# 2021 YUKON FOREST HEALTH REPORT

Yukon

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# WHY WE HAVE A **FOREST HEALTH PROGRAM** IN YUKON

The Government of Yukon's Forest Management Branch manages Yukon forests for sustainability. A major component of Yukon forest management is monitoring and reporting on forest health. The Forest Resources Act 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 *Forest Resources Act*, the Director of the Forest Management Branch 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 as the risk-based Yukon Forest Health Monitoring Strategy, which was adopted by the Forest Management Branch in 2009.

## Yukon Forest Health Monitoring Strategy

The Yukon Forest Health Monitoring Strategy focuses on forest insects, diseases and abiotic disturbances that pose the greatest risk to resource values of Yukon's forests. Since its implementation in 2009, the strategy has met the following priorities each year:

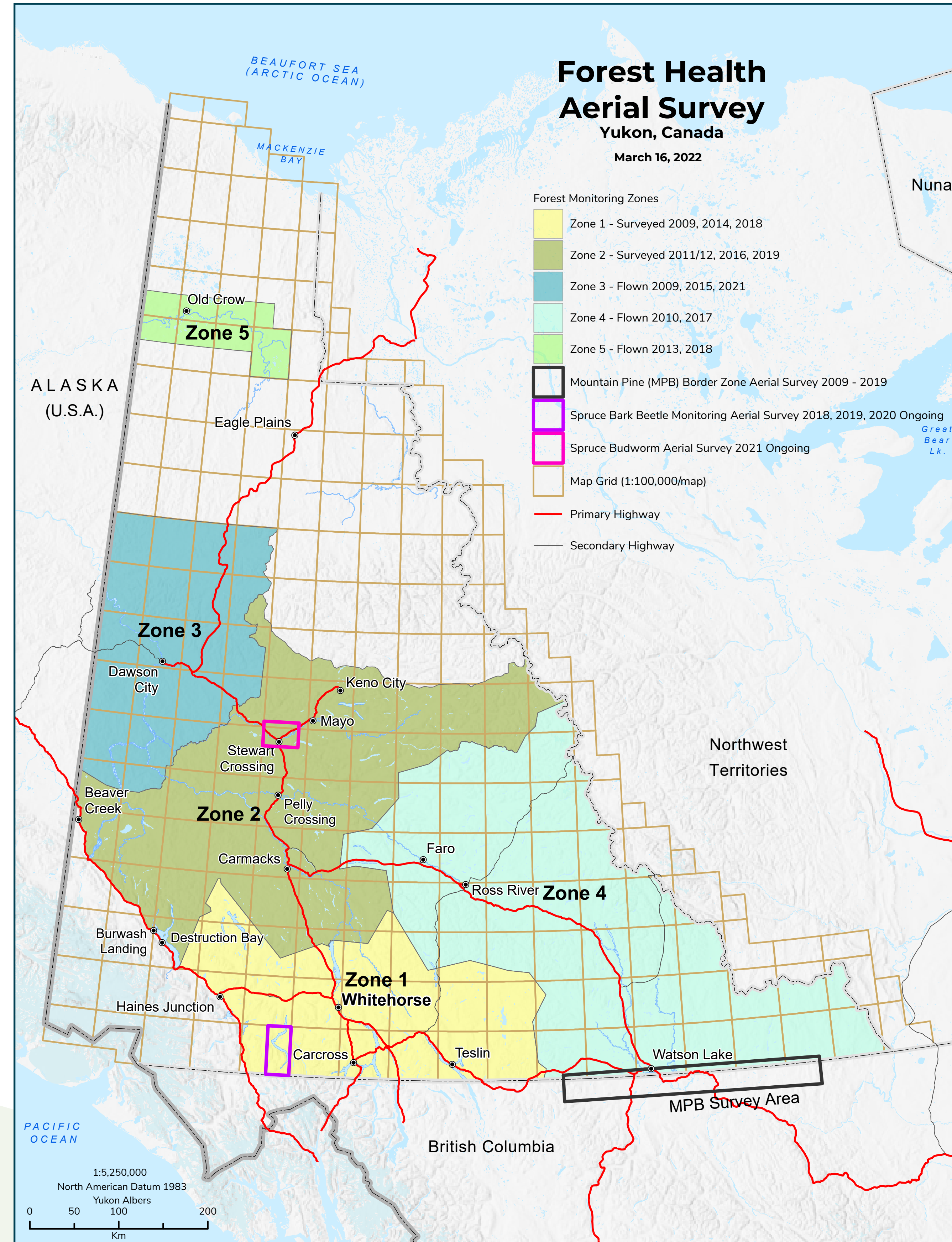
1. To provide a Yukon-wide overview of forest health issues;
2. To focus monitoring activities on high-risk forest health concerns across forested landscapes that are considered most valuable to Yukon residents; and
3. To monitor and assess forest health concerns and to determine and evaluate forest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

## Rotational Monitoring of Forest Health Zones

The Yukon is divided into five forest health zones (FHZ) (Map 1). In these areas, monitoring focuses on forest stands that are susceptible to the forest insects, diseases and abiotic disturbances forest health agents of greatest concern. Each year since 2009 FMB forest health specialists have completed aerial surveys in one of the five zones. In 2021, forest health surveys focused on the Dawson region (FHZ 3).

Forest Management Branch produces annual forest health reports that 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 produced by the Canadian Forest Service. In 2018, an additional source of historical FIDS spatial data was made available, and it will be used for interpretation of population t rends 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.






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

# **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. Aerial overview surveys are also adequate for regional and provincial summaries, and to meet national requirements for the Forest Health National Forest Pest Strategy.

As a result, aerial overview surveys are the primary tool for monitoring forest health in the Yukon. The forest health aerial overview survey standards used by the British Columbia Ministry of Forests, are also used in the Yukon, which ensures continuity across jurisdictions. Field checks are important for validating the data collected from the aerial surveys. Forest Management Branch (FMB) forest health specialists conduct field checks on a portion of the 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 the Yukon:

- Use a Cessna 206 or equivalent high wing single engine airplane.
- Flying height of 800 metres 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 7 kilometre (km) wide corridor (14 km gridlines).
- 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.

Upon completion of ground verification, spatial aerial survey results are finalized and stored in the Government of Yukon Geographic Information System.



# IDENTIFYING THE YUKON'S **MAJOR FOREST HEALTH CONCERNS**

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

All of these concerns can be effectively monitored with aerial surveys, as 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 the 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.


1a


1b

**PHOTO 1a.** *Stand level damage - grey trees, spruce bark beetle.*

**PHOTO 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 the 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 the Yukon. Spruce engraver beetle infestation was mapped in southwest Yukon at over 3,000 hectares (Garbutt, 2013).


2a


2b

**PHOTO 2a.** *Single tree attack, northern spruce engraver beetle.*

**PHOTO 2b.** *Young adults and larva, northern spruce engraver beetle.*






## 3 Western balsam bark beetle
(*Dryocoetes confuses*)

This beetle attacks subalpine fir (*Abies lasiocarpa*). Western balsam bark beetle moved north from British Columbia in the late 1980s and has become established in mature subalpine fir stands in southern Yukon.

**PHOTO 3a.** *Trees showing new (bright red), and old attack (dull red and grey)- western balsam bark beetle.*

**PHOTO 3b.** *Adult 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, all cause similar defoliation damage to spruce, subalpine fir and larch (*Larix laricina*) forests. In 2008, eastern spruce budworm damage was mapped across 1,000 hectares in the Yukon, primarily near Stewart Crossing. Historically, eastern spruce budworm damage has been mapped in the extreme southeast portion of Yukon (Garbutt, 2013).

**PHOTO 4a.** *Eastern spruce budworm defoliation, west of Beaver River, 2017.*

**PHOTO 4b.** *Late instar larva of spruce budworm.*

## 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.

**PHOTO 5.** *Larch sawfly - note gregarious feeding habit.*



## 6 Aspen serpentine leafminer
(*Phyllocnistis populiella*)

This insect occurs throughout the Yukon range of trembling aspen, and it defoliates balsam poplar (*Populus balsamifera*). Starting in the early 1990s, a massive outbreak of aspen serpentine leafminer extended from Alaska through the Yukon, and into British Columbia. Repeated infestations, in combination with large aspen tortrix, are contributing to aspen decline.

**PHOTO 6a.** *Landscape-level serpentine leafminer, southern Yukon.*

**PHOTO 6b.** *Silvery leaf mining of aspen serpentine leafminer.*



## 7 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 the Yukon, including Teslin Lake, Braeburn, Haines Junction, Pelly Crossing and Champagne. Repeated infestations, in combination with aspen serpentine leaf miner, are contributing to aspen decline.

**PHOTO 7a.** *Stand level defoliation by large aspen tortrix, Haines Junction, Yukon.*

**PHOTO 7b.** *Large aspen tortrix larva.*



## 8 Pine needle cast
(*Lophodermella concolor*)

This pathogen is the most common cause of premature needle loss of lodgepole pine (*Pinus contorta*) in the 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 located 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 hectares (Garbutt, 2014).

**PHOTO 8a.** *Damage to needles of young pine caused by pine needle cast.*

**PHOTO 8b.** *Stand level damage from pine needle cast, Minto, Yukon.*





## 9 Mountain pine beetle (*Dendroctonus ponderosae*)

Though endemic to North America, this bark beetle has not been recorded in the 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 most recent outbreak in British Columbia is responsible for killing over 13 million hectares 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 the Yukon. Monitoring for MPB is a high priority because of its severe impact on pine forests during outbreaks, and nearing proximity to the Yukon border.

**PHOTO 9a.** *Mountain pine beetle old and new attack, Rocky Mountain Trench, British Columbia, 2012.*

**PHOTO 9b.** *Surviving larvae at the base of lodgepole pine, Rocky Mountain Trench, British Columbia, 2012.*

## 10 Tree dieback due to drought stress

Trembling aspen tends to occupy the driest sites in the 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).

