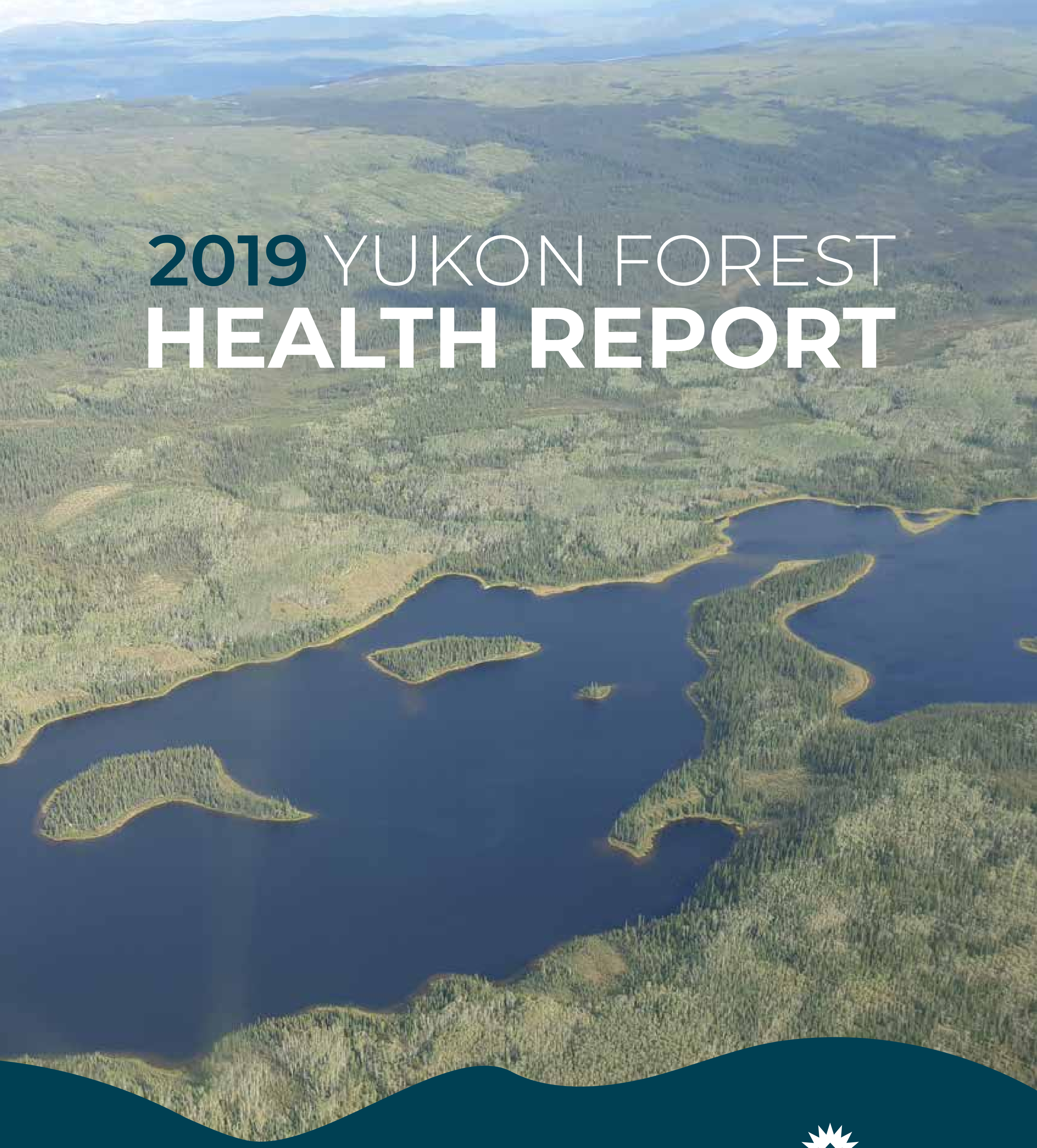
# 2019 YUKON FOREST HEALTH REPORT



Yukon

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**FOR FURTHER INFORMATION, PLEASE CONTACT:**

Energy, Mines and Resources, Government of Yukon
Forest Management Branch

Physical Address:
Mile 918.07 Alaska Highway
Whitehorse, Yukon

Reception:
Phone: 867.456.3999
Toll free in Yukon: 1.800.661.0408 ext. 3999
Fax: 867.667.3138
Email: forestry@gov.yk.ca

Mailing Address:
Box 2703 (K-918)
Whitehorse, Yukon Y1A 2C6

**www.yukon.ca/forestry**

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# 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 the 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 2 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 2019, a combination of grid and drainage flying was conducted, using a 14km grid.

Forest health reports are produced annually by FMB. These reports summarize the results of forest health monitoring and related-activities and draw on historical data to access 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 was made available and will be used for interpretation of population trends going forward. 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**







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.

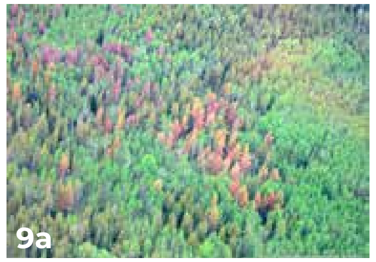
**6b** Adult moth, Large aspen tortrix.

## 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.




## 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.

For further information on these and other Yukon forest health disturbances please refer to the EMR forest health website at **http://www.yukon.ca/forestry** This website contains forest health brochures and annual reports prepared by EMR.



# SUMMARY OF 2019 FOREST HEALTH INITIATIVES

The following four initiatives were completed by FMB in 2019:

## COMPONENT 1: Annual Forest Health Aerial and Ground Surveys

In 2019, aerial surveys were undertaken in central Yukon, Forest Health Zone 2 (FHZ 2), in order to map Yukon forest disturbances as described in the Yukon Forest Health Monitoring Strategy (Map 1). The survey took five days to complete. Weather conditions in 2019 were rather unsettled with rain, mist and low clouds as well as smoke, all of which made for less than optimum lighting conditions.

## COMPONENT 2: Proactive Management of Mountain Pine Beetle

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 the Yukon. This plan has provided effective and efficient management for tracking the northern expansion of the MPB population. Since 2014 surveys have been undertaken along the BC border using a 30 km east-west grid. The grid was adaptive in that it was based on the MPB risk in BC; initially the grid was 300 km*30 km (5 km north of border in Yukon, and 25 km south of border in BC), but was reduced to 300*25 km over the last few years given the decreasing populations in BC.

This will be the last year that FMB monitors the border zone given the diminishing MPB risk in northern British Columbia, extensive wildfires in the border zone, and 10 years of monitoring with no MPB detected. This decision will be revisited if and when MPB poses a risk to Yukon pine forests as determined by annual surveys conducted by the British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

## COMPONENT 3: Special Projects: Enhancing Knowledge Base to Inform Risk Management

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).

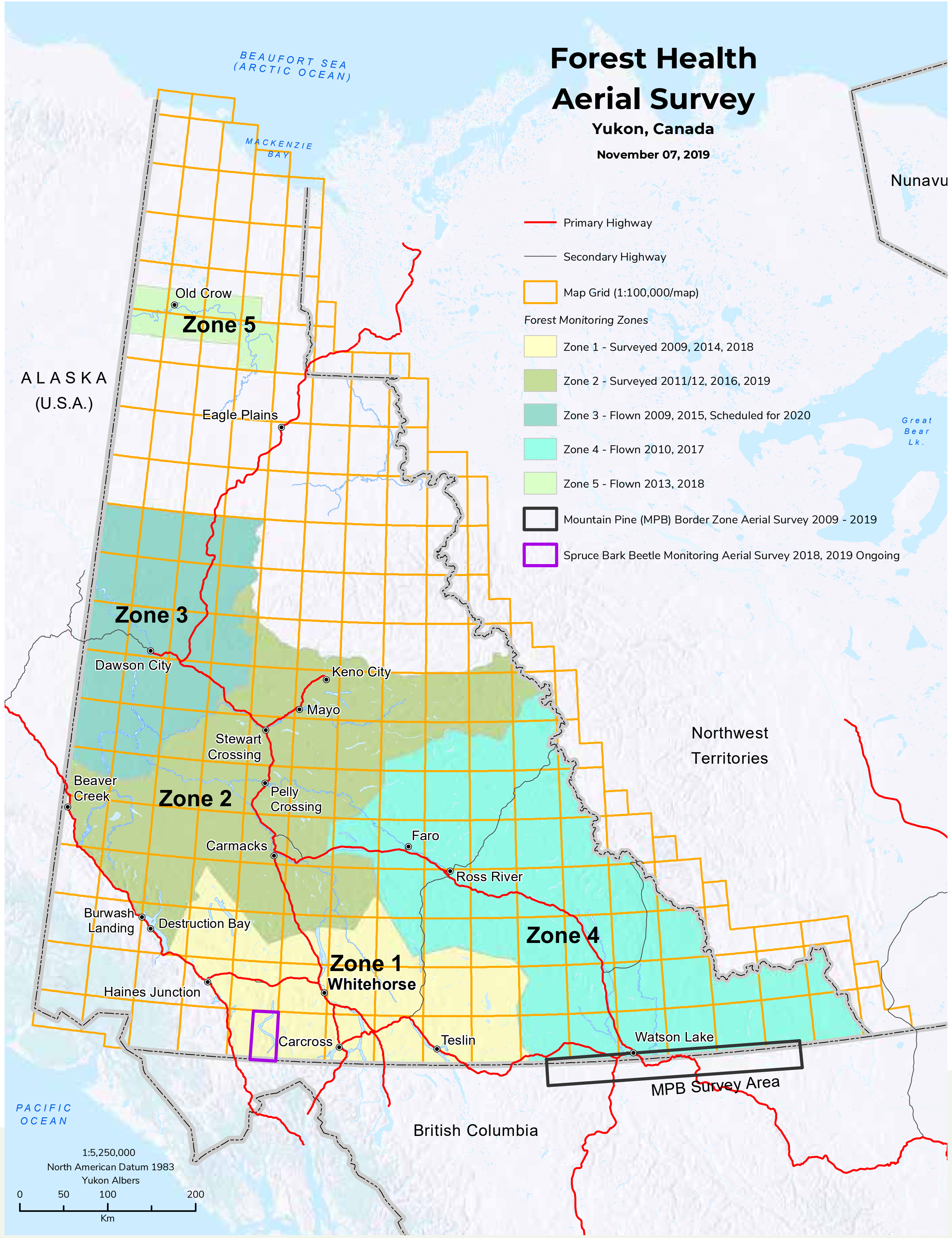
Two special projects were undertaken in 2019; one a continuation of a 2018 project.

1. In 2018 and 2019, spruce beetle pheromone trapping was undertaken in the Haines Junction area to 1) monitor populations of spruce beetle in Haines Junction Timber Harvest Planning areas, 2) understand the timing of the spruce beetle flight period in the Haines Junction area; and 3) and to determine the spatial distribution of the spruce beetle populations in Haines Junction area
2. Helicopter reconnaissance and ground surveys of spruce beetle populations in the Kusawa Lake area and eastward towards Carcross.

## COMPONENT 4: Extension – Community Engagement

FMB prepares and delivers presentations regarding forest health, either for special projects - e.g. mountain pine beetle, 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 2019, contained in this forest health report.




**MAP 1** Yukon Forest Health Aerial Surveys by year (2009 – 2019) and planned surveys for 2020.

# ANNUAL FOREST HEALTH AERIAL AND GROUND SURVEYS

In 2019 forest health surveys were directed at biotic and abiotic disturbances in FHZ 2. A five day aerial survey of the forested area within FHZ 2 was undertaken using an extended Cessna 206 fixed-wing aircraft (Photo 1). The area was flown in an east-west grid pattern with 14 kilometres between grids, allowing each surveyor to map seven km on either side of the plane. In 2019 two additional FMB staff accompanied the primary aerial observer for one or two days each for the purposes of mentoring (Photo 2).

FHZ 2 includes a section of the Porcupine River drainage basin. This is a large area bounded on the south (approximately) by latitude 61° 00' North, extending northward to latitude 64° 10' North. To the north it runs along the Hess River, south towards the Glenlyon Range and then to Mount Black. To the west it is bordered by Kluane National Park and to the NE from Kluane to Ogilvie Mountains. It falls mostly into the northern boreal cordillera ecozone but also includes western boreal cordillera, Mackenzie-Selwyn Mountains, and a very small portion in the Wrangell Mountains in Kluane National Park (Map 2, Photo 3-7).

**PHOTO 1** Two-person aerial survey crew and extended Cessna 206.

**PHOTO 2** Aerial survey trainee, primary aerial surveyor, and pilot.

**PHOTO 3** White River drainage NW of Haines Junction with predominantly spruce forests.

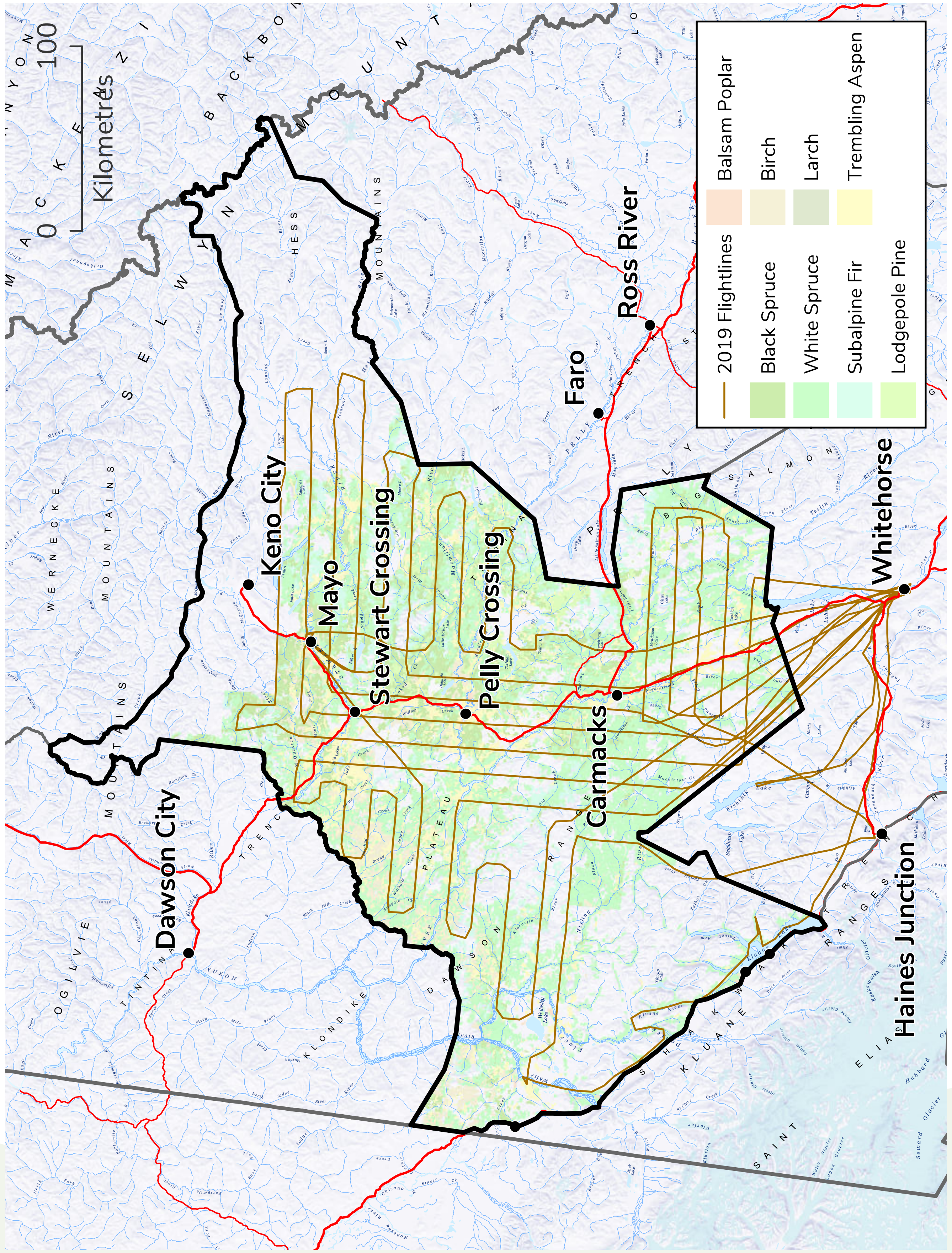
**PHOTO 4** Stewart River east of Mayo with mixed forest types including spruce and trembling aspen.



