom rust, Whitehorse.



PHOTO 44 Powdery mildew on willow along the Yukon River, Whitehorse.



PHOTO 45 Cytospora canker of aspen South of Teye Lake off the Alaska Highway.



PHOTO 46 Atropellis stem canker, Annie Lake road.

TABLE 6 Summary of animal damage associated with pest incident reports in 2018.

ANIMAL	HOST	SETTING	LOCATION	PICTURES
Porcupine feeding damage	Lodgepole pine	Mature pine forest	Annie Lake road area	Photo 47
Squirrel feeding	Lodgepole pine	Mature pine forest	Annie Lake road area	Photo 48
Woodpecker feeding	Lodgepole pine	Mature pine, spruce forest	Annie Lake road area	Photo 49
Old bear damage or mechanical damage from axe cuts	White spruce	Mature pine, spruce forest	Annie Lake road area	Photo 50



PHOTO 47 Porcupine feeding damage, Annie Lake road.



PHOTO 48 Squirrel feeding, Annie Lake road.



PHOTO 49 Woodpecker feeding, Annie Lake road.



PHOTO 50 Old bear damage or mechanical damage from axe cuts, Annie Lake road.

TABLE 7 Summary of abiotic and other pests associated with pest incident reports in 2018.

DISTURBANCE	HOST	SETTING	LOCATION	PICTURES
Environmental, winter desiccation, red needles on young pine.	Lodgepole pine	Young lodgepole pine forest along roadside	Johnson's Crossing	Photo 51
Leaf scorch	Trembling aspen	Young aspen along Yukon river	Whitehorse area	Photo 52
Spider egg sac	Lodgepole pine	Mature pine, forest	Annie Lake road area	Photo 53



PHOTO 51 Environmental, winter desiccation; red needles on young pine near Johnson's Crossing.



PHOTO 52 Leaf scorch on trembling aspen, Whitehorse.



PHOTO 53 Spider egg sac, Annie Lake road.

TABLE 8 Summary of pest complexes associated with pest incident reports in 2018.

DISTURBANCE	HOST	SETTING	LOCATION	PICTURES
Red belt ¹ with some pine needle cast <i>Lophodermella concolor</i> ²	Lodgepole pine	Mature lodgepole pine forest	Near Rancheria	Photos 54, 55
Comandra stem rust, <i>Cronartium comandrae</i> with rodent feeding damage of canker.	Lodgepole pine	Young lodgepole pine forest along roadside	Nahanni road	Photo 56
Porcupine feeding and Elytroderma needle disease, <i>Elytroderma deformans</i> ³	Lodgepole pine	Mature pine, spruce forest	Annie Lake road area	Photo 57

² Red belt refers to a red-banding appearance in conifer landscapes in the spring/early summer. This phenomena is not thoroughly understood but is thought to be caused by above-freezing temperatures in early spring, which cause the needles to start transpiring. As groundwater is still frozen, it is not available to the transpiring needles and leads to needle desiccation. Red belt often occurs in valleys where inversions occur. This is a temporary condition resulting in the loss of some foliage but trees normally recover quickly.

³ Elytroderma needle disease is suspected based on the broom appearance of some of the branches. Another characteristic is the stocky or large diameter of the branches with brooms.



PHOTO 55 Red belt with some pine needle cast near Rancheria.



PHOTO 54 Red belt with some pine needle cast near Rancheria.



PHOTO 56 Comandra stem rust with rodent feeding damage of canker, Nahanni road.



PHOTO 57 Porcupine feeding damage and Elytroderma needle disease, Annie Lake road.

TABLE 8 CON'T Summary of pest complexes associated with pest incident reports in 2018.

DISTURBANCE	HOST	SETTING	LOCATION	PICTURES
Environmental and/or pine needle cast, <i>Lophodermella concolor</i>	Lodgepole pine	Mature pine forest	North of Little Salmon Lake	Photo 58, 59, 60
Environmental and pine needle cast, <i>Lophodermella concolor</i>	Lodgepole pine	Young pine forest along roadside	Nahanni road	Photo 61



PHOTO 58 Environmental and/or pine needle cast north of Little Salmon Lake.



PHOTO 59 Environmental and/or pine needle cast north of Little Salmon Lake.



PHOTO 60 Environmental and/or pine needle cast north of Little Salmon Lake.



PHOTO 61 Environmental and pine needle cast along Nahanni road.

REFERENCES

Anon, 2008. Understanding the effects of flooding on trees. Sustainable Urban Landscapes, Iowa State University, University Extension. 4 p.

B.C. Ministry of Forests. 2016. Lindgren funnel traps to monitor beetle development and flight, as described in *Omineca* Region Guidelines for Spruce Beetle Haul and Mill Strategies, section 8.

B.C. Ministry of Forests and Canadian Forest Service. 2000. *Forest Health Aerial Overview Survey Standards for British Columbia*. Prepared for the Resources Inventory Committee. 36pp.

Canadian Council of Forest Ministers. 2007. *National Forest Pest Strategy*. 13pp.

Campbell, E.M., R.I. Alfaro, and B. Hawkes. 2007. *Spatial distribution of mountain pine beetle outbreaks in relation to climate and stand characteristics: a dendroecological analysis*. Journal of Integrative Plant Biology 49: 168-178.

Carroll, A.L. 2007. When forest management and climate change collide: The eruption and spread of mountain pine beetle populations in western North America. Page 11 in Climate change impacts on boreal forest disturbance regimes; Conference program & abstracts. Disturbance dynamics in boreal forests, VI International Conference. Fairbanks, Alaska, 30 May – 2 June.

Carroll, A.L., S.W. Taylor, J. Régnière, and L. Safranyik. 2003. *Effects of climate change on range expansion by the mountain pine beetle in British Columbia*. Pages 223-232 in Shore, T.L., J.E. Brooks, and J.E. Stone (editors).

Ciesla, W.M. 2000. *Remote sensing in forest health protection*. USDA Forest Service, Forest Health Technology Enterprise Team, FHTET Report No. 00-03. 266pp.

Garbutt, R. 2013. *Yukon Forest Health Report: 2013*. Yukon Energy Mines and Resources, Forest Management Branch.

Garbutt, R. 2009. *Yukon forest health report: 2008*. Government of Yukon Energy, Mines and Resources, Forest Management Branch.

Hadley, J.L. and W.K. Smith. 1983. Influence of wind exposure on needle desiccation and mortality for timberline conifers in Wyoming. *Arctic and Alpine Research*. 15 (1):232-239

Logan, J.A., and J.A. Powell. 2001. *Ghost forests, global warming, and the mountain pine beetle* (Coleoptera: Scolytidae). *American Entomologist* Fall: 160-172.

Mitton J.B. and M.C. Grant. 1980. *Observations on the Ecology and Evolution of Quaking Aspen, Populus tremuloides in the Colorado Front Range*. *Amer. J. Bot.* 67 (2): 202-209.

Mitton, J. and S.M. Ferrenberg. 2012. *Mountain Pine Beetle Develops an Unprecedented Summer Generation in Response to Climate Warming*. *The American Naturalist* 179 (5): 163 – 171.

Ott, R.A. 2008. *RAO Ecological Consulting Services trip report for the 2008 Yukon forest health survey*. RAO Ecological Consulting Services, Bennington, Vermont. Government of Yukon Contract Number GN08533048-55495. 19pp.

Worrall J.J., G.E. Rehfeldt, A. Hamann, E.H. Hogg, S.B. Marchetti, M., Michaelian, and L.K. Gray. 2013. *Recent declines of Populus tremuloides in North America linked to climate*. *Forest Ecology and Management*. 299:35-51.



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