**PHOTO 10.** *Tree dieback and aspen stand decline due to drought stress.*

For further information on these, and other Yukon Forest health disturbances, please refer to the **https://yukon.ca/en/science-and-natural-resources/forests/learn-about-forest-health**. This website contains forest health brochures and previous annual reports prepared by the Forest Management Branch. This Forest Health report can be found on **Yukon.ca**.



# SUMMARY OF 2021 FOREST HEALTH INITIATIVES

The following four initiatives were completed by Forest Management Branch (FMB) in 2021:

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

In 2021, aerial surveys were undertaken in Dawson Region, Yukon, Forest Health Zone 3 (FHZ 3), in order to map Yukon forest disturbances as described in the Yukon Forest Health Monitoring Strategy (Map 1). This year marks the third year that FHZ 3 has been re-surveyed. In 2021, a combination of grid and drainage flying was conducted, using a 14 kilometre grid.

The survey took three days to complete. Wet weather conditions with cloud and fog resulted in low light and challenging flying 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). The Five-Year Mountain Pine Beetle Monitoring Strategy, first implemented in 2013, describes and outlines monitoring activities in the Yukon. This plan continues to provide effective and efficient management for tracking the northern expansion of the MPB. From 2014 -2019, surveys have been undertaken along the border between Yukon and BC. In 2019, a decision was made to discontinue border monitoring based on the decision matrix in the Monitoring Strategy. FMB continues to review British Columbia's aerial surveys annually. Monitoring the border zone will resume in 2022, based on the unconfirmed 2021 British Columbia aerial survey results (See Monitoring Mountain Pine Beetle in 2021 section).

## 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 2021; both are a continuation of existing projects.

1. Bark beetle monitoring via pheromone trapping in the Haines Junction region
2. Assessment of risk associated with blowdown north of Whitehorse, at Deep Creek near Lake Laberge.

## COMPONENT 4:
### Pest Incidence Reporting

In addition to the annual monitoring program, FMB also responds to general forest health and pest incident reports from the public and from government agencies throughout the Yukon. Pest reports are followed up with ground checks to identify the cause and severity of the forest health disturbance.

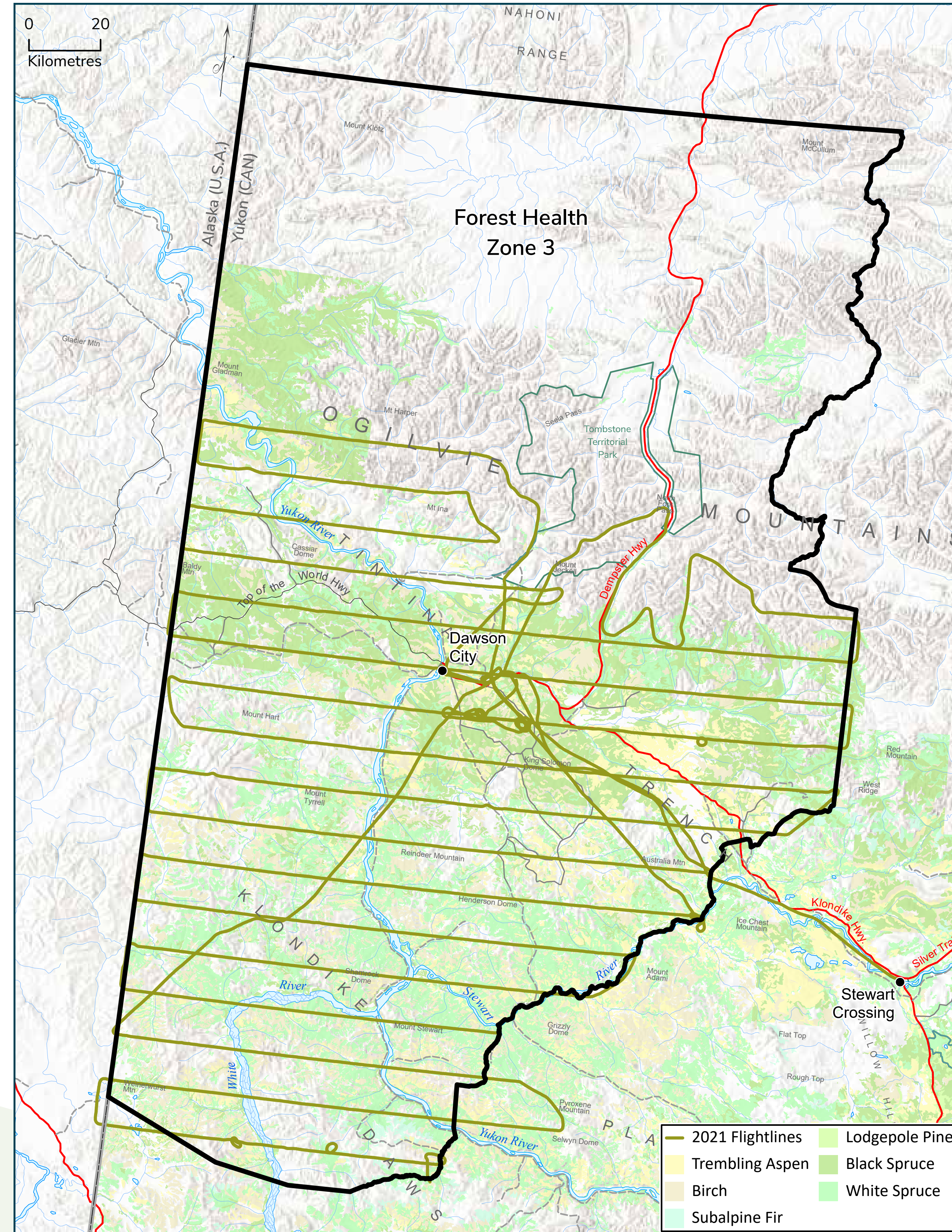
# ANNUAL FOREST HEALTH AERIAL AND GROUND SURVEYS

In 2021, forest health surveys focused on biotic and abiotic disturbances in the Dawson Region (FHZ 3). In mid-August, a three-day aerial survey of the forested area within FHZ 3 was undertaken using an extended Cessna 206 fixed-wing aircraft (Photo 11). The area was flown in an east-west grid pattern with 14 kilometres between grids, allowing each surveyor to map seven kilometres on either side of the plane (Map 2). The survey was based out of Dawson City.

FHZ 3 is a large area bounded on the south (approximately) by latitude 62° 45' North, and extending northward to latitude 65 30' North. To the northeast, it is bound by the Hart River, to the southeast the Stewart and Yukon rivers, to the south the White River, and to the west the Alaska border. The Northern portion of this zone, in particular the Ogilvie Mountains, lies within the taiga cordillera ecozone, with only narrow strips of forested land in the river drainages. The majority of the zone lies within the boreal cordillera ecozone, where up to 80% of the forests have been affected by wildfire within the past 30 years. Given the harsher climate and lack of forest continuity, forest health biotic concerns are not very diverse, while the abiotic concerns (such as fire, drought and associated dieback) are becoming more prevalent.


**PHOTO 11.** *Two-person aerial survey crew and extended Cessna 206.*






**MAP 2.** *Aerial survey flight lines in 2021 over forest health zone 3. .*

# WEATHER

Weather influences forest pests by affecting their development, survival, reproduction, spread and establishment rates, as well as altering tree phenology (life cycle events) and susceptibility. Indirectly, weather influences the levels of predators to forest pests 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. 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. Weather reporting generally compares current conditions to climate "normals" which represent a 30-year average. References to "normal" in this report refer to the 1981-2010 time period.

The following provides a summary of 2021 weather in the Yukon based on 21 weather stations throughout the territory.

## 2021 YUKON WEATHER SUMMARY

**October-December 2020 | Fall and early winter:** The fall started slightly cooler than normal with arctic air making its presence felt. Late fall was dominated by two storms that brought significant snowfall to southern and parts of central Yukon: first in early November, and again in early December. This brought precipitation to 150-250% of normal throughout southern Yukon. Central Yukon's precipitation was more variable, with well above normal November snowfall, followed by a warm and dry December with 30% of normal precipitation.

**January-March 2021 | Late winter and early spring:** The new year started off with a series of weak storms moving inland from the Gulf of Alaska, they brought warmer air but little precipitation across the territory. This changed in February, with a series of northerly flows and stagnant arctic air drawing temperatures to near 5 degrees cooler than normal across the Yukon. The pattern switched again late month and through March, with a series of storms bringing up to 150% of normal precipitation to the south and Dawson, while central and northern regions remained dry and cool.

**April-June 2021 | Spring and early summer:** The transition into summer began with slightly cooler than normal (1-5 degrees C) temperatures across the territory, and above normal precipitation. The latter is slightly misleading, as normal precipitation in April is less than 10 millimetres at most stations. May switched to a stormier pattern with wetter conditions across the territory, and June had near normal temperatures and precipitation. The northern tip of a record-breaking upper ridge brought hot temperatures and rapid melt to southern Yukon for the last five days of the month, but average monthly temperatures were near climactic normals.

**July-August 2021 | Summer:** July was marked by a mix of stagnant air and weak storms, bringing near normal temperatures and very dry conditions to most of central and northern Yukon. Southern Yukon saw 100-130% of normal rainfall, which continued into August with well above normal (150-250%) rainfall that extended into central Yukon as well.



The following figures depict October 2020-December 2021 precipitation and temperature to climate normals for the Dawson Region (FHZ 3).