**PHOTO 5** Predominantly white spruce stands with pockets of trembling aspen near Coghlan Lake, north of Whitehorse.

**PHOTO 6** Spruce, lodgepole pine, and trembling aspen mixed forests near Ragged Lake, SE of Pelly Crossing.

**PHOTO 7** Treeless hillside in the Russell Range east of Mayo.






**MAP 2** Aerial survey flight lines in 2019 over Forest Health Zone 2.

# 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 2019 based on 21 weather stations throughout Yukon and are depicted in Figures 1-4.

## 2019 YUKON WEATHER SUMMARY

- October 2018-February 2019 was warmer than normal throughout Yukon, and was marked by well below normal snowfall throughout central Yukon
- The warm and dry trend continued through March 2019 with temperatures as much as 11 degrees warmer than normal throughout northern Yukon. By April 1, the warm and dry conditions resulted in most or all of the seasonal snowpack melting at lower elevations, and in many cases at high elevations as well
- Late spring and summer were consistently warmer than normal while rainfall patterns varied, with central Yukon receiving well below normal amounts while most of southern Yukon received near or above normal rainfall
- Temperatures in August cooled to 1-2 degrees cooler than normal except for southwest Yukon.

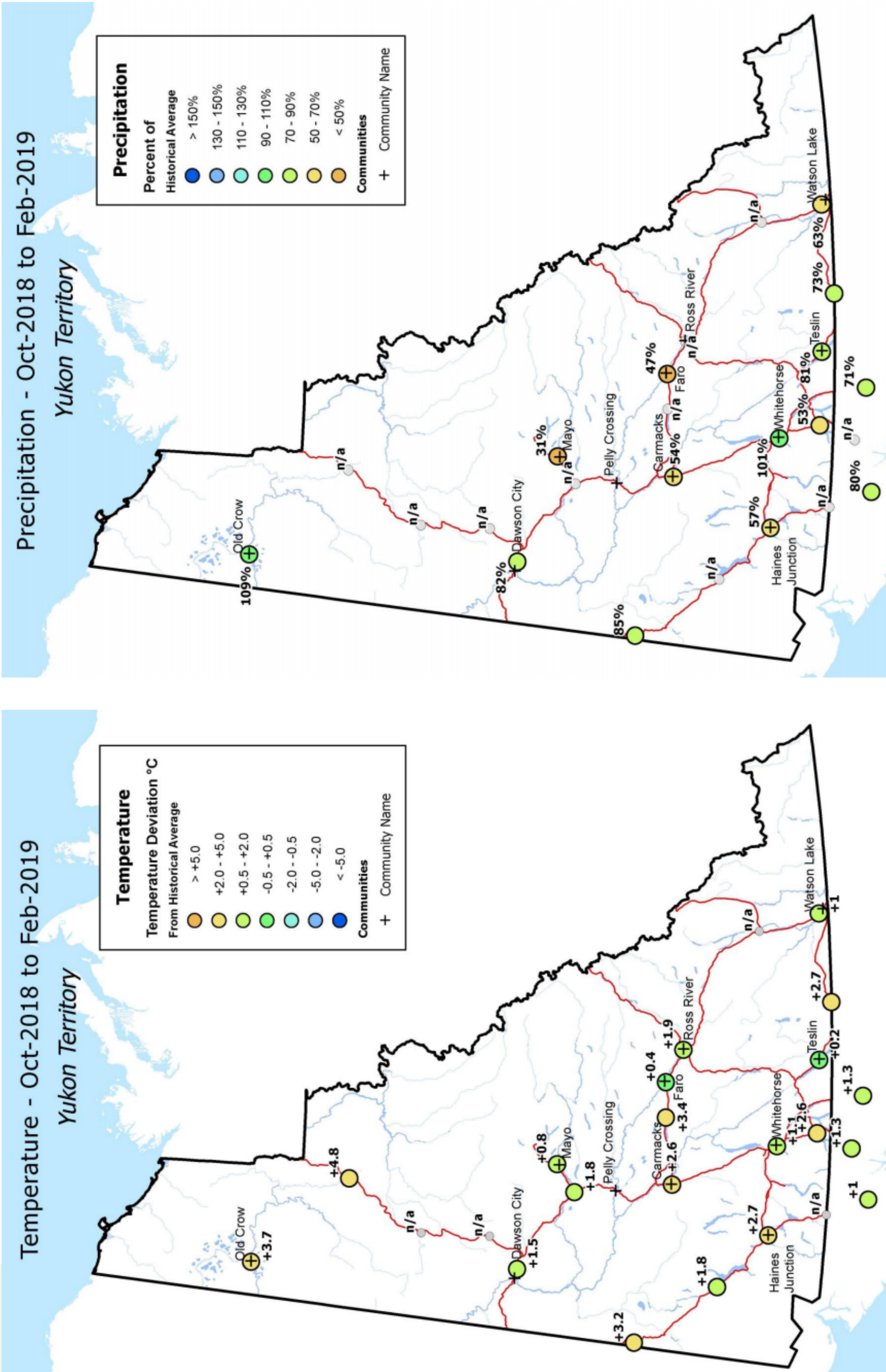





**FIGURE 1** Temperature (left) and precipitation (right) anomalies, October 2018 to February 2019.

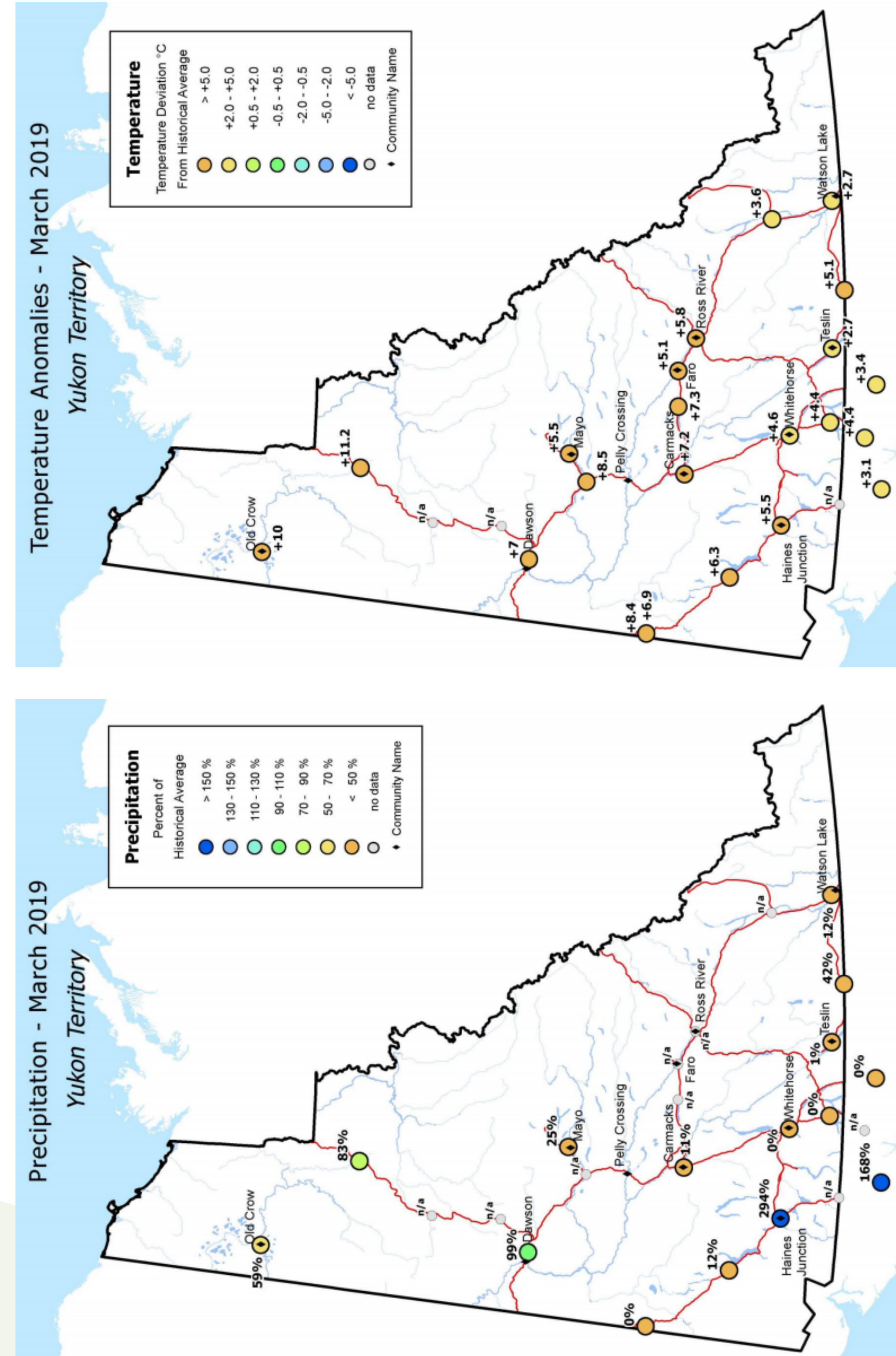



**FIGURE 2** Precipitation (left) and temperature (right) anomalies, March 2019.

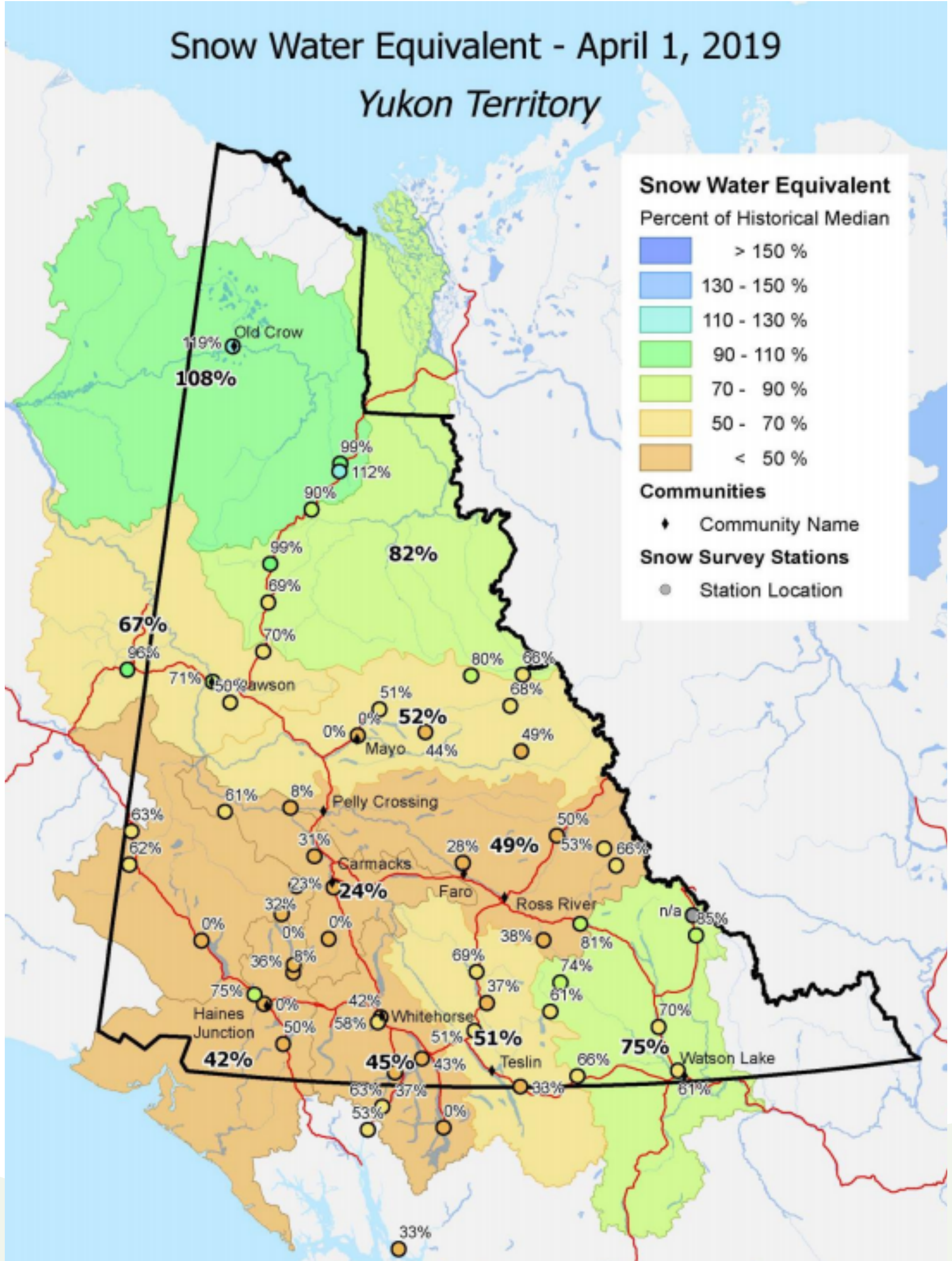





**FIGURE 3** April 1 snow water equivalent.
Source: Yukon Water Resources April Snow Survey and Water Supply Bulletin.

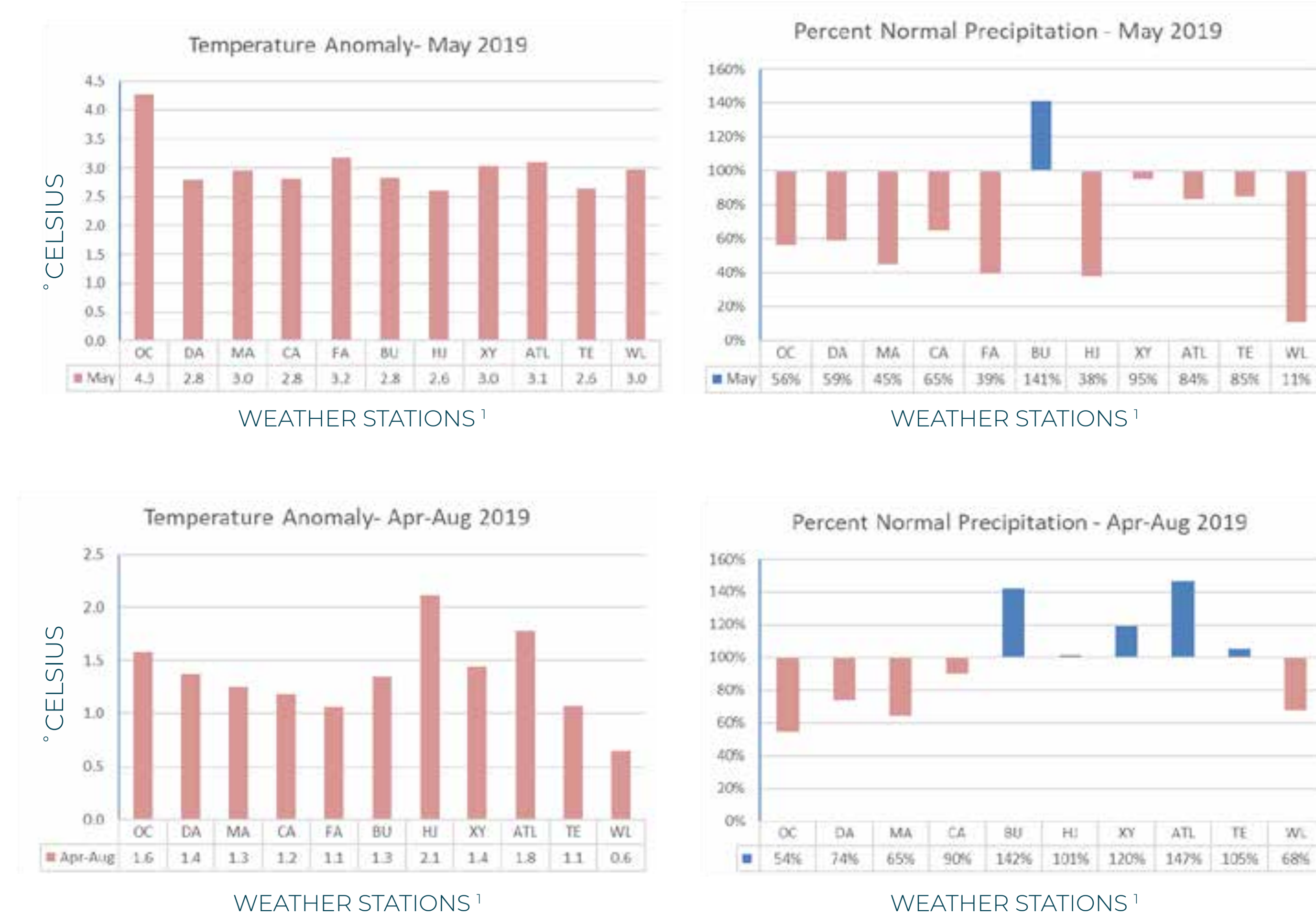



**FIGURE 4** May 2019 temperature and precipitation anomalies (top) and April – August 2019 temperature and precipitation anomalies (bottom). Source: Climate.weather.gc.ca and Yukon Wildland Fire Management.

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

# SUMMARY OF 2019 **BIOTIC** AND **ABIOTIC DISTURBANCES**

Given that FHZ 2 was surveyed in 2011/2012 and in 2016 it is possible to assess trends over time by comparing pest activity in these years (Table 1). In addition, special surveys were conducted in FHZ 1 to follow-up on the spruce beetle infestation mapped in 2018 in the Kusawa drainage area; all forest health factors were mapped during this survey and are included in Table 1.

**TABLE 1** Summary of forest health disturbances in a portion of FHZ 1, and FHZ 2 in 2011/2012, 2016, and 2019. Note some stands had a combination of pests – the most dominant pest is noted first.

| | FHZ 1 | FHZ 2 | | |
|---|---|---|---|---|
| **DISTURBANCE TYPE** | **2019 (ha)** | **2011/12 (ha)** | **2016 (ha)** | **2019 (ha)** |
| **Biotic** | | | | |
| Aspen serpentine leaf miner | - | 181,900 | 32,884 | 96,132 |
| Large aspen tortrix | 342 | 730 | 6,106 | 726 |
| Birch leaf roller | - | 468 | 847 | - |
| Spruce beetle | 709 (old) | 48 | - | 54 |
| Western balsam bark beetle | 34 | 6 | 27 | 10 |
| Willow blotch miner | 28 | 168 | 526 | 5,823 |
| Northern spruce engraver beetle | - | - | 36 | - |
| Pine needle cast | - | 7,116 | 85 | 629 |
| **Abiotic** | | | | |
| Aspen decline | - | 906 | 513 | 4,769 |
| Flooding | - | 213 | 48 | 132 |
| Drought - spruce | - | - | 35 | - |
| Drought - aspen | - | 20 | - | - |
| Landslide | - | 234 | - | 5 |
| Windthrow | - | - | - | 5 |
| **Pest Complexes** | | | | |
| Aspen serpentine leaf miner/aspen decline | - | - | 145,719 | 90,083 |