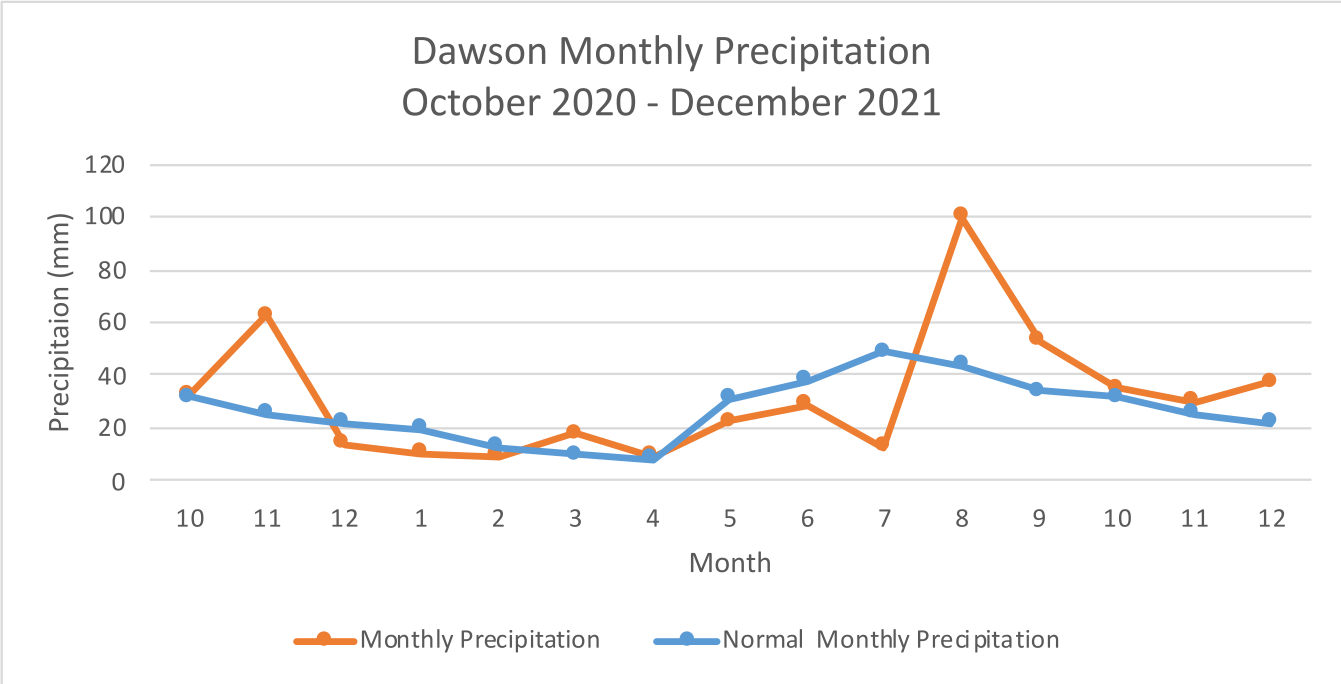



**FIGURE 1**. *Precipitation in millimetres with reference to normal rainfall for the Dawson region (FHZ 3) October 2020-December 2021.*

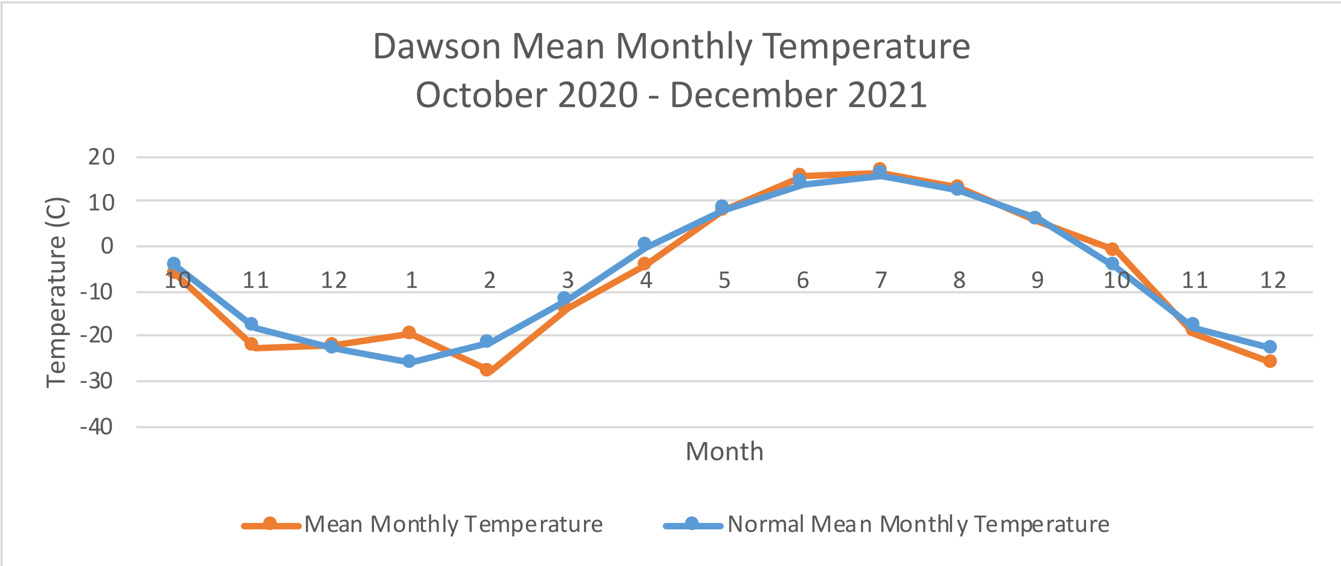



**FIGURE 2.** *Mean monthly temperature in degrees celsius, with reference to normal temperature for Dawson region (FHZ 3).*

# SUMMARY OF 2021 **BIOTIC** AND **ABIOTIC DISTURBANCES**

*Aerial view of Top of the World highway NW of Dawson City.*

The Dawson Region (FHZ 3) was surveyed in 2009 and 2015, making it is possible to assess trends over time by comparing pest activity in these years (Table 1). The Kusawa drainage area (FHZ 1) was also surveyed for the third consecutive year following the spruce beetle mapped in 2018. All forest health factors mapped on-route to Kusawa Lake (in FHZ 1) and to Dawson City (FHZ 2) are included in Table 1 (opposite page).



| | FHZ 1 | | FHZ 2* | FHZ 3 | | |
|---|---|---|---|---|---|---|
| **DISTURBANCE TYPE** | **2019** | **2021** | **2021** | **2009** | **2015** | **2021** |
| **Biotic** | | | | | | |
| Aspen serpentine leaf miner | - | 4,705 | 197 | 180,118 | 3,801 | 24,468 |
| Aspen serpentine leaf miner/ large aspen tortrix | - | - | - | | 177 | 15,333 |
| Large aspen tortrix | - | 1,760 | - | - | 42,849 | 5,457 |
| Large aspen tortrix/aspen serpentine leaf miner | - | - | - | 3,130 | 1,388 | - |
| Spruce beetle | 709 (old) | 1,394 (old with <1% current attack) | - | 32 | - | 2,274 (old with <1% current attack) |
| Willow blotch miner | - | 0.25 | | 1,429 | 30 | - |
| Spruce needle rust | - | - | 224 | - | - | 6,997 |
| Porcupine | - | - | - | | - | - |
| **Abiotic** | | | | | | |
| Flooding | - | - | - | 259 | 67 | 3 |
| Drought - spruce | - | - | - | 613 | - | - |
| Landslide | - | - | - | 23 | 0 | - |
| Windthrow | - | 914 (old and new) | - | - | - | - |
| Landslide | - | | | 234 | - | 5 |
| Windthrow | - | | | - | - | 5 |
| **Pest Complexes** | | | | | | |
| Aspen decline | - | - | 810 | 602 | 5,621 | 14,268 |
| Aspen serpentine leaf miner/ aspen decline | - | - | 2,369 | - | - | 12,030 |
| Aspen serpentine leaf miner/ large aspen tortrix/aspen decline | - | - | - | - | - | 920 |
| Large aspen tortrix/aspen decline | - | - | 643 | - | - | 27,678 |
| Large aspen tortrix/aspen decline/ willow leaf miner | - | - | - | - | - | 4 |
| Aspen decline/aspen serpentine leaf miner | - | - | - | - | - | 350 |
| Spruce beetle/flooding | - | - | - | - | - | 2 |
| Porcupine/pine engraver beetle | - | 0.5 | - | - | - | - |
| Windthrow/pine engraver beetle | - | 118 | - | - | - | - |

**TABLE 1.** *Summary and history of forest health disturbances recorded in FHZ 3 in 2009/2015/2021, and a small portion of FHZ 1 and FHZ 2 where special surveys were conducted. Table shows area in hectares of affected forests.*

# 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 the Yukon. Widespread defoliation of aspen by this leafminer has been occurring since the mid-1990s, with variation in annual levels, severity, and extent. Leafminer's activity was first recorded in the early 1950s along the Alaska Highway. Current outbreaks in Alaska and Yukon have affected hundreds of thousands of hectares of mature and immature aspen forests. Decades of unprecedented and 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. Repeated infestations, in combination with large aspen tortrix, are contributing to aspen decline.

Aspen serpentine leafminer affects photosynthesis by mining the leaf tissue and impairing the function 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 four weeks earlier on severely mined foliage (Wagner et al. 2018), reduced growth, and tree mortality (Wagner and Doak 2013; Doak and Wagner 2015).

Tree ring analysis of several tree species in Alaska found that if the warming trend of the last several decades persists, 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 aligns with recent research, which suggests that persistent and greater declines in aspen growth and increases in mortality are expected due to warming climate and increased insect outbreaks, including aspen serpentine leafminer (Boyd et al, 2021). 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 leafminer outbreak. While the role of aspen serpentine leafminer in the aspen decline complex has not been studied extensively in the Yukon, it is speculated that this biotic factor is indeed a contributing factor (see aspen decline section).

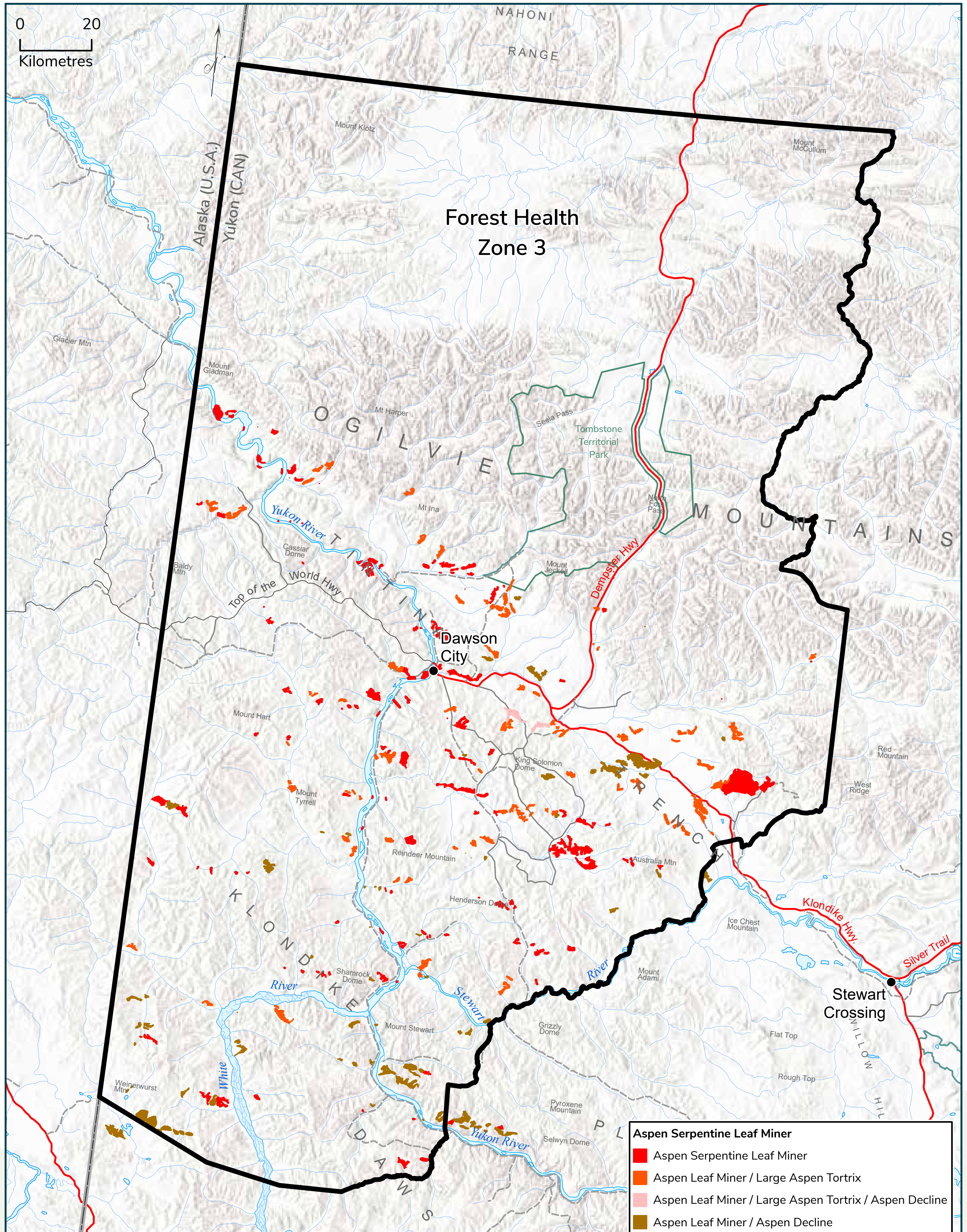
### STATUS IN 2021

In 2021, area infested in Forest Health Zone (FHZ) 3 increased tenfold to 53,101 hectares, up from 5,366 hectares in 2015, and down from 185,617 hectares in 2009. The majority occurred southwest of Dawson in previously infested stands (Map 3). In nearby FHZ 2, 2,566 hectares were also observed along the Yukon and McQuesten rivers. The silvery leaves characteristic of this leafminer (Photo 12) were noted throughout the host range and in combination with aspen decline (Photo 13) in 25% of the stands, and with aspen decline and large aspen tortrix in 54% of the infested stands.



**PHOTO 12.** *Scattered light-to-moderate aspen serpentine leafminer infestation between bonanza creek and last chance creek south of dawson city. Inset close up of leaves.*

**PHOTO 13.** *Aspen serpentine leafminer in stands with advanced symptoms of aspen decline, located between independence creek and soda creek southeast of dawson city.*




**MAP 3.** *Extent of aspen serpentine leaf miner defoliation in FHZ 3 in 2021.*

**PHOTO 14.** *Severe large aspen tortrix defoliation north of Black Hills Creek.*

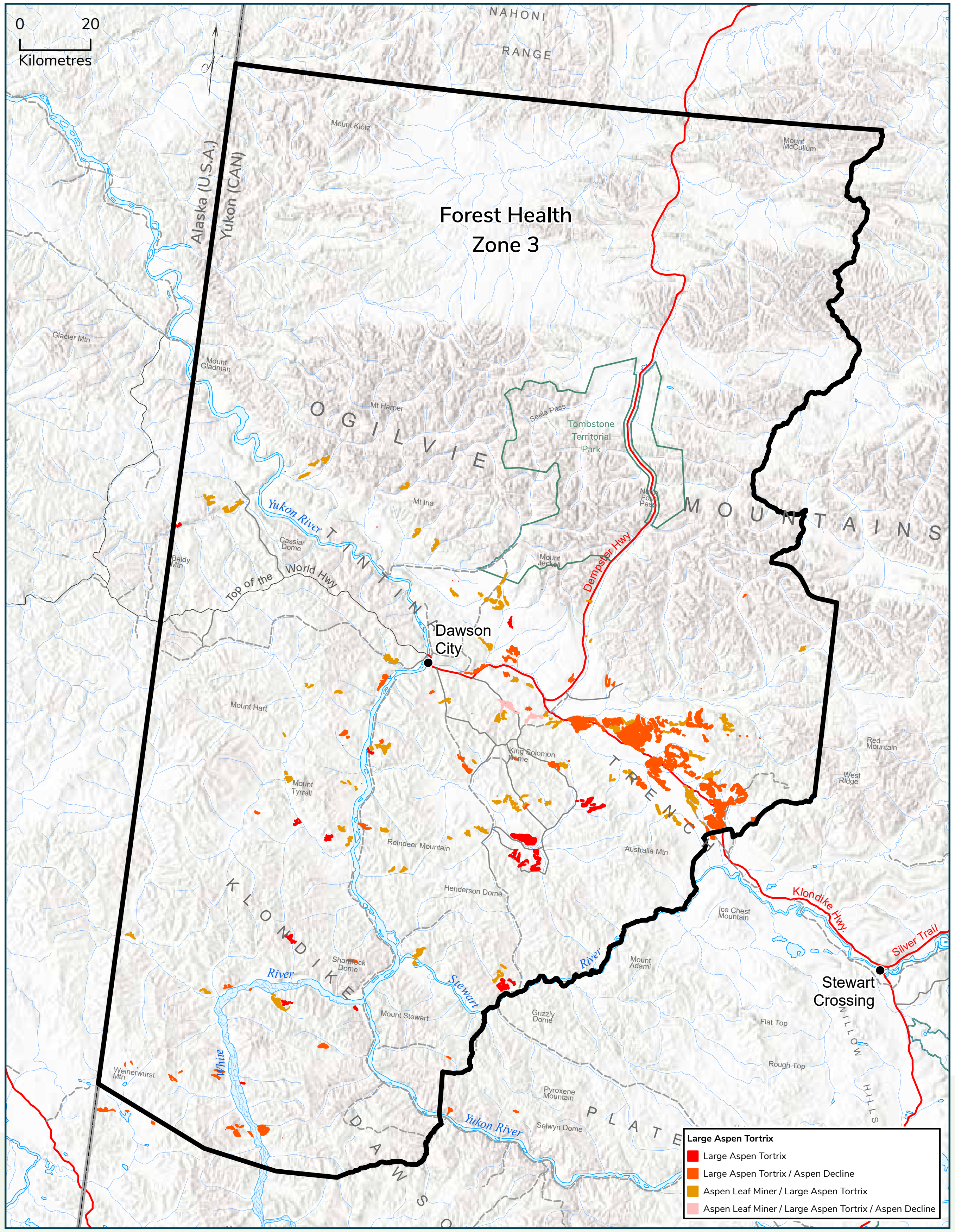
## Large Aspen Tortrix (*Choristoneura conflictana*)

Native to North America, the large aspen tortrix is found throughout the range of trembling aspen. 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.

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 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 have 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.

### STATUS IN 2021

In FHZ 3 the area defoliated by large aspen tortrix decreased slightly to 33, 139 hectares from 44, 414 hectares in 2015, most of which was east of the Yukon River (Photo 14) and along the Klondike River east of Dawson. The majority (83%) was in association with aspen decline, as dieback associated with successive years of defoliation persists in previously defoliated stands. The largest concentration of infested stands occurred along the highway corridor between Dawson and Stewart Crossing (Map 4). Defoliation totalling 643 hectares was also noted in FHZ 2 in infested stands adjacent to FHZ 3.