| Large aspen tortrix/aspen decline | - | - | 12,648 | - |
| Pine needle cast/abiotic | - | - | - | 767 |
| Porcupine/lodgepole pine beetle | 0.5 | 26 | 15 | 3 |



# 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. The tell-tale signs of silvery foliage and reduced growth can be seen along most of the highways in Yukon.

Aspen serpentine leaf miners affect photosynthesis by mining the leaf tissue and impairing the functioning of the stomata on the bottom of the leaves (Wagner et al. 2008; Doak and Wagner 2015). This can lead to premature leaf loss, up to 4 weeks earlier on severely mined foliage (Wagner et al. 2018), reduced growth, and tree mortality (Wagner and Doak 2013; Doak and Wagner 2016).

Tree ring analysis of several tree species in Alaska found that if the warming trend of the last several decades persist aspen productivity will remain low with elevated risk of ongoing mortality (Cahoon et al. 2018). Based on their findings they speculate that aspen may be eliminated on the warmest and driest sites. This is due to a combination of a warmer and drier climate which increases the vulnerability to defoliators or initiates/exacerbates the severity of an aspen serpentine leaf miner outbreak. While the role of aspen serpentine leaf miner in the aspen decline complex has not been studied in the Yukon it is speculated that this biotic factor is indeed a contributing factor (see aspen decline section).

In Yukon this leafminer has been present every year for the last two decades with variation in annual levels, severity and extent. In 2019 FHZ 2 had a slight increase from 2016 and 2011/2012. Infested areas accumulated to 186,215 ha in 2019, 178,603 ha in 2016 and 181,900 ha in 2011/2012.

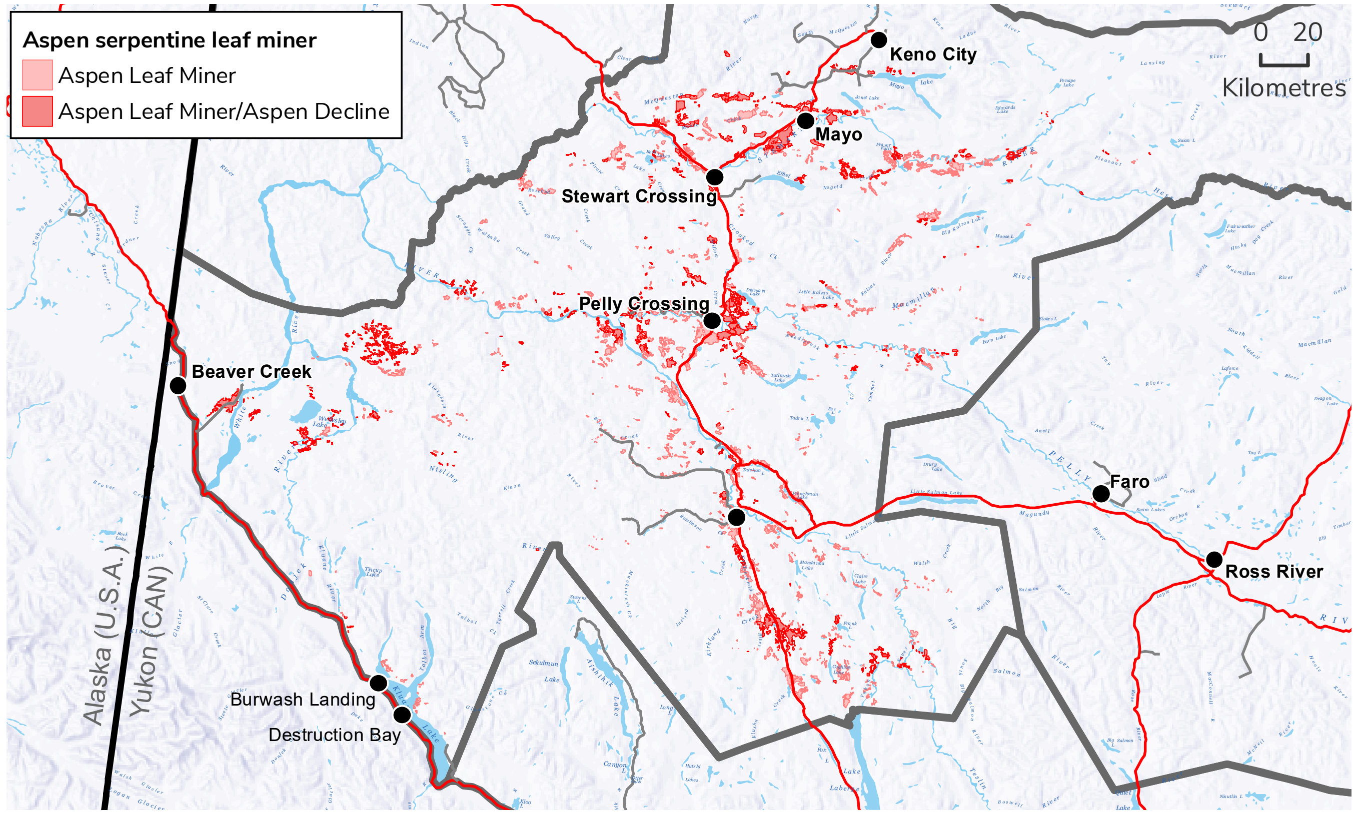
Silvery leaves characteristic of this defoliator (Photo 8) were noted throughout the host range in FHZ 2, and in combination with aspen decline (Photo 9 and Photo 10) in 48% of the stands (Map 3).

**PHOTO 8** Moderate aspen serpentine leaf miner west of Wellesley Lake.

**PHOTO 9** Moderate aspen serpentine leaf miner with light aspen decline northeast of Wellesley Lake.

**PHOTO 10** Severe aspen serpentine leaf miner with light aspen decline along Donjek River.

**PHOTO 11** A vibrant and healthy aspen stand; an uncommon sighting.




**MAP 3** Aspen serpentine leaf miner defoliation and occurrence with aspen decline in FHZ 2 in 2019.

## 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 in forest stands north of the village of Haines Junction. 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.

**PHOTO 12**
Moderate large aspen tortrix defoliation (light pinkish hue of the aspen) near Alligator Lake, SW of Whitehorse.

The most recent outbreaks began in FHZ 1 in 2012, and in FHZ 2 and FHZ 3 in 2015. In FHZ 4 sporadic defoliation has been noted between Francis Lake to Ross River, and Little Salmon Lake, but there has not been any recorded landscape-level events. While it appeared that populations had collapsed in FHZ 1 in 2017, 1,060 hectares of defoliation was recorded in 2018 in the Whitehorse-Haines Junction corridor. In 2019 no defoliation was noted in this corridor, however 726 hectares of trembling aspen forests were infested near Annie and Alligator Lakes (Photo 12). Defoliation was also noted south of Minto near Big Creek, Rosebud and Scroggie Creek west of Pelly Crossing, and McQuesten River and Lake Creek (Map 4) between McQuesten and Stewart Crossing (Map 5). Dieback associated with successive years of defoliation persists in previously defoliated stands.