**MAP 4.** *Extent of large aspen tortrix defoliation in 2021, FHZ 3 and FHZ 2.*

## Eastern Spruce Budworm (*Choristoneura fumiferana*)

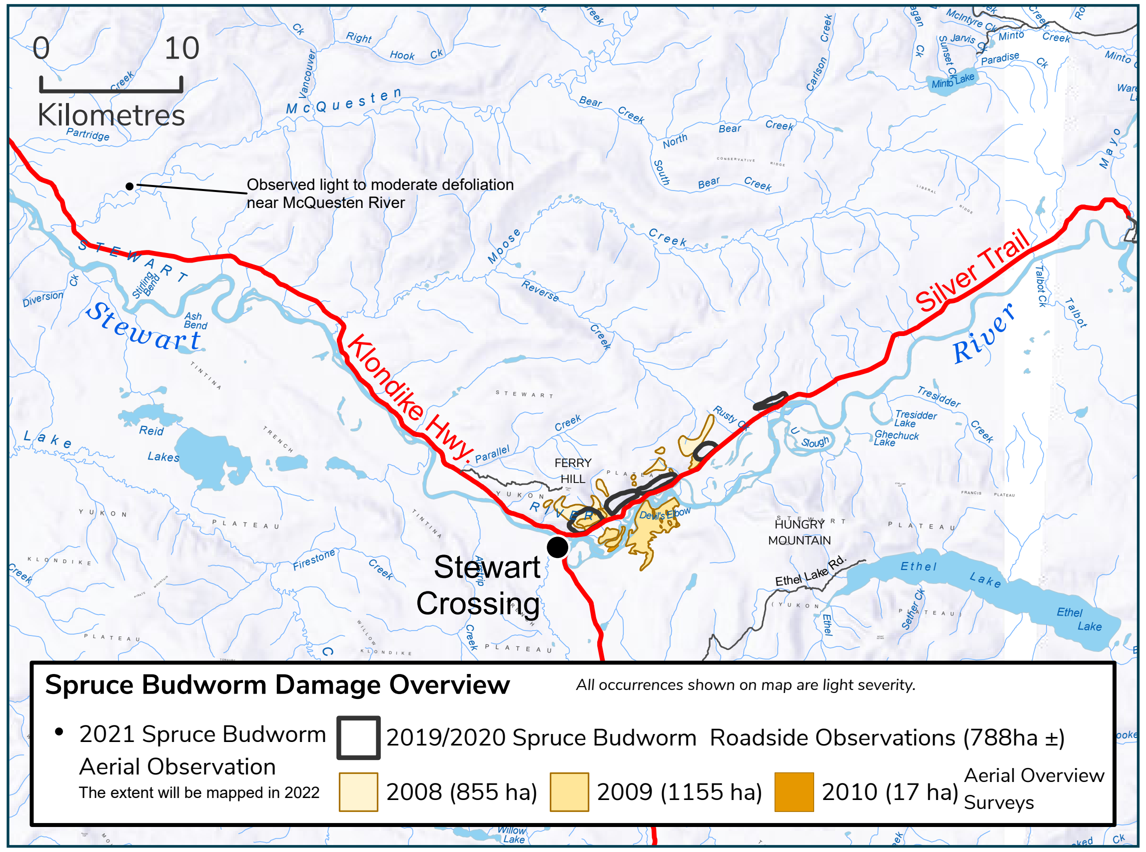
The eastern spruce budworm has long been known to inhabit white spruce stands in the interior of the Yukon, residing primarily in areas in and adjacent to the Tintina Trench which is a northern extension of the Rocky Mountain Trench. Moderate to severe defoliation can result in top kill and tree mortality in mature forests, mortality of regenerating trees, and increased susceptibility to secondary bark beetles (e.g., northern spruce engraver beetle (*Ips perturbatus*)). Budworm outbreaks are often cyclical, occurring every four to ten years and persisting for one to four years. The exact causal factors for this cycling are unknown, but natural enemies are known to play a role in eastern forests. The forests of southeast Yukon were moderately affected by defoliators throughout the late 1980s and early 1990s.

Eastern spruce budworm recorded in 2008 during the annual aerial survey was the first instance of one location having over 1,100 hectares of light defoliation. In 2009, aerial surveys mapped 1,150 hectares of light defoliation with the majority occurring on the Devil's Elbow area along the Stewart River. Egg mass sampling was conducted that fall to determine the health of the population and forecast defoliation levels for 2010. The results from the limited sampling suggested there would be little to no defoliation in 2010. The forecast was accurate with less than 17 hectares of light defoliation recorded in 2010 at Stewart Crossing. At this time, it was determined that the population had all but collapsed. In 2019 and 2020, residents of Mayo reported light defoliation on the tops of spruce trees in the Stewart Crossing area on Ferry Hill and along the ridges above Silver Trail Highway.

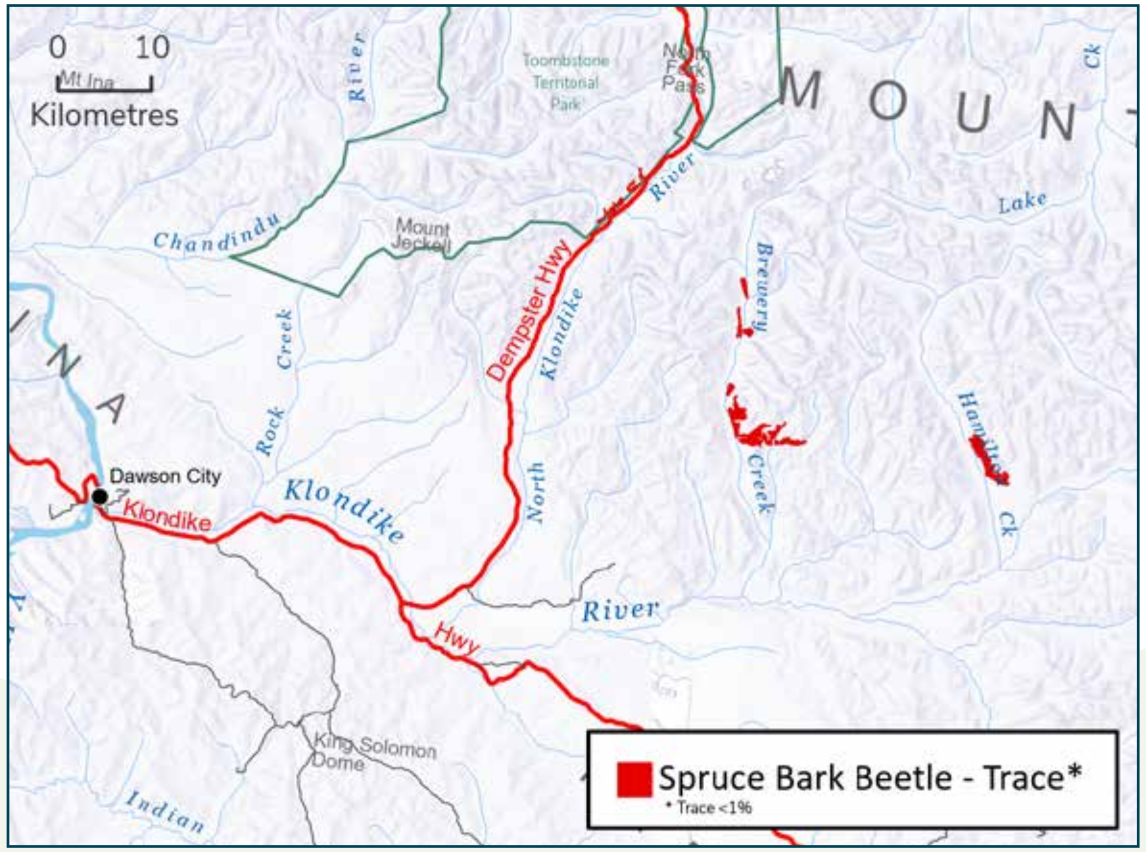
### STATUS IN 2021

In 2021 aerial surveys were conducted in the Stewart Crossing area to follow up on the observations from Mayo in 2019 and 2020. Aerial surveys did not record any defoliation, however a forestry crew working near McQuesten River, detected small patches of light defoliation on the top of spruce trees (Photo 15). These were north of the McQuesten River approximately 3 km east of the North Klondike Highway (Map 5), and approximately 40 km to the north of Stewart Crossing where the budworm was recently detected. This could suggest a northward migration and/or suitable phenological conditions further north. In 2022, the Forest Management Branch will conduct aerial surveys along the McQuesten River to determine the extent and severity of this infestation.

**PHOTO 15.** *Light to moderate defoliation of white spruce along the McQuesten River - this extent will be aerial surveyed in 2022..*




**MAP 5.** *Spruce budworm damage overview from 2008-2021 northeast of Stewart Crossing.*






**MAP 6.** *Spruce beetle disturbance near Brewery Creek (FHZ 3).*

## 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 infests downed trees, logging debris, decked timber, dying or stressed trees and only occasionally causes tree mortality. During periods of outbreak, beetles will attack and kill live trees, causing widespread mortality. In the 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 hectares were infested. It is thought that logging during the building of the Haines Road contributed to this outbreak. In the mid-1970s a smaller (100 hectare) outbreak occurred during the construction of the Aishihik Power Project. Both outbreaks were likely caused or exacerbated by human activities, as trees were felled and left during construction, providing ideal breeding habitat for spruce 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 hectares 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. The climatic conditions favoured increased beetle fecundity. Over the same period, warmer winters also resulted in reduced brood mortality.