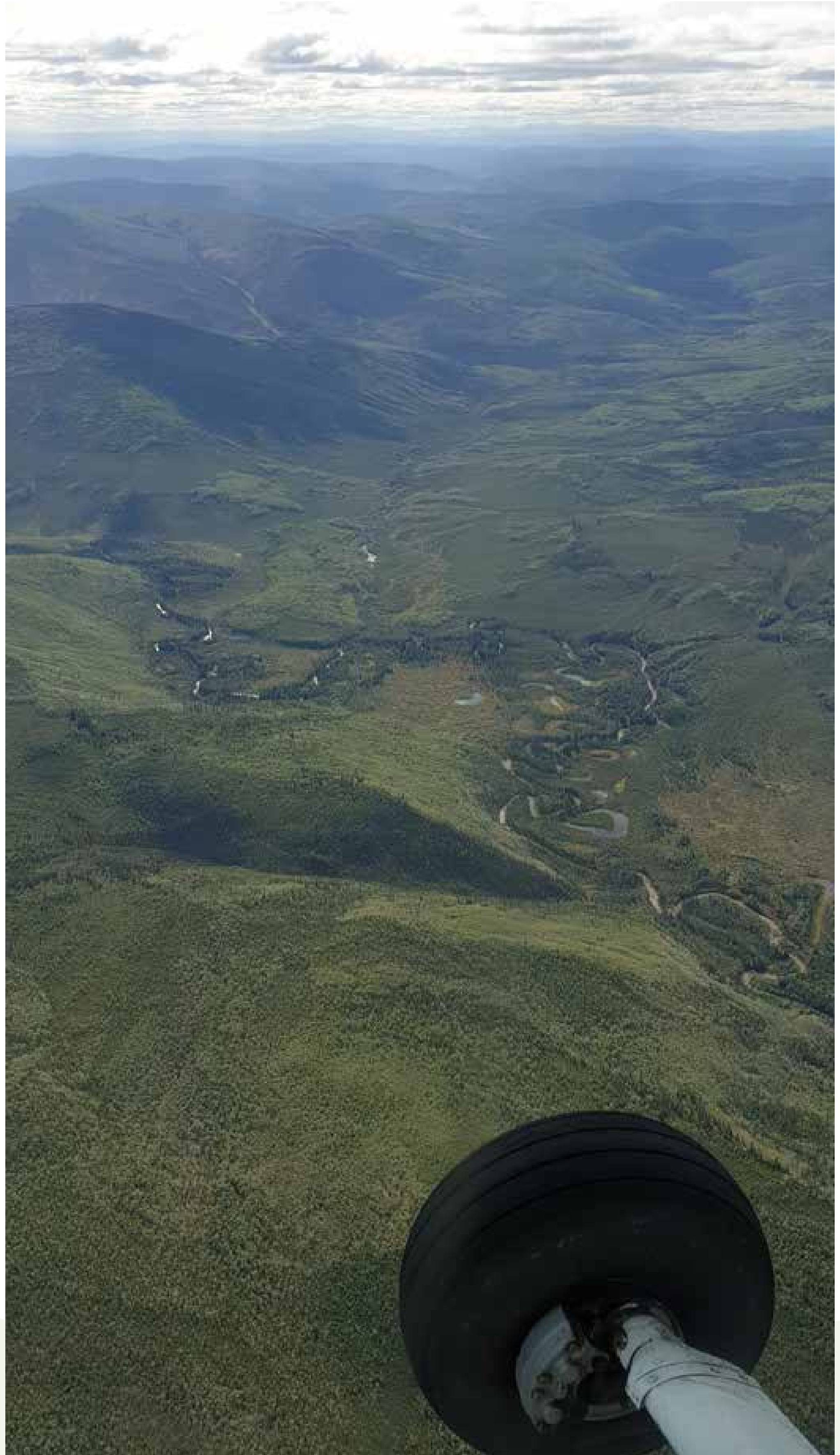
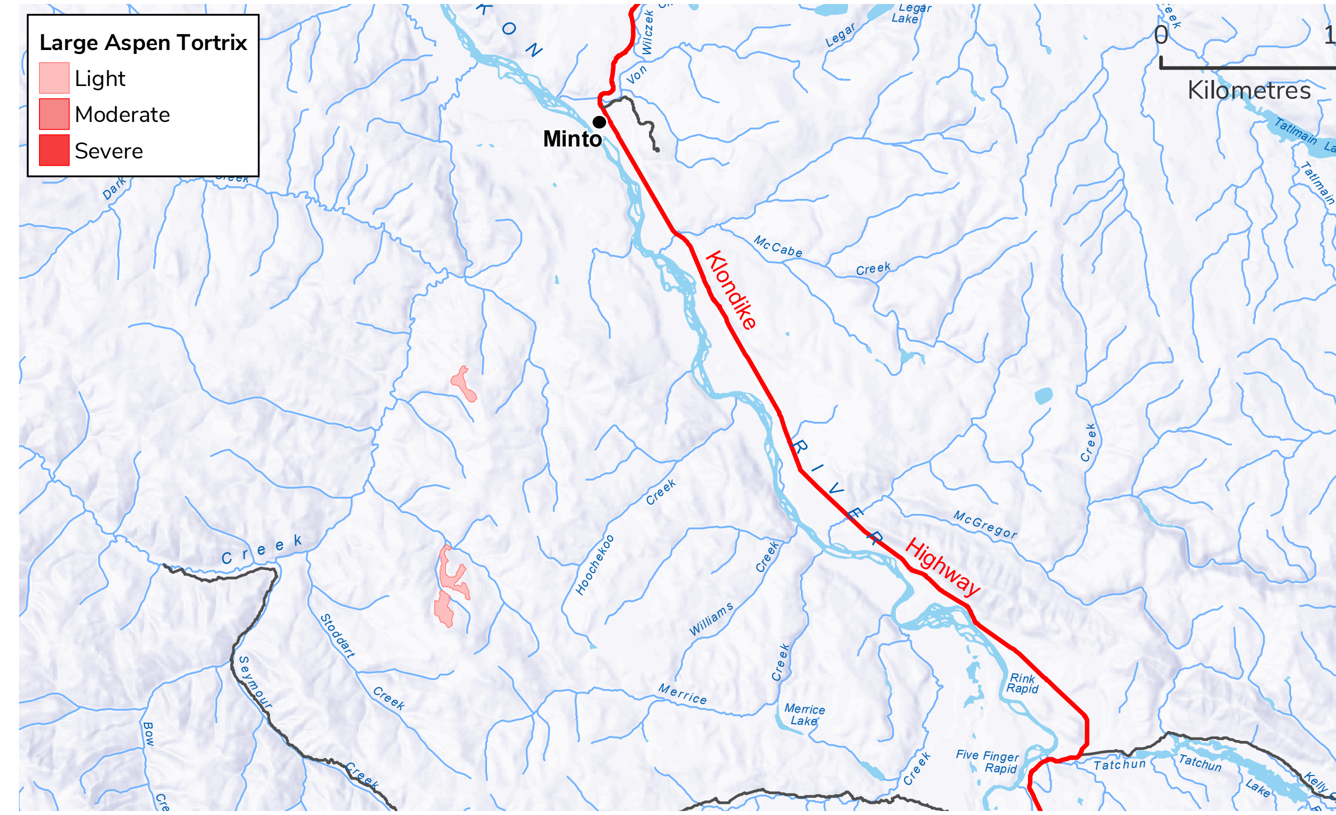
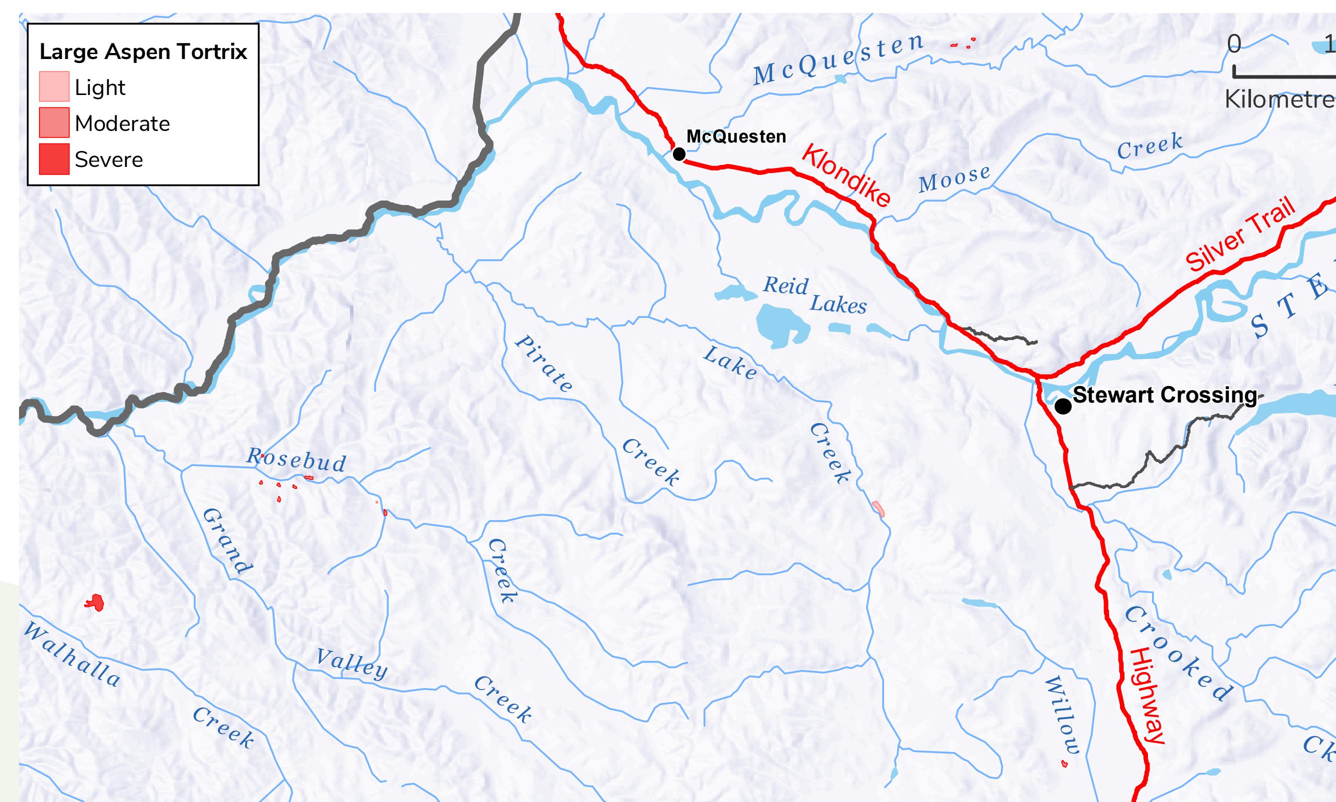


**PHOTO 13** Light large aspen tortrix defoliation near Rosebud Creek.




**MAP 4** Large aspen tortrix defoliation southwest of Minto.




**MAP 5** Large aspen tortrix defoliation southwest of McQuesten.

## **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 vast 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 hectares.

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 hectares 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. At the end of the last outbreak populations were persisting, albeit at very low levels, in the Devilhole Creek/Kusawa Lake area. 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.

The life cycle of the spruce beetle typically takes one to three years depending on site position, temperature and elevation. In the two- year cycle, early instar larvae overwinter and mature the following summer. In the late summer or early fall two years after the initial attack, brood adults may emerge from the bole and crawl to the base where they enter at the root collar to hibernate. During one-year cycling, larvae grow throughout the summer months, pupate in late summer (July/August) and overwinter as adults. Regardless of the length of the life cycle, a beetle must overwinter as an adult before it can reproduce.

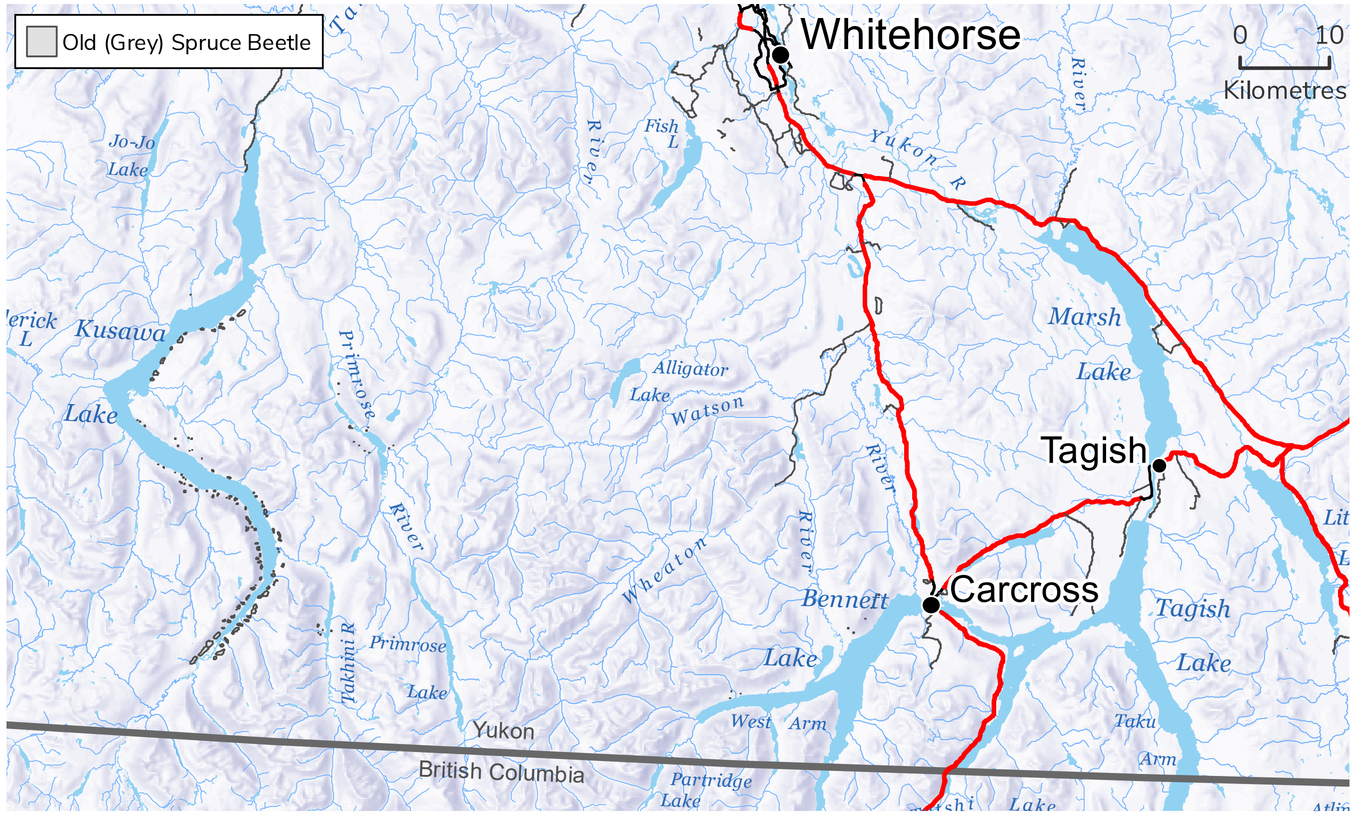
Normally between 12 to 18 months following attack the foliage of dying trees will turn yellow-orange/red. Discolouration may vary between branches on the same tree over time. Needles usually drop from the tree 14 to 20 months following attack. The exposed twigs of the upper crowns have a yellowish-orange/red hue and later, turn to grey. In Yukon depending upon the site and climatic factors, discolored foliage can be retained for a few years, although duller in colour than the initial colour fade (Table 2). This phenomena makes it more difficult to assess outbreak stage based on the ratio of reds to greys. It is possible that some of the red trees are two-year old attack with adult beetles overwintering in the root collar. Duller red trees are three-year old attack with no beetle present.

**TABLE 2** Life stages and associated tree discoloration in a spruce beetle two-year life cycle.

| **LIFE STAGE** | | **TREE COLOUR** |
|---|---|---|
| Spring 2017 | Attacking adult/lays eggs | Green foliage |
| Fall 2017 | Overwinter as larvae | Green foliage |
| Summer/Fall 2018 | Develop to adult and overwinter in root collar | Yellowing foliage can also appear-orange-<br>Trees showing this color are referred to as “Faders” |
| Spring 2019 | Emerging Adult | Red foliage-before needle drop<br>Foliage may appear bright red |
| Summer 2020 | No longer contains Spruce beetle. | Dull red foliage, (as trees begin needle drop), to grey (all needles completely off tree) |

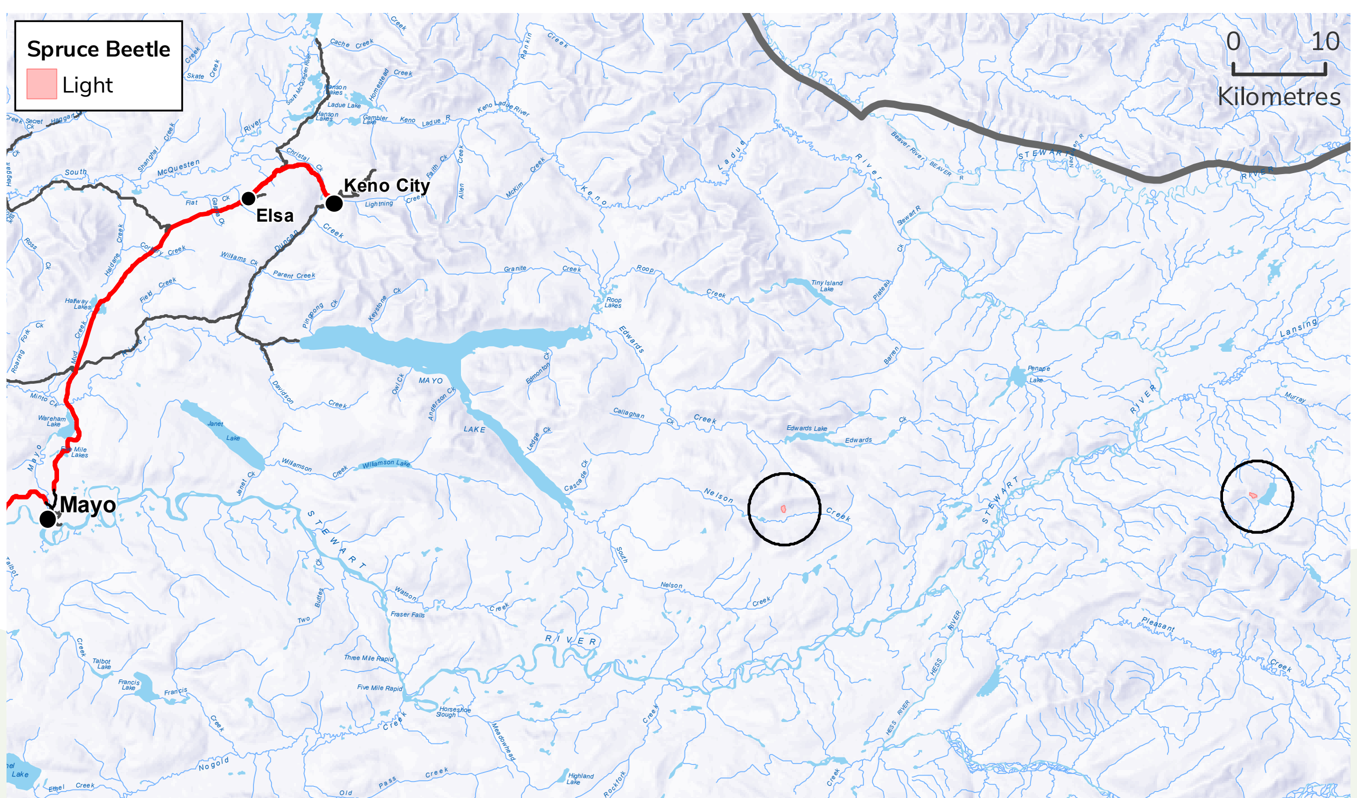
In 2019, 709 hectares of old spruce beetle attack was mapped in the same area that was mapped in 2018 near Kusawa Lake (Map 6). No recently attacked trees were recorded. The ratio of reds to greys at the south end of the lake indicates declining spruce beetle populations; however, there is much greater variation on the east side of the lake making the ratio of reds to greys more difficult to interpret. As mentioned above, some of the ‘brighter’ red trees may have overwintering adults at the base which will emerge and attack new trees in the spring of 2020. Ground assessments in 2019 were limited to one site which indicated poor recruitment and survival, and no overwintering adults. As a cautionary measure FMB will continue to monitor this area annually, weather permitting, as part of a proactive approach to forest health management (see Special Projects section for more information).

In FHZ 2, four spot infestations and 2 polygons totaling 54 hectares were mapped east of Mayo Lake (Map 7).




**MAP 6** Old attack (greys) in the Kusawa Lake area, 2019.

**PHOTO 14** Scattered grey and minor red attack on the west side of south Kusawa Lake.




**MAP 7** Location of spruce beetle polygons east of Mayo 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. 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.

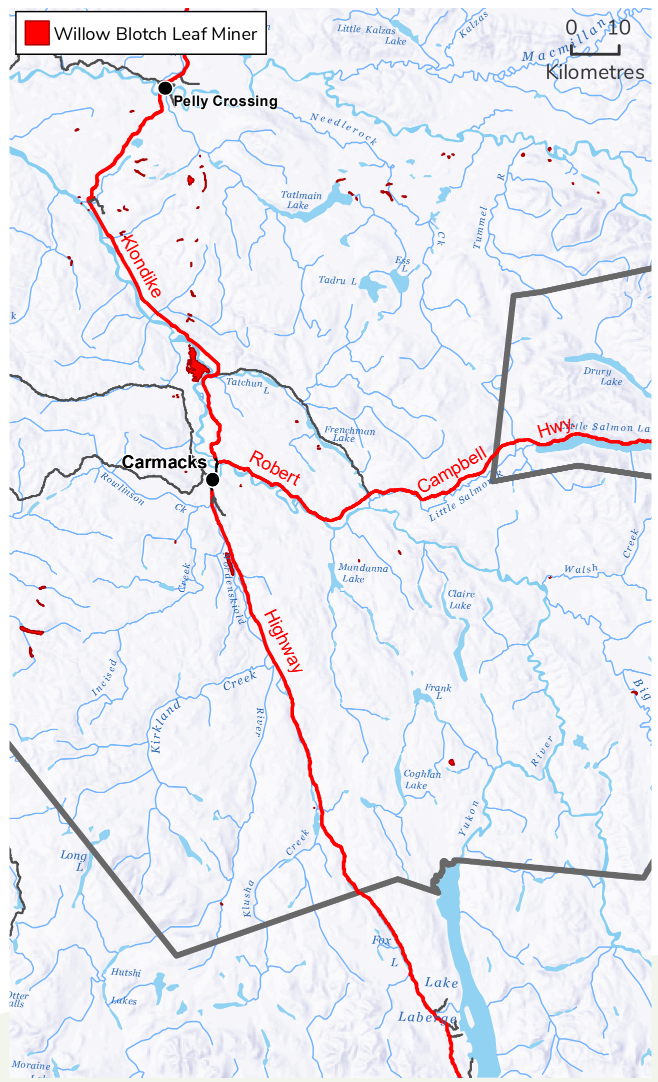
Over the last 20 years, the western balsam bark beetle has advanced north from British Columbia into southern Yukon. Surveys from the mid-1980s to the early 1990s recorded the beetle's northerly spread across the 60th parallel. With the change in climatic conditions, extensive amounts of mature and semi-mature 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 SE 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 2019 in FHZ 2, western balsam bark beetle populations declined to 10 hectares from 27 hectares in 2016.

## Willow Blotch Leafminer *(Micrurapteryx salicifoliella)*

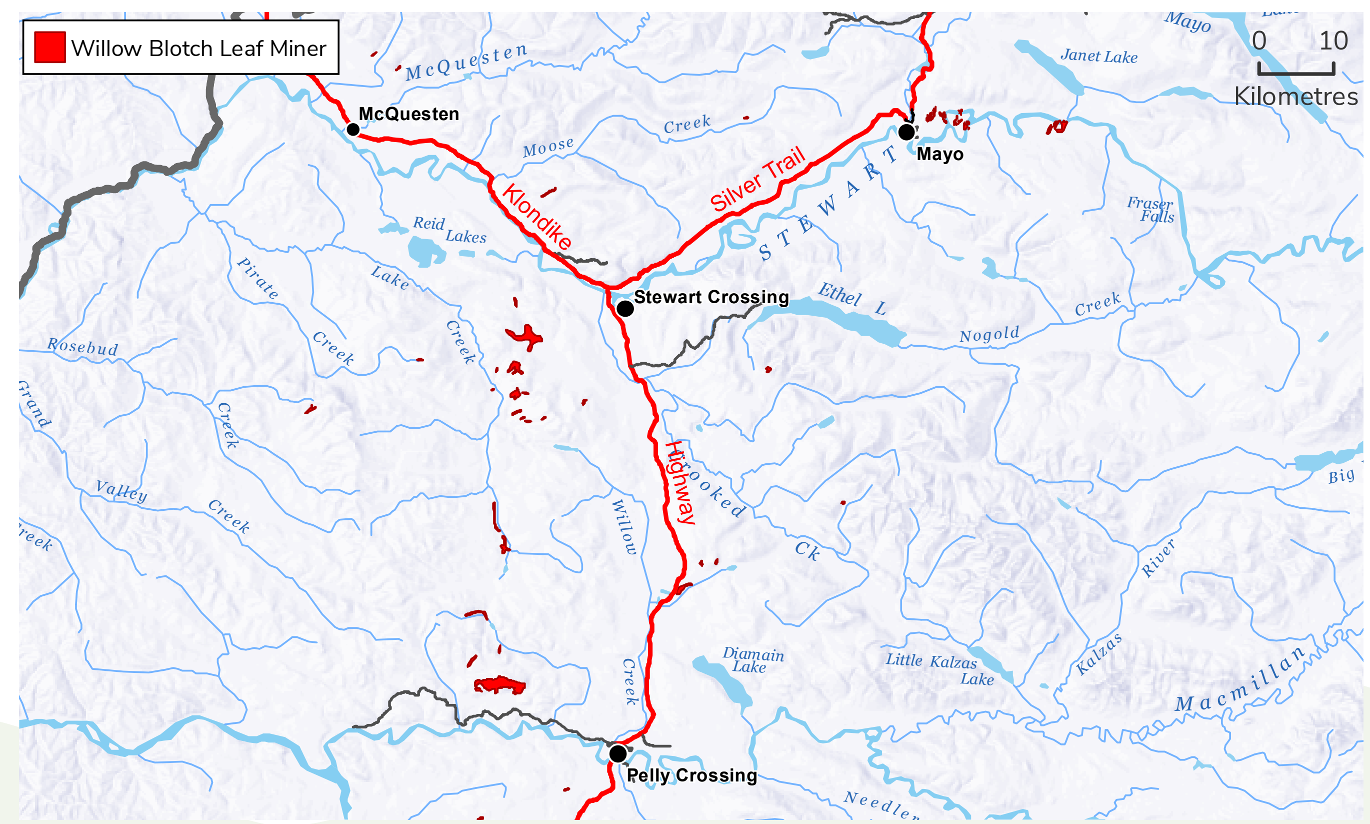
This common leaf miner was first recorded in Yukon in 2007 adjacent to the Stewart River at Stewart Crossing. In 2019 willow leaf blotch miner damage increased tenfold from 526 hectares in 2016 to 5,823 hectares. Infested willow were noted throughout most riparian zones in FHZ 2 (Map 8 and Map 9; Photo 15 and Photo 16). Studies in Alaska have found branch dieback and mortality associated with successive years of defoliation such that there are concerns regarding the impacts to vertebrate populations including moose (Wagner and Doak 2018).

**PHOTO 15** Severe willow blotch leaf miner defoliation along the shoreline of Braeburn Lake.




**MAP 8** Willow leaf blotch miner defoliation between Pelly Crossing and southwest of Carmacks.

**PHOTO 16** Severe willow blotch leaf miner defoliation near Needlerock Creek.




**MAP 9** Willow leaf blotch miner defoliation southwest of Stewart Crossing and Pelly Crossing.

# 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. 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 "lions tailing".

In FHZ 2 pine needle cast led to foliage discoloration over 1,396 hectares up from 85 hectares in 2016 (Photo 17). Abiotic (winter drying) damage was also suspected in 55% of the affected stands due to the retention of older needles. Stands with pine needle cast were found west of the Stewart and Pelly Crossing area (Map 10), while those combined with abiotic damage were found SW of Minto and south of Little Salmon Lake (Map 11). Recorded precipitation at the Mayo weather station in June 2018 was 283% above normal. These moist conditions provide ideal conditions for dispersal and spread of pine needle cast spores. Ground surveys will be conducted in 2020 to confirm the causal factor(s).