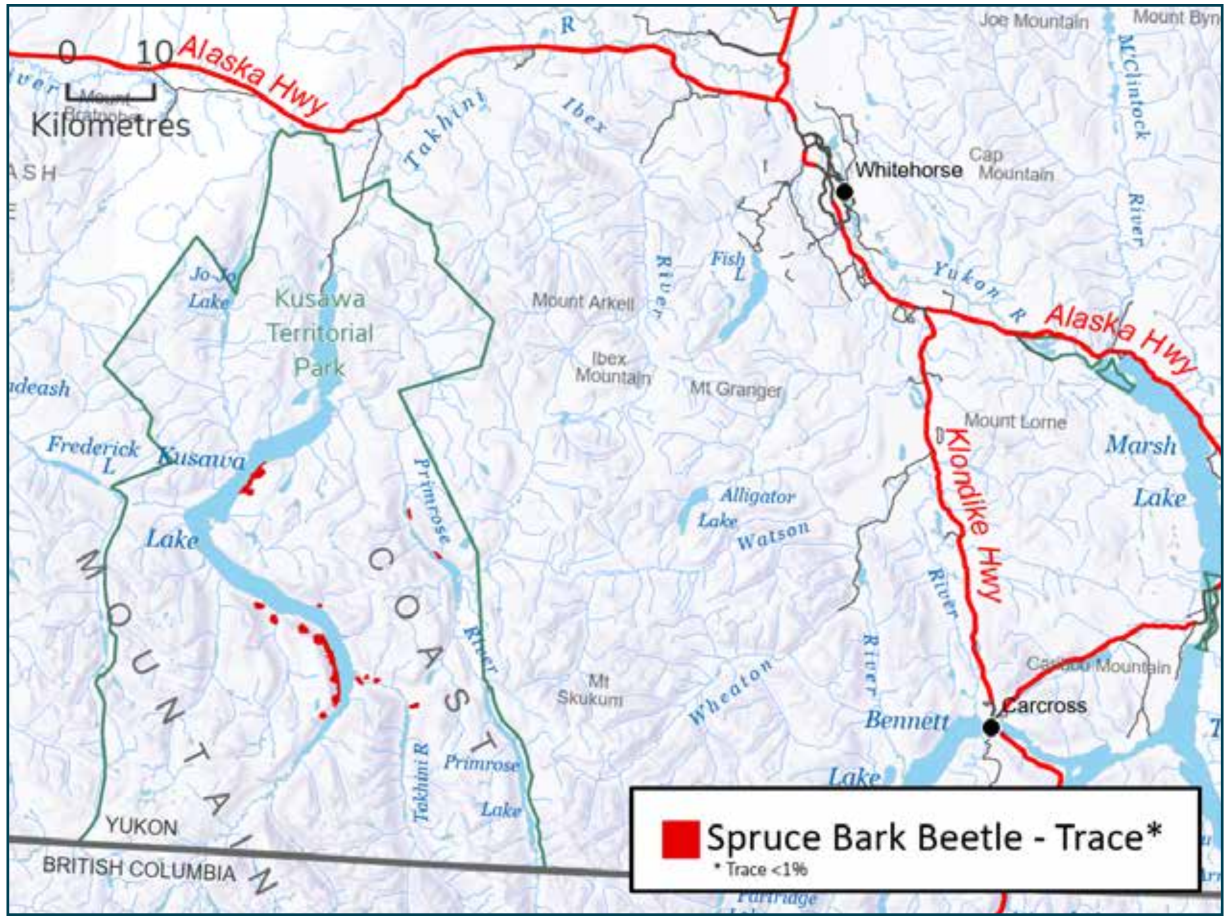
The life cycle of the spruce beetle typically takes one to three years depending on site position, temperature, and elevation. In the two-year cycle, early instar larvae overwinter and mature the following summer. In the late summer or early fall, two years after the initial attack, brood adults may 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 14 to 20 months following attack. The exposed twigs of the upper crowns have a yellow-orange/red hue and later, turn to grey. Dull red trees are three-year old attack with no beetle present. In the 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. This phenomenon makes it more difficult to assess outbreak stage based on the ratio of reds to greys.

### STATUS IN 2021

In 2021 aerial surveys recorded 2,274 hectares of trace (<1% of trees) attack in stands east of Dawson, near Brewery Creek in FHZ 3 (Map 6). Elsewhere, ongoing monitoring of the spruce beetle infestation at Kusawa Lake mapped 1,394 hectares of trace (<1% of trees) attack in stands previously infested. e.g., with red (recent attack,) and grey (older attack) trees (Map 7, Photo 16). This is up slightly from 709 hectares of old attack mapped in 2019, however the ratio of old attack to new attack continues to be low in the Kusawa Lake area. Forest Management Branch will continue proactive forest health management in this region through ongoing monitoring of the Kusawa Lake area. The Haines Junction region continues to show low levels of spruce beetle infestation.




**MAP 7.** *Spruce beetle disturbance in the Kusawa Lake area (FHZ 1).*

## Willow Blotch Leafminer (*Micrurapteryx salicifoliella*)

This common leafminer was first recorded in the Yukon in 2007, adjacent to the Stewart River at Stewart Crossing. Depending upon the year, this leafminer can be quite widespread, causing extensive damage to foliage. Studies in Alaska have found branch dieback and mortality associated with successive years of defoliation, at levels causing concern regarding the impacts to vertebrate populations including moose (Wagner and Doak 2018).

### STATUS IN 2021

In 2021, there was no willow blotch leafminer mapped in FHZ 3. It should be noted that due to the timing of the survey, many willow stands had started to change to fall colours, making identification of willow blotch minor difficult.

**PHOTO 16.** *Scattered 'faders' (yellowing of needles) associated with attack by 2020 adult spruce beetle at Kusawa Lake in FHZ 1.*



# FOREST DISEASES

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

Small-spored spruce Labrador tea rust *(Chrysomyxa ledi)* and large-spored spruce Labrador tea rust (*Chyrsomyxa ledicola*) are fungal diseases affecting the current year's needles of white spruce (Photo 17). 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. groenlandiculum*) 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 causes 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. Similarly, in 2020, spruce needle rust was reported locally along the Alaska highway in spruce stands in the Ibex Valley area. 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. These conditions existed in the Burwash Landing, Whitehorse, Atlin and Teslin areas in 2019 (see 2019 report weather section), and therefore, it is suspected that this foliar rust may have been present in these areas.

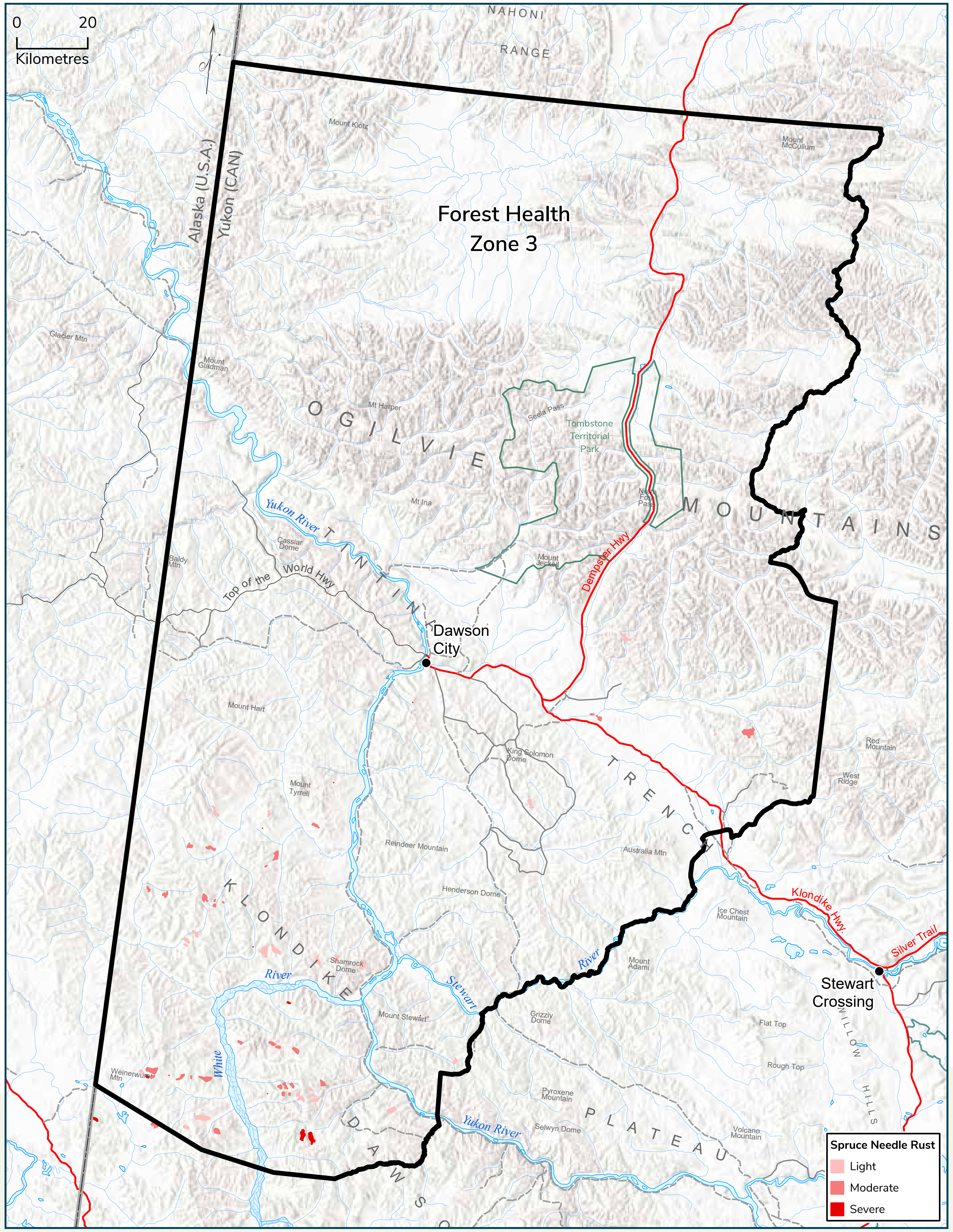
### STATUS IN 2021

In 2021, optimum conditions for the proliferation of needle rust occurred once again, with above normal rainfall recorded at several locations: 148% and 159% above normal respectively at Mayo and Carmacks in March, and in April 89% of normal in Mayo and 509% above normal at Carmacks (see Weather section). Discoloration of spruce from needle infections was noted over 6,997 hectares in 2021, mostly south of Dawson and on both sides of the Yukon River, with a few areas east of Dawson and east of the Klondike River (Photo 18, Map 8).