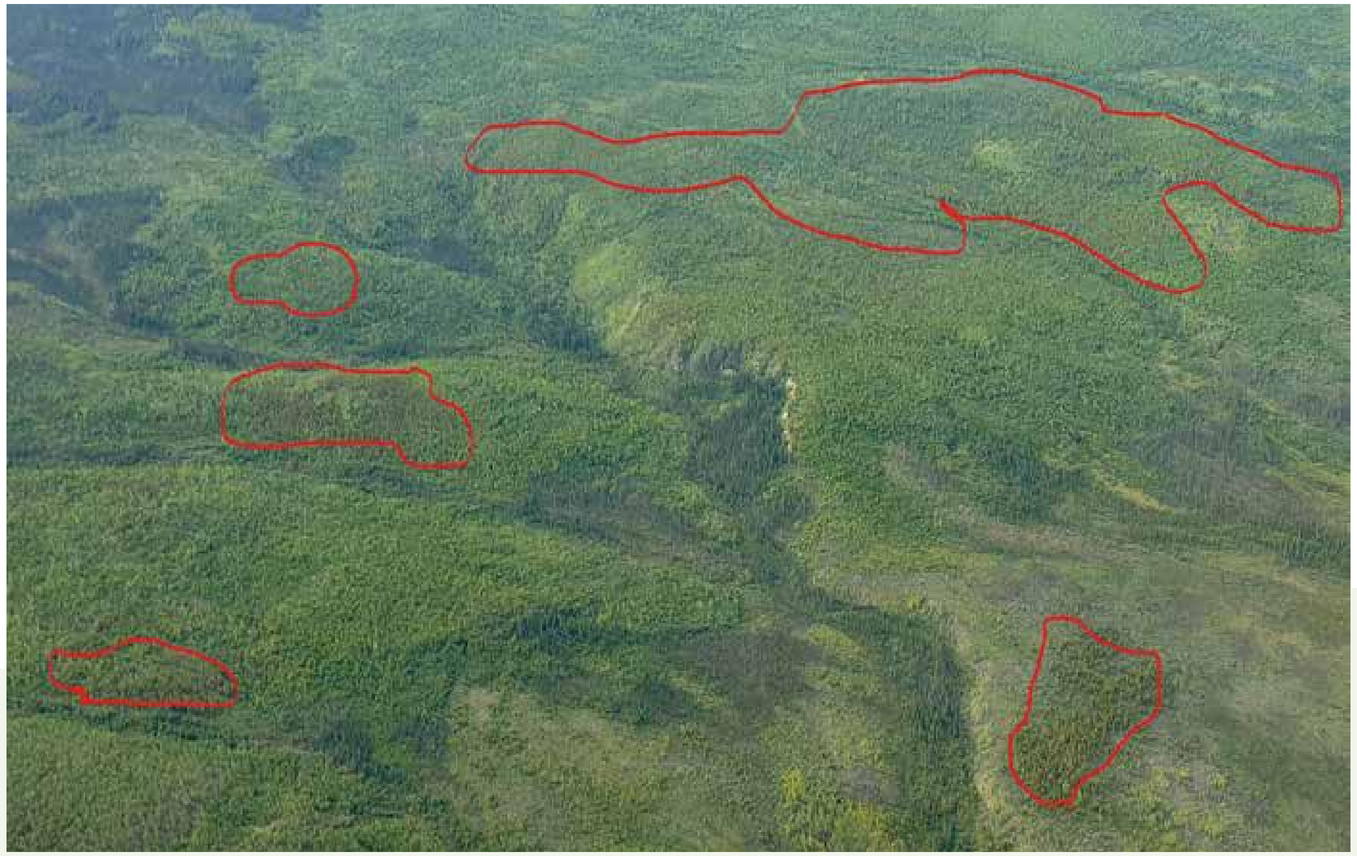
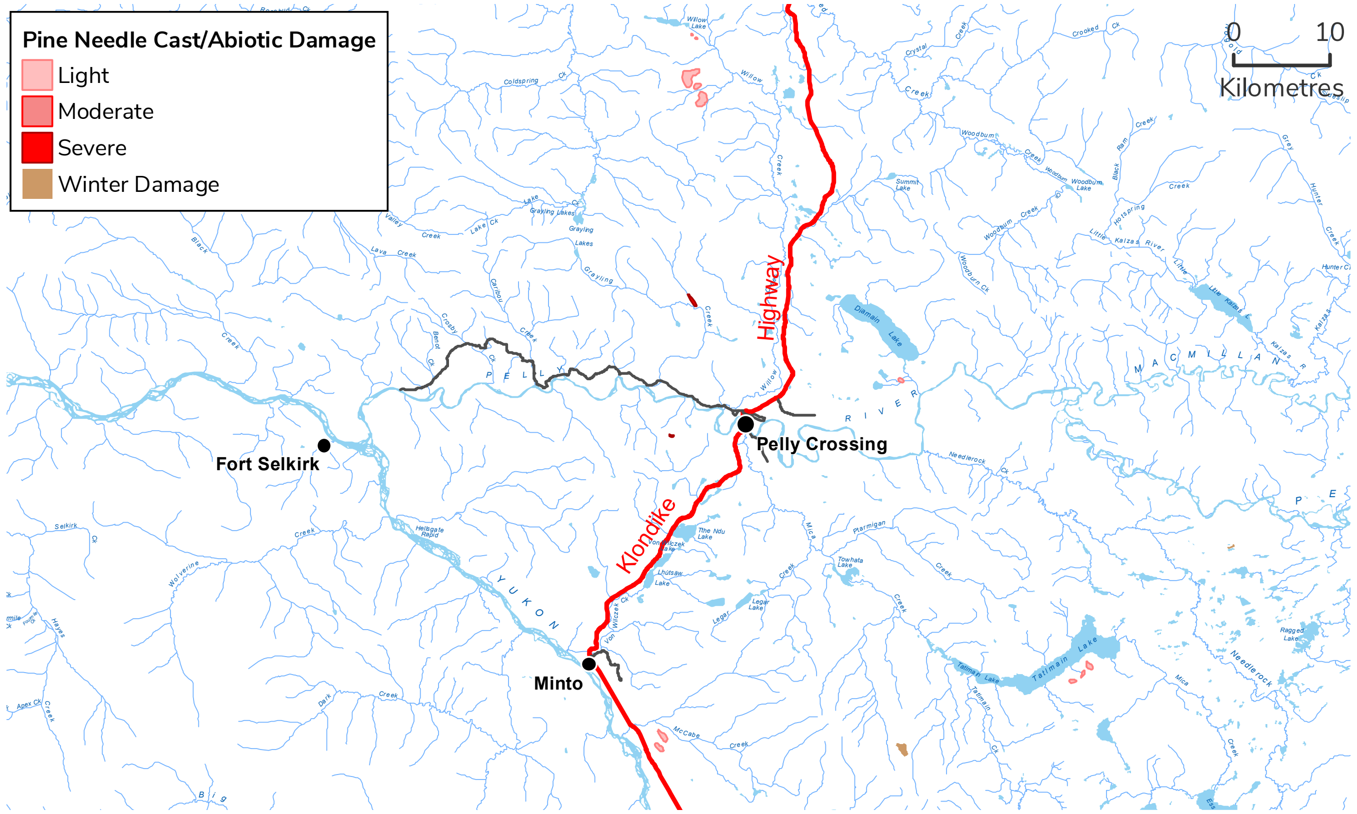
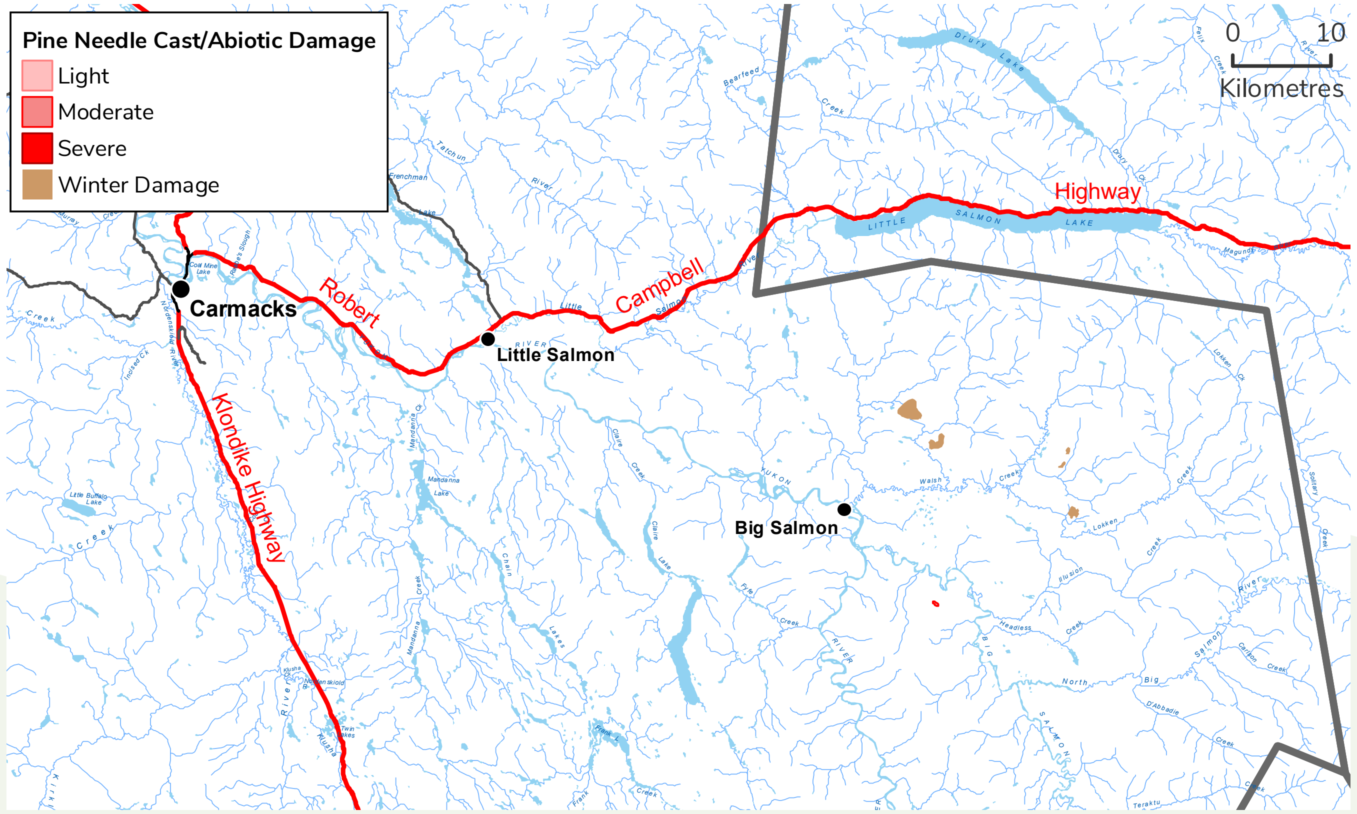


**PHOTO 17** Barely discernible pine needle cast south of Stewart Crossing.




**MAP 10** Location of pine needle cast and abiotic damage.




**MAP 11** Location of pine needle cast and abiotic damage.

# 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 (Iles and Gleason 2008).

In 2019 in FHZ 2 flooding was recorded at 11 different sites, totaling 132 hectares. This is up from 48 hectares in 2016. The majority occurred in spruce stands but lodgepole pine was also affected in a few areas.

## Other Abiotics

Shallow-rooted tree species, such as spruce, are more prone to wind throw. In 2019 only five hectares of spruce windthrow was mapped near Caribou Creek, Pelly River area. Also in 2019 a five hectare landslide was recorded at Owl Creek, near Mayo Lake.

# PEST COMPLEXES

## Aspen Decline

Aspen decline or dieback refers to mortality or damage to forests due to multiple causes, including a possible combination of biotic and abiotic factors. Symptoms include thin crowns, top dieback, stem mortality, and stem breakage. 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 dating 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 of decline 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. Observations from aerial surveys also suggest microclimate effects, such as those associated with inversions or cold air pooling (Photo 18), and clonal resistance (Photo 19); some clones may be more resistant to defoliators or phenological or genetic characteristics may make them less vulnerable to abnormal or extreme weather events.

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 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.



**PHOTO 18** Microclimate effects on trembling aspen with healthy hillside stands versus stands with aspen decline along Mayo River.

As the climate warms the likelihood of ongoing decline is possible given the potential for increased frequency of drought events, particularly since trembling aspen has a low tolerance for water deficit. Warmer springs could also 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. Ongoing monitoring of these forests, and ideally establishment of permanent sample plots, using protocol developed by Canadian Forest Service for examination of climate impacts on health and productivity of aspen (CIPHA), will help determine the factors involved and extent and changes in damage levels.

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

In 2019 in FHZ 2 the area of aspen decline decreased to 94,852 ha from 158,880 ha in 2016. Symptoms mapped throughout the host range were often in association with areas with a history of defoliation (Map 12). Poor lighting due to smoke and haze may be partially responsible for this decrease, as decline symptoms are difficult to detect in less than optimum lighting conditions. Another possibility is that stands with advanced symptoms deteriorate such that they are barely visible (Photo 20, Photo 21).

The area with the most extensive and pronounced damage was near Wellesley Lake, where many of the aspen stands were affected (Photo 22, 23). This area is within the Klondike Plateau Ecoregion and is known for its weather extremes. The coldest January and warmest July temperatures are recorded in the lowest topographic settings in the ecoregion with extreme temperatures in the lower valleys range from –60 to 35°C (Yukon Ecoregions Working Group 2004). These temperature fluctuations and potential for cold air pooling, given the terrain, are undoubtedly a factor in the extent and severity of aspen decline in this area.

**PHOTO 19** Healthy aspen clone within a stand affected by aspen decline near Janet Lake.

**PHOTO 20** Advanced symptoms of aspen decline with only a few stems remaining; near Aishihik Lake.

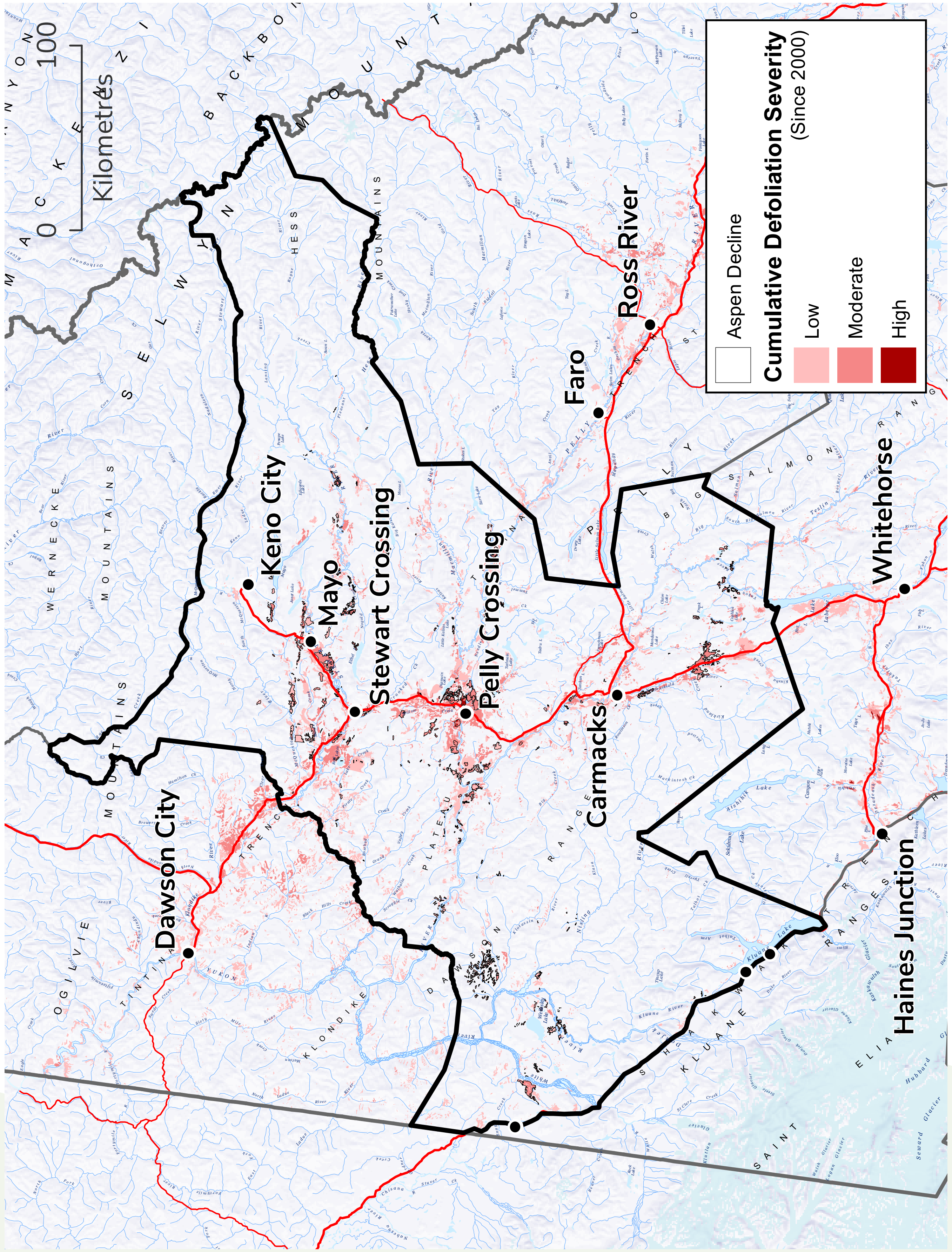


**PHOTO 21** Advanced symptoms of aspen decline with only a few stems remaining; near Britannia Creek.

**PHOTO 22** Landscape level aspen decline (with aspen serpentine leaf miner) near Wellesley Lake.

**PHOTO 23** Landscape level aspen decline (with aspen serpentine leaf miner) near Wellesley Lake.

**PHOTO 24** Discontinuous aspen decline symptoms SW of Mayo.

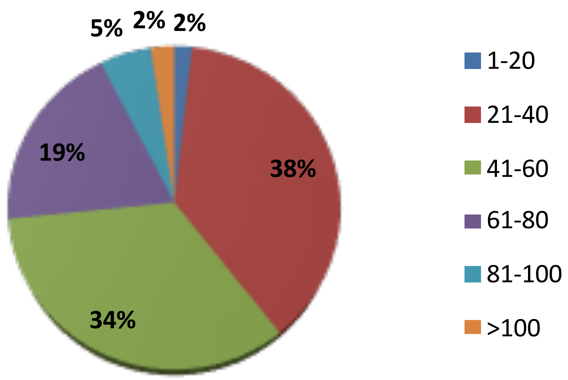



**MAP 12** Location of aspen decline in relation to areas with defoliator history and severity.

A spatial analysis was completed to determine if aspen decline was a function of stand age - e.g. stands naturally deteriorating as they age rather than biotic and abiotic causal agents. Looking at the age distribution of stands with aspen decline in 2016 and in 2019, this does not seem to be the case, as 72% and 56% respectively of the affected stands are <60 years old (Figure 6).

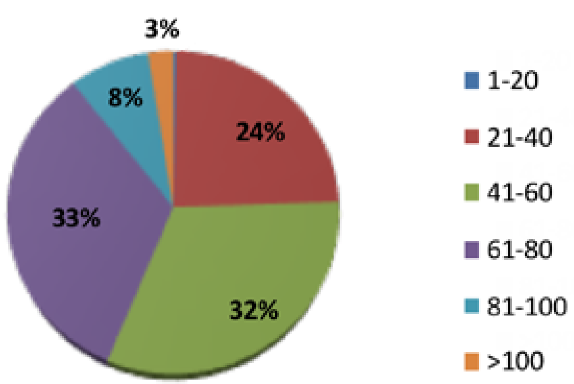
**Age Class Distribution of Aspen Stands with Decline in 2016**

| AGE CLASS | SUM OF HECTARES |
|---|---|
| 1-20 | 2,092 |
| 21-40 | 44,611 |
| 41-60 | 40,285 |
| 61-80 | 22,651 |
| 81-100 | 6,145 |
| >100 | 2,772 |




**Age Class Distribution of Aspen Stands with Decline in 2019**

| AGE CLASS | SUM OF HECTARES |
|---|---|
| 1-20 | 208 |
| 21-40 | 16,154 |
| 41-60 | 21,269 |
| 61-80 | 22,117 |
| 81-100 | 5,406 |
| >100 | 1,700 |






## 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.

In 2014 ground checks were conducted on pockets of lodgepole pine that had a signature similar to stands infected with mountain pine beetle. Several ground checks revealed mortality or damage due to porcupine solely (Photo 25), porcupine and lodgepole pine beetle, and in some cases pine engraver beetle. Hence similar damage is now deemed affected by this pest complex.

In 2019 only three hectares of this mammal/bark beetle complex was recorded.

**PHOTO 25** Top-kill due to porcupine feeding on main stem of lodgepole pine.

# 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 2019

This marks the tenth 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 B.C. were very high (within 150 kilometers 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 kilometer border zone straddling the Yukon/B.C. border, as well as the Rocky Mountain Trench in British Columbia. 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 2010, severe winter cold has killed beetle broods within the trees in the RMT. 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.

**PHOTO 26** Legacy of the 2018 wildfires in northern BC: a discontinuous landscape of lodgepole pine.

## Border Zone

In 2019 no MPB was detected in the border zone. Similar to previous years scattered single red lodgepole pines were observed in this area, suggesting attack by either the lodgepole pine beetle (*Dendroctonus murrayanae*) or 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. Currently, MPB is not present in Yukon.

Given the diminishing MPB risk in northern British Columbia, extensive wildfires in the border zone, and 10 years of monitoring with no MPB detected, FMB will no longer monitor the border zone as per the 2013 MPB Monitoring Plan. The 2018 wildfires in northern BC burned vast expanses of mature lodgepole pine in the northern Rocky Mountain Trench, thereby altering the homogeneity and continuity of the pathway into Yukon, and the amount of hazard within border monitoring zone (Map 13, Photo 26). FMB will continue to review BC's annual aerial surveys results and make decisions on an annual basis as to whether aerial surveys in the border area are warranted. Based on BC's 2018 aerial survey results (see next section), it is anticipated that FMB will conduct reconnaissance surveys over the 2019 MPB infestation that was mapped south and east of the border zone. As such, portions of the border zone will be flown in 2020.

## British Columbia Observations

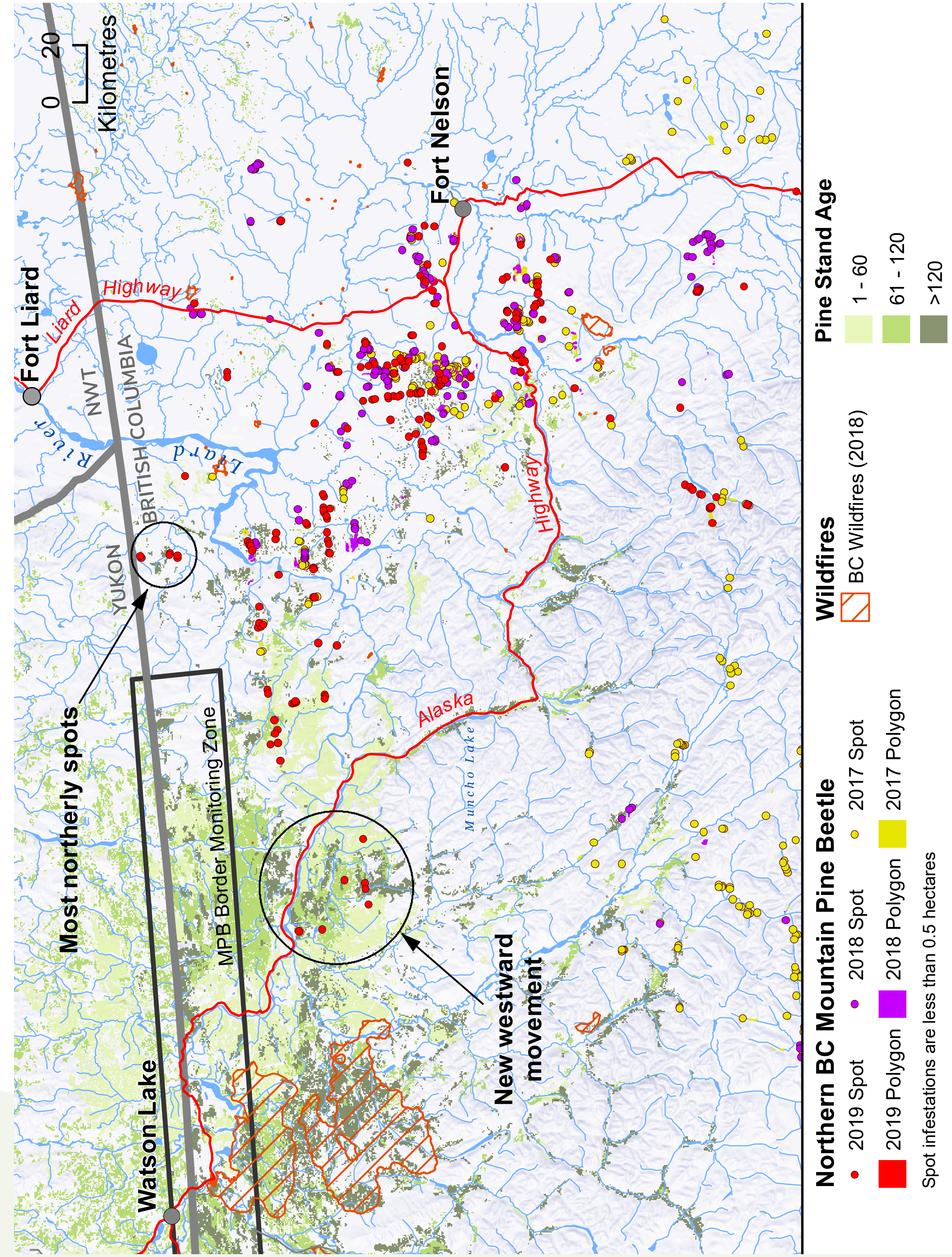
B.C.'s Ministry of Forests, Lands and Natural Resource Operations also conducts aerial surveys in northern BC. These surveys have found that since 2013 populations in the northern Rocky Mountain Trench (RMT) have retreated with only a few spots noted from 2015-2019.

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.

In 2019 only portions of northern BC were flown, including the area where the highest risk MPB has occurred for the last several years. This area, northwest of Fort Nelson, BC, has a discontinuous corridor of lodgepole pine but a more favorable climate (Hodge 2012) contributing to the persistence of local populations.

Populations in 2019 expanded northward and westward (Map 13). The northern movement marks the closest populations; within 3 kilometers of the Yukon border near Beaver River. This area is located 42 km east of the border zone boundary, meaning that it is outside the area considered to have high connectivity or hazard of lodgepole pine. Established populations in the Grayling Creek area spread westward across the Alaska Highway with seven spot infestations noted near Nloil Lake and Long Mountain Lake. These are 44 kilometers south of the Yukon border. It is anticipated that continued 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, and the more recent 2018 wildfires. Young stands in the "Egg Fire" will act as sinks rather than sources given the smaller diameter and thin bark. Mature lodgepole pine in any refugia (Unburned sites within the fire) of the 2018 wildfires might support MPB populations depending upon their overall health and local climate; historic temperatures in the Rocky Mountain Trench are much colder than that east of the Alaska Highway. Given the right climatic conditions small populations could become established and slowly move northward and cross the B.C./Yukon border into southeast Yukon, killing scattered individual trees or small groups of trees.






**MAP 13** Mountain pine beetle in northern BC from 2017-2019 and extent of 2018 BC wildfires.

**PHOTO 27** Vast expanse of mature lodgepole pine; looking north to the Yukon border southwest of Watson Lake.

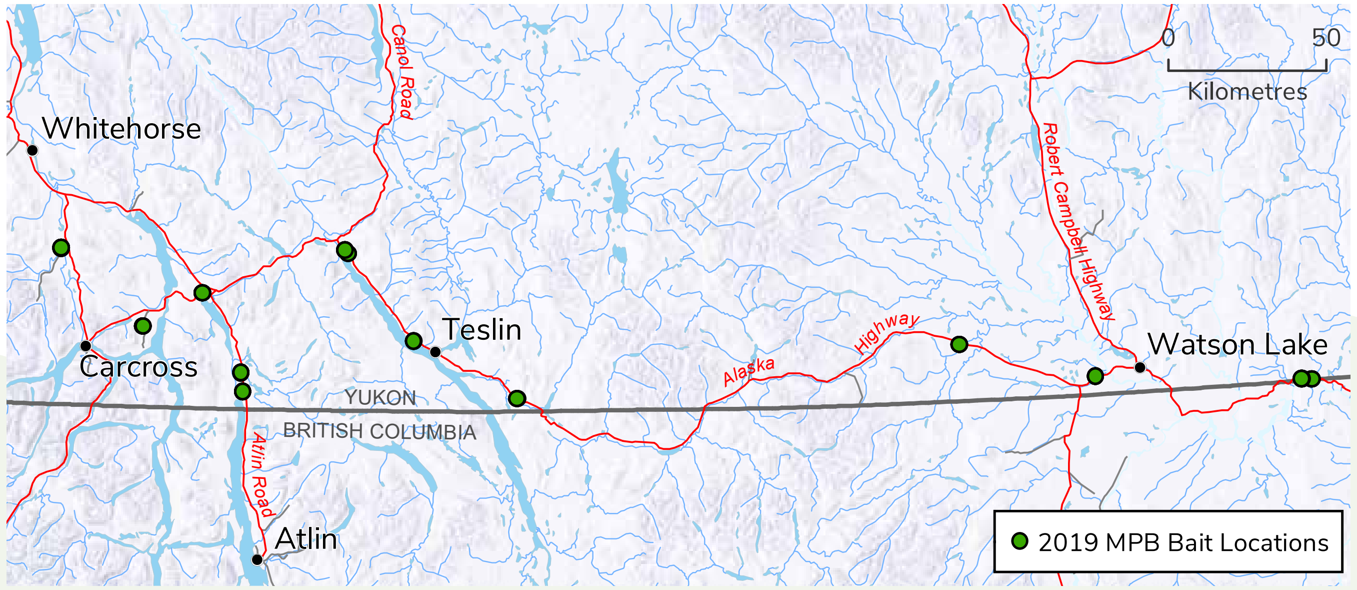


**PHOTO 28** Pheromone placed on the north side of the tree.

**PHOTO 29** MPB bait 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 14, Photo 28 and 29). 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 2019.




**MAP 14** Mountain pine beetle monitoring bait trap locations in southern Yukon and BC, conducted by FMB.

# SPECIAL PROJECTS

Two special projects were undertaken in 2019. The first was an assessment of spruce beetle risk in the Kusawa Lake area that had been mapped in 2018. The second is an ongoing project that was initiated in 2018 to better understand pest disturbances and inform risk management.

### Assessment of Spruce Beetle Risk in the Kusawa Lake Area

In order to better understand the origin and risk of the Kusawa Lake spruce beetle infestation, a reconnaissance helicopter survey and ground survey was undertaken by FMB. The helicopter provided better visual assessments of crown colors and infestation age, as well as facilitating landing for ground surveys.

Lack of landings only allowed for ground assessments at one site on the east shore of Kusawa Lake, where red trees were observed from the air. Ground assessments confirmed spruce beetle but no new attacks were found, nor was there any evidence of live adults, pupa, or larva, including overwintering adults at the base of the tree. The red trees examined had short adult galleries and no larval galleries (Photo 30, 31, 32), indicating poor recruitment rates and survival. Assessing infestation age is challenging in the colder Yukon climate as red foliage can be retained for a number of years. This complicates the ability to predict the likelihood of emerging spring beetles at the base of red trees throughout Yukon (see spruce beetle section).

Overall based on the lack of progeny, and/or ratio of reds (recent attack) to greys (older attack) it appears as though populations are declining. The uncertainty is higher on the east side of Kusawa Lake, where the ratio of reds to greys is variable (Photo 33, Photo 34). Given a two-year life cycle, adults could emerge from the base of red trees in the spring of 2020. Hence FMB will continue to monitor this area because of this variation and the presence of suitable host material.

**PHOTO 30** Woodpecker activity on dead tree attacked by spruce beetle.

**PHOTO 31** Spruce beetle adult galleries with no larval galleries.

**PHOTO 32** Two-to-three-year old recent spruce beetle red attacked tree.

**PHOTO 33** High ratio of red trees (recent attack) to grey (older attack) on east side of Kusawa Lake.

**PHOTO 34** Closer 1:1 ratio of reds (recent attack) to greys (older attack) on the east side of Kusawa Lake.

## Spruce Beetle Pheromone Trapping

In the summer of 2019, spruce beetle (*Dendroctonus rufipennis*) monitoring plots were established in the Haines Junction, Yukon area. The objective of the monitoring plots were to collect information on spruce beetle populations.

### Background – Spruce Beetle Life History and 1990-2000's Attack

The spruce beetle is a natural forest 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 was located in Southwest Yukon (Kluane region) and started in the early 1990's. The outbreak lasted well over a decade, peaking in 2004. It is the largest, most severe and long-lasting spruce beetle infestation in Canada, affecting over 400,000 hectares of white spruce (*Picea glauca*) forest. During the outbreak, annual aerial surveys were conducted from 1994 to 2012 to monitor insect activity and map white spruce mortality. At the peak of infestation in 2004, nearly 100,000 hectares of newly attacked spruce forests were detected. After 2004, the area of newly infested forest steadily declined to 263 ha of light infestation in 2012. Aerial surveys (specific to spruce beetles in southwest Yukon) ceased in 2013 because the infestation had returned to endemic levels (Garbutt 2013). While spruce beetle populations remain at endemic levels in southwest Yukon, monitoring high hazard spruce forests is a proactive measure that will give early warning should accelerated population increase 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 occurs under spruce bark, adults briefly emerge (for the flight period) from trees and search for new host material (new live trees) where they mate, excavate galleries, and lay eggs. During the outbreak, the primary tool for monitoring spruce beetles was 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 periods and the spatial variation in population levels. This work indicates that the flight period occurs from May to the beginning of August. In the summer of 2018 and 2019, the Forest Management Branch implemented similar ground-based monitoring plots with the following objectives:

1. To monitor populations of spruce beetle in Haines Junction Timber Harvest Planning areas;
2. To understand the timing of the spruce beetle flight period in the Haines Junction area;
3. To determine the spatial distribution of spruce beetle populations in the Haines Junction area; and,
4. To detect increases of spruce beetle populations should they occur.

The Forest Management Branch uses these findings as indicators of forest ecosystem function and ability to maintain natural processes, both of which are goals outlined in the Champagne and Aishihik Traditional Territory Strategic Forest Management Plan.

### Description of monitoring plots & duration

Lindgren© funnel traps were used to monitor spruce beetles (*Dendroctonus rufipennis*) through the spring and summer of 2018 and 2019. These funnel traps are specifically designed for monitoring and sampling insect populations (BC FLNRO 2016). Ten traps were erected across locations surrounding Haines Junction (Photo 35). Traps were established in locations with a 30-meter buffer between traps and live spruce trees to reduce the risk of attacks on live trees. Traps were set on stand-alone metal posts, and chemical lures were attached to the traps to attract spruce beetles. Two different chemicals (lures) were used to attract spruce beetles to traps; Englemann spruce terpene blend, and frontalin, both developed by Synergy Semiochemicals Corporation of, Burnaby, BC. The Englemann spruce terpene blend has a similar chemical composition as the natural volatile organic compounds released by spruce trees, which is attracts spruce beetles. Frontalin is an aggregation pheromone common to many insect species. Spruce beetles emit Frontalin to signal others to attack a specific tree. Traps 4 and 9 were discontinued in 2019 and replaced by setting traps in more preferable sites. Trap 12 was removed due to the proximity of the Bear Creek forest fire.