**PHOTO 17.** *Severe infection of spruce needle rust on current year's growth.*

**PHOTO 18.** *Moderate discoloration of mature sprue caused by spruce needle rust near independence creek, between Yukon River and White River (FHZ 3).*






**MAP 8.** *Spruce needle rust infections in areas near Yukon and White River in FHZ 3.*

# ABIOTIC DISTURBANCES

## Flooding and High-Water Tables

Flooding affects trees by reducing the supply of oxygen to the soils and roots. Other effects of flooding include 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 2021, flooding in FHZ 3 was recorded at four different sites, totalling three hectares near Brewery Creek. This is down from 67 hectares in 2015.

## Windthrow

Shallow-rooted tree species, or those on coarse or shallow soils, are more prone to windthrow. No windthrow was noted in FHZ 3 however In FHZ 1, 1,032 hectares of lodgepole pine and spruce windthrow were mapped in the Takhini River Valley, north of Mount Vanier. Ground checks of a small portion of this area found evidence of old pine engraver beetle, *Ips pini*. See pest complexes section for more information.

# PEST COMPLEXES

## Aspen Decline

Aspen decline (or dieback) refers to mortality or damage to forests due to multiple causes, including a combination of biotic and abiotic factors. Symptoms include thinning crowns, top dieback, stem mortality, and stem breakage. In Western Canada, decline has been observed on several 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.

Ground assessments of aspen mortality in 2008 between Whitehorse and Stewart Crossing, found that site and stand conditions also play 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 19), and clonal resistance (Photo 20); 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 19.** *Microclimate effects on trembling aspen with healthy hillside stands versus stands with aspen decline along Mayo River.*

**PHOTO 20.** *Healthy aspen clone within a stand affected by aspen decline.*

In 2019, Yukon FMB completed a spatial analysis 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% (2016) and 56% (2019) of the affected stands are less than 60 years old (Figures 3 and 4).

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. Indeed, closer examination of decline-causing factors in Alaskan trembling aspen forests has identified a novel and aggressive fungal canker (*Neodothiora populina*) causing widespread mortality (Reuss, Winton, and Adams, 2021). Stand-level infection rates across a range of sites representing six ecoregions ranged from <1 to 69%, with an average of 70% of the dead trees due to this canker. Analysis found that sites with higher summer vapour pressure deficits (drier sites), had higher levels of canker infection and mortality. The researchers conclude that the combined effects of the canker, drought and persistent aspen serpentine leaf miner infestations are responsible for widespread aspen mortality. This is supported by recent findings which found that aspen leaf miner negatively impacts water relations in trembling aspen (Wagner, Wheeler and Burr, 2019), and that persistent and greater declines in aspen growth, and increases in mortality, are expected due to warming climate and increased insect outbreaks, including aspen serpentine leaf miner (Boyd et al. 2021).

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

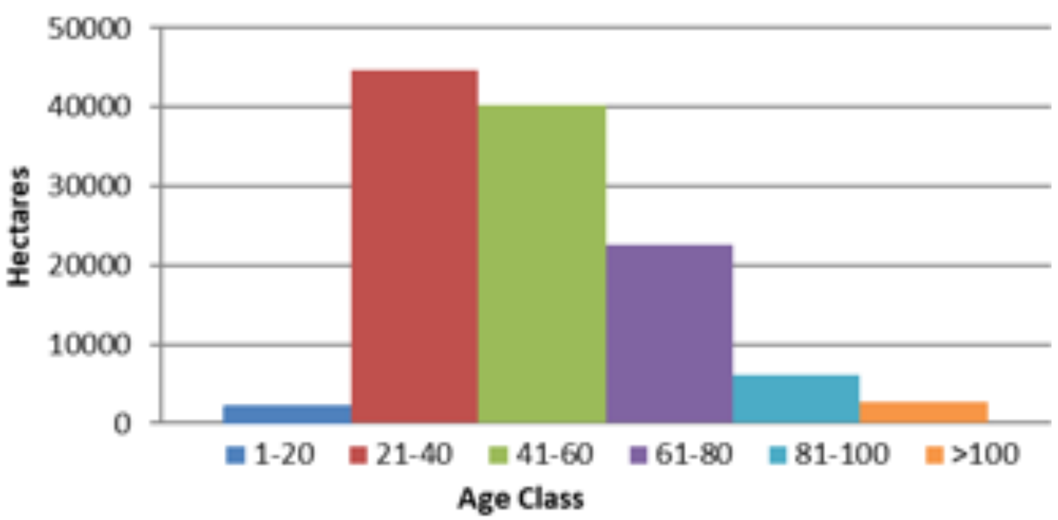



**FIGURE 3.** *Age Class Distribution of Aspen Stands with Decline in 2016*

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

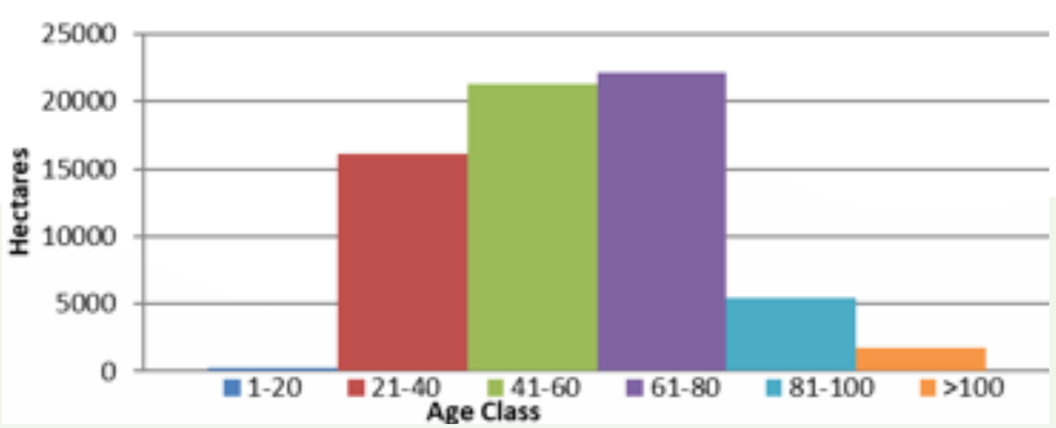



**FIGURE 4.** *Age Class Distribution of Aspen Stands with Decline in 2019*

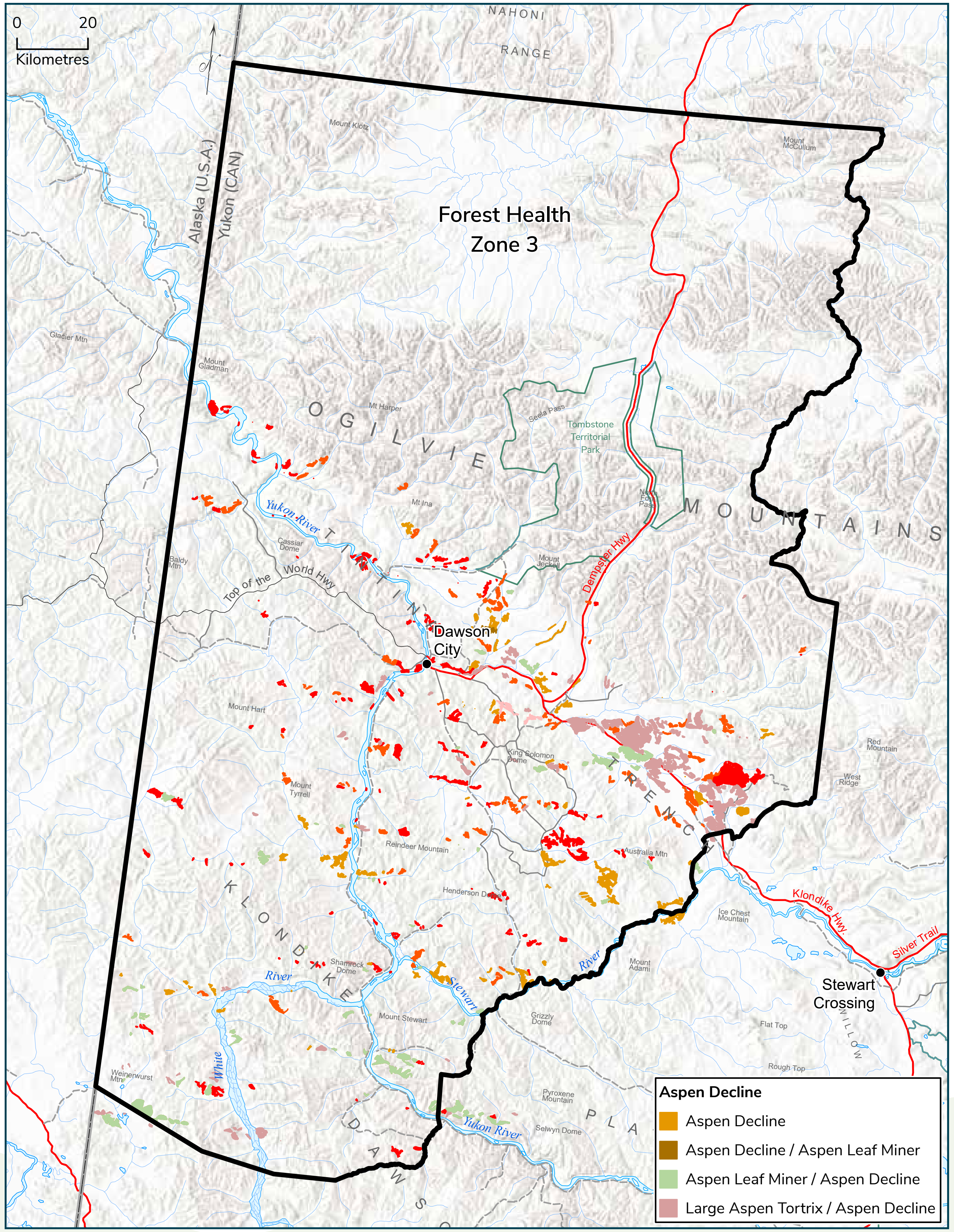


As the climate warms, the likelihood of ongoing aspen decline is possible given the potential for increased frequency of drought events, particularly since trembling aspen has a low tolerance for water deficits. Warmer springs could also result in early spring flush followed by late spring frosts. Given the recent and historical observations of decline, the recent findings of a widespread novel canker in Alaskan trembling aspen forests, and the potential for continuation and possibly expansion of decline, the Forest Management Branch has and will continue to conduct 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.