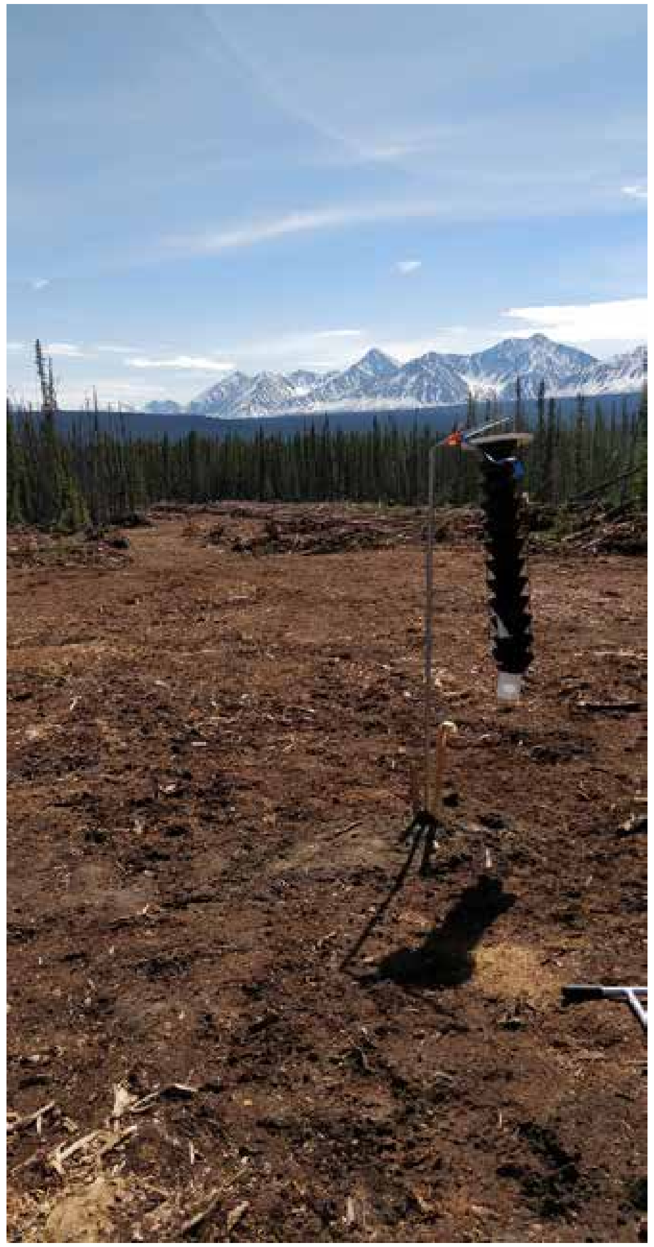


**PHOTO 35** Lindgren© funnel trap # 5 (Pine Canyon).

## Findings

Traps were established during the first two weeks of May, and were checked on a weekly basis for 12 weeks. Trap catches indicated that spruce beetle flight began during the last week of May and continued to increase with peak activity observed in mid-June (June 6th - June 14th). After June 14th, trap catches decreased, and by the beginning of August the flight period had ended. The pheromone traps were removed after several weeks where few spruce beetles were observed. Overall, a small number (76) spruce beetles were collected for all traps over the spring and summer.

There was considerable variation in the number of spruce beetles collected between traps (Table 2). At the minimum, Trap 7 and Trap 11 each collected one spruce beetle over the entire season, at the maximum, Trap 6 collected 27 beetles over the season. Based on trap catches, 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 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, not stacking infested firewood next to healthy trees, and removing any stacked green wood prior to the next beetle flight.

The Lindgren© funnel traps collected many other insect species of over the summer, including other bark beetles, moths, flies, bees, etc. Northern spruce engraver beetle or Ips (*Ips perturbatus*) was commonly found in the traps. Ips is a secondary bark beetle that attacks stressed or predisposed trees, including those already infested with spruce beetle. The traps collected a lower number of Ips compared to spruce beetles, however Ips catchment is incidental and may be not be representative of the population. Across all traps for the entire collection period, 35 northern spruce engraver beetles were collected.

The 2019 pheromone trap catches are considerably lower than the results from the 2005-2007 pheromone trapping results from the decline of the last outbreak and the 2018 pheromone trapping results. The 2019 pheromone trap catches had an average of 9 spruce beetles per trap, compared to the 2018 trap catches with an average of 15 spruce beetles per trap. Figure 7 compares weekly trap results from 2018 and 2019. In several traps, this decrease may be due to the availability of stacked green trees nearby, which spruce beetle preferentially attacked over the pheromone traps. The stacked trees had been harvested while addressing the 2019 Bear Creek forest fire. More data is required to further understand spruce beetle dynamics at a harvest site level. Another observation relates spruce beetle flight to daily high temperatures. Spruce beetle flight occurs when under bark temperatures reach 15 °C. Figure 7 also shows that in 2018 and 2019 more spruce beetles were caught after experiencing daily high temperatures greater than 15 °C and subsequent catches decreased after reaching a threshold temperature.



## Summary and Considerations for Next Year

The 2019 spruce beetle monitoring plots provided further insight into spruce beetle populations, spatial distributions and spruce beetle flight period in Southwest Yukon. Given the biennial flight pattern observed in the previous infestation and the potential effects of climate change on flight periods, it is recommended to continue the spruce beetle pheromone trapping project to inform best management practices, such as timing of harvesting, transport of timber and milling operations.

| TRAP NUMBER | LOCATION (TIMBER HARVEST PLANNING AREA) | TOTAL NUMBER OF SB COLLECTED |
|---|---|---|
| 1 | Pine Canyon | 4 |
| 2 | Pine Canyon | 12 |
| 3 | Haines Junction Fuel Abatement | 2 |
| 5 | Quill Creek | 4 |
| 6 | Bear Creek | 27 |
| 7 | Pine Canyon | 1 |
| 8 | Mackintosh East | 7 |
| 10 | Pine Canyon | 18 |
| 11 | Quill Creek | 1 |
| 12 | Mackintosh East | N/A |
| Total | | 76 |

**TABLE 3** Location information and total number of spruce beetles collected for each Lindgren© funnel traps established near Haines Junction in spring/summer 2019

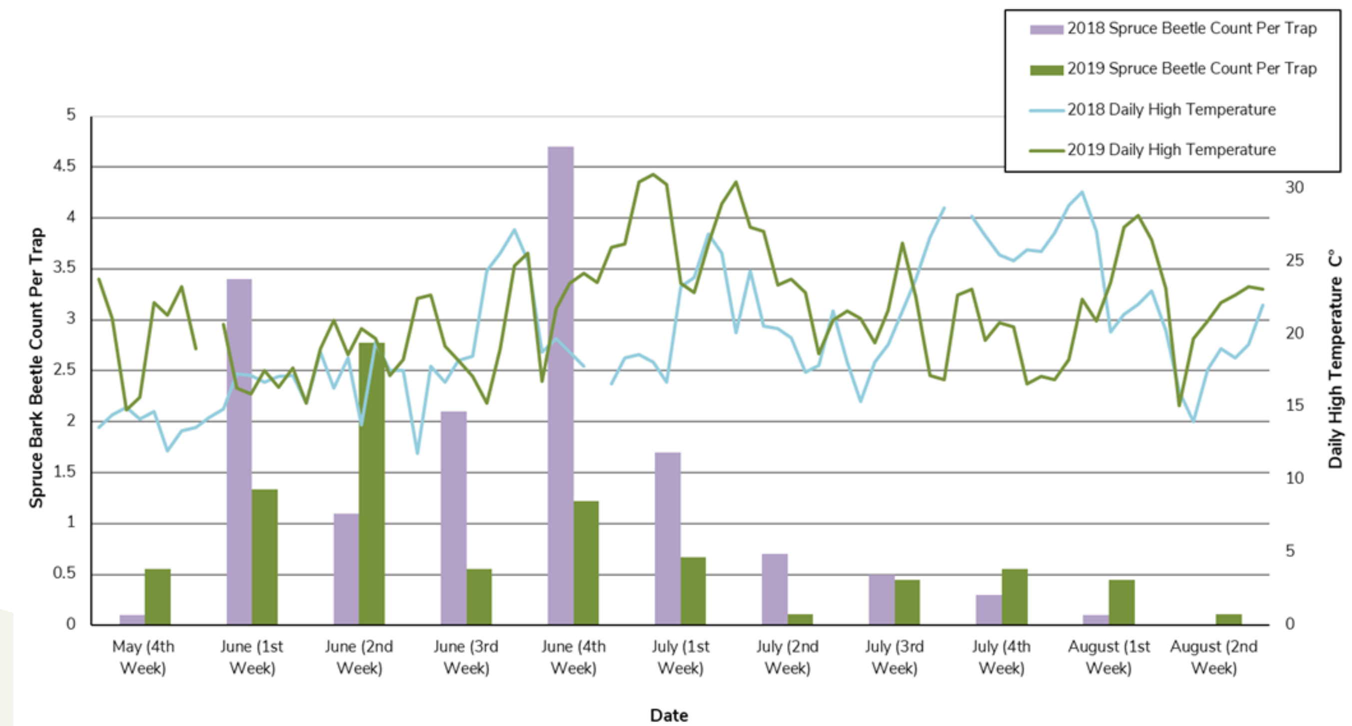



**FIGURE 7** Catchment of spruce beetles per trap and daily high temperature over the spring/summer of 2018 and 2019. Bars represent spruce beetle catches per trap by study week. The trend lines represent daily high temperatures. Dates indicate the month and week when traps were checked. There were 10 traps in 2018 and 9 traps in 2019.

# FOREST HEALTH EXTENSION

Forest Management Branch made several presentations to various stakeholders in 2019 to familiarize them with various aspects of the forest health program.

# OTHER NOTEWORTHY DISTURBANCES IN 2019

As part of the forest health program FMB assists both the public and other government agencies in the identification of forest pests (Table 3). This section includes those pest which are either mostly urban in their occurrence, or those observed on the ground but not visible during aerial surveys.

**TABLE 4** Summary of pest incident reports in 2019.

| DISTURBANCE | HOST | SETTING | LOCATION | PICTURES |
|---|---|---|---|---|
| Environmental; discolored needles Purplish colour of needles can be a sign of pollutants. | White spruce | Conifer trees adjacent to road right of ways can be susceptible to calcium spray from dust abatement in summer and salting in winter. This can cause stress and mortality to roadside trees. | Marsh Lake Dump access road | Photo 36, 37 |
| Environmental or disease. Branch flagging; discoloured and reddish needles | White spruce | Mature white spruce on residential property with frequent watering. Cause of decline of trees is uncertain. Damage to trees caused by unknown pest, pathogen or environmental stress. | Country Residential | Photo 38, 39 |
| Roundheaded woodborer in dead conifer *Monochamus spp* | White spruce | Recently dead white spruce with woodborer larvae. Woodborers generally attack weakened or dead and down trees of most conifer species. | Country residential | Photo 40, 41, 42 |
| Comandra blister rust *Cronartium comandrae* | Lodgepole pine | Young lodgepole pine with Comandra blister rust. The blister rust can cause cankers on stems and branches of infected trees. However this rust rarely causes significant damage to pine forests. | Chadburn Lake area | Photo 43 |
| Eastern spruce budworm *Choristoneura fumiferana* | White spruce | Defoliation of upper crown and branch tips on mature white spruce along roadside. | Stewart Crossing/ Silver Trail Highway | Photo 44 |
| Pine needle cast *Lophodermella concolor* | Lodgepole pine | Young lodgepole pine. Defoliation, straw coloured and red needles on the previous year's foliage. During successive years of attack only the current years foliage remains on the tree resulting in "lions tailing". | Country Residential, Ibex Valley | Photo 45 |



**PHOTOS 36 and 37** Spruce trees adjacent to road right of ways can be susceptible to calcium spray from dust abatement, the purplish color of needles can be a sign of pollutants.

**PHOTOS 38 and 39** Unknown pest, pathogen or environmental damage to mature Spruce on a private, rural property.



**PHOTOS 40, 41 and 42** Roundheaded woodborer larvae in dead mature Spruce at private residence in the Haines Junction area.

**PHOTO 43** Comandra blister rust in the Chadburn Lake area, Whitehorse. Note the orange yellow pustules are visible.

**PHOTO 44** Spruce budworm damage on White spruce near Stewart Crossing/Silver Trail.

**PHOTO 45** "Lions tailing" and straw coloured needles on Lodgepole pine caused by needle cast near the Ibex Valley, Whitehorse.

# REFERENCES


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. 36. Available from: https://www.for.gov.bc.ca/ftp/HFP/external/!publish/Aerial_Overview/Data_stds/BC_AerialSurvey_Standards.pdf

Cahoon, S. M. P., Sullivan, P. F., Brownlee, A. H., Pattison, R. R., Andersen, H. E., Legner, K., and Hollingsworth, T. N. 2018. Contrasting drivers and trends of coniferous and deciduous tree growth in interior Alaska. Ecology, 99(6):1284–1295. https://doi.org/10.1002/ecy.2223

Doak, P., and Wagner, D. 2015. The role of interference competition in a sustained population outbreak of the aspen leaf miner in Alaska. Basic and Applied Ecology, 16(5):434–442. https://doi.org/10.1016/j.baae.2015.04.001

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

Garbutt, R. 2013. Yukon Forest Health Report: 2013. Yukon Energy Mines and Resources, Forest Management Branch. Available from: http://www.emr.gov.yk.ca/forestry/pdf/forest_health_report_2013.pdf

Hodge, J.C. 2012. Mountain pine beetle pest risk analysis for Yukon lodgepole pine forests. Contract report for Yukon Energy, Mines and Resources, Forest Management Branch, Whitehorse, Yukon. 79.

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. 19.

Iles, J., and Gleason, M. 2008. Understanding the Effects of Flooding on Trees. Iowa State University Extension, 4. Available from: https://store.extension.iastate.edu/product/Understanding-the-Effects-of-Flooding-on-Trees-Sustainable-Urban-Landscapes

Yukon Ecoregions Working Group. 2004. Yukon Coastal Plain. In: Ecoregions of the Yukon Territory:

Biophysical properties of Yukon landscapes, C.A.S. Smith, J.C. Meikle and C.F. Roots (eds.),

Agriculture and Agri-Food Canada, PARC Technical Bulletin No. 04-01, Summerland, British Columbia, 63-72.

Wagner, D., DeFoliart, L., Doak, P., and Schneiderheinze, J. 2008. Impact of epidermal leaf mining by the aspen leaf miner (Phyllocnistis populiella) on the growth, physiology, and leaf longevity of quaking aspen. Oecologia 157(2):259–267. https://doi.org/10.1007/s00442-008-1067-1

Wagner, D., and Doak, P. 2013. Long-term impact of a leaf miner outbreak on the performance of quaking aspen. Canadian Journal of Forest Research 43(6): 563–569. https://doi.org/10.1139/cjfr-2012-0486

Worrall, J. J., Rehfeldt, G. E., Hamann, A., Hogg, E. H., Marchetti, S. B., Michaelian, M., and Gray, L. K. 2013. Recent declines of Populus tremuloides in North America linked to climate. Forest Ecology and Management 299:35–51. https://doi.org/10.1016/j.foreco.2012.12.033

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