## STATUS IN 2021

In 2021, the area affected by aspen decline increased tenfold, from 5,621 hectares in 2015 to 55,250 hectares in 2021. The area affected by aspen decline in FHZ 3 has been steadily increasing with observations dating back 10 years; in 2011, 529 hectares were recorded, 10 hectares in 2010, and 2,488 hectares in 2009. In 2021, half of the area with aspen decline occurred in areas with large aspen tortrix, most of which was along the highway corridor between Stewart Crossing and junction of north Klondike and Klondike River (Photo 21, Map 9,).

**PHOTO 21.** *Severe aspen decline in foreground, and aspen serpentine leafminer and aspen decline on opposite side of creek near Stewart River.*




**MAP 9.** Extent of aspen decline in Forest Health Zone 3.



## Windthrow and Pine Engraver Beetle

Windthrow over 1,032 hectares was mapped on-route to conduct ground checks at Kusawa Lake. Subsequent ground assessments were conducted to determine level of disturbance and to assess presence of any forest pests. Ground checks verified blowdown of approximately 10% of trees (118 hectares) within this area.

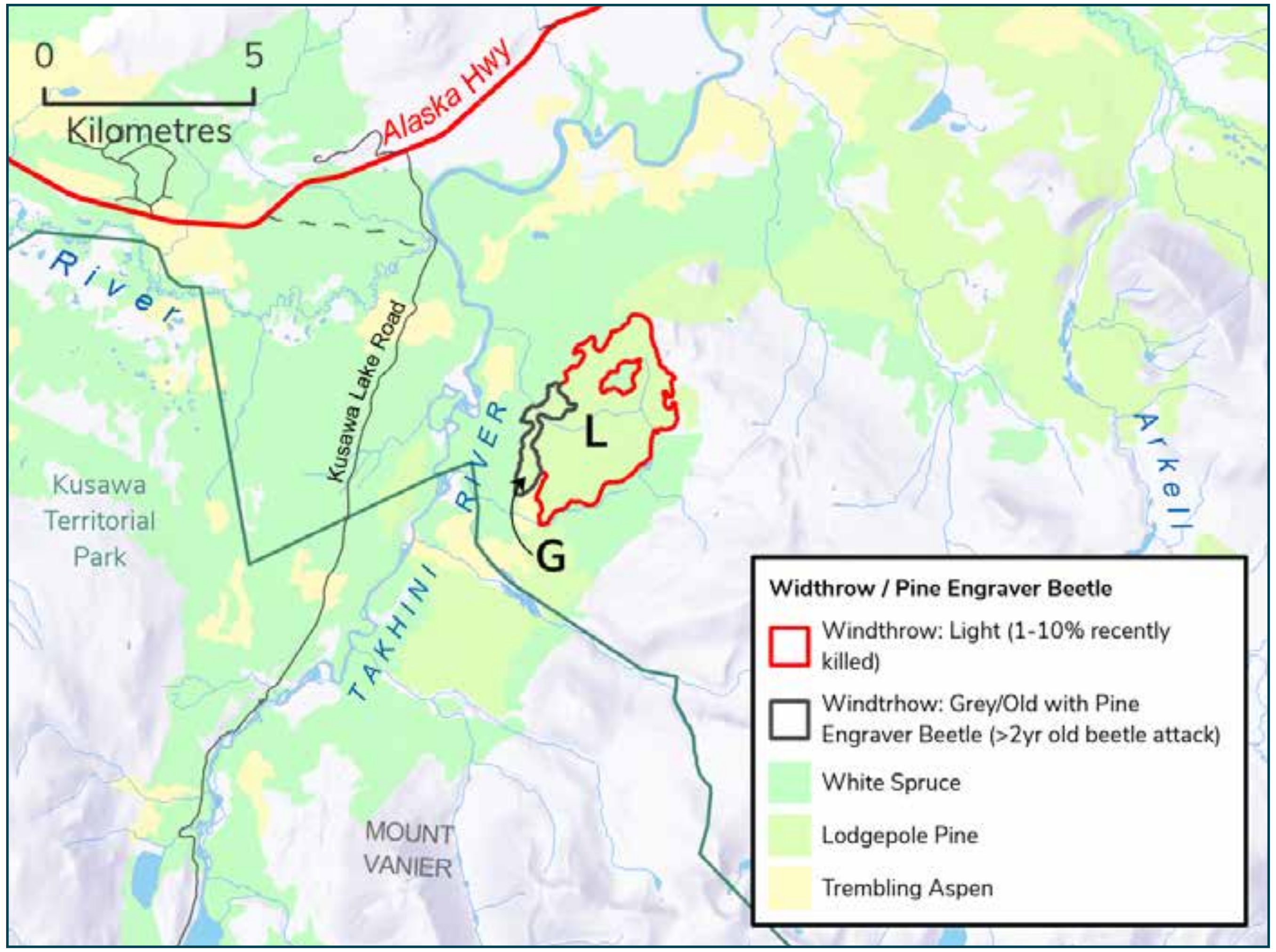
More detailed observations via helicopter found that the entire valley east of Takhini River and north of Mount Vanier has evidence of reoccurring wind events, perhaps spanning decades (Photo 22, Photo 23, Map 10).

The area where the ground surveys were conducted was predominately mature pine leading forest, with some spruce (Photo 24).

**PHOTO 23**. *Closer view of lodgepole pole and spruce windthrow.*

**PHOTO 22.** *Old and new windthrow of lodgepole pine and spruce near takhini river in FHZ 1.*

**PHOTO 24**. *Ground examinations in open lodgepole pine-dominated stand with some spruce (FHZ 1).*




**MAP 10.** *Extent of aspen decline in Forest Health Zone 3.*

**PHOTO 25.** *Trees downed in similar direction, confirming windthrow (FHZ 1).*



Ground checks found dead trees laying in the same direction (North-South) which confirmed wind as a contributing factor rather than tomentosus root disease (*Onnia tomentosa*) (Photo 25). The lodgepole pine windthrow created host material for local endemic populations of pine engraver beetle, Ips pini, identified by the characteristic Y-shaped galleries noted on the downed trees (Photo 26). The ground checked area is denoted as "G" (grey) on Map 10, and refers to the dead trees with evidence of pine engraver and lodgepole pine beetle (*Dendroctonus murryanae*). These bark beetles generally attack weakened or stressed trees, and if sufficient populations build, they can attack standing live trees. Dead standing trees were observed with mortality due to both of these bark beetles. Lodgepole pine beetle attacks at the base, causing the tree to produce tell-tale pitch tubes as a defense mechanism (Photo 27). This bark beetle is native to Yukon forests and is similar to pine engraver beetle in that it attacks stressed standing trees, but dissimilar in that they do not attack trees affected by windthrow.

While ground surveys found no evidence of any new beetle attacks e.g., trees fading to yellow, Yukon FMB will continue to monitor the area as pine engraver beetle populations can build quickly. It is likely that the populations have collapsed, as they tend to suffer high overwinter mortality rates.

**PHOTO 27.** *Lodgepole pine pitch tubes at base of dead tree, a tell-tale sign of lodgepole pine beetle attack (FHZ 1).*

**PHOTO 26.** *Characteristic y-shaped pine engraver beetle gallery on bole of standing dead tree (FHZ 1).*

## Flooding and Spruce Beetle

Flooding weakened white spruce predisposing them to attack by spruce beetle at six spots totalling two hectares near Lee Creek. There was less flooding mapped in FHZ 3 in 2021 than in previous years.

# 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.
- 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 lures 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 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, 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).

MPB is a native North American bark beetle that is distributed throughout most of the range of lodgepole pine in British Columbia (BC). The most recent MPB outbreak is responsible for killing over 13 million hectares of lodgepole pine forest in BC alone. Historically, climate has impeded its expansion northward, and until the current outbreak, it was only recorded south of 56°N. MPB is currently the single biggest forest health concern in western Canada.

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, Forest Management Branch 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 yet expanded into the Yukon, it moved quickly northwards within the Rocky Mountain Trench (RMT) in northern BC, during the peak of the British Columbia outbreak. The RMT 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 dynamics of mountain pine beetle. 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 geographic expansion of the beetle, possibly allowing for earlier emergence and mating in the spring and summer (Mitton and Ferrenberg, 2012).



# MONITORING MOUNTAIN PINE BEETLE IN 2021

In 2010 when aerial surveys were initiated, mountain pine beetle (MPB) populations and subsequent pine mortality within the Rocky Mountain Trench (RMT) in British Columbia were very high (within 150 kilometers of the 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 border zone straddling the Yukon/BC border, as well as the RMT in British Columbia (Map 11).

The border zone stretches from the Rancheria River to approximately 75 km west of the Northwest Territories border and encompasses areas with lodgepole pine (*Pinus contorta*) as the dominant species (Map 11). The boundaries of the border zone delineate the area with the highest concentration of pine-leading stands with a continuous pathway into Yukon. This zone was delineated due to the distribution and homogeneity of susceptible lodgepole pine and presents a high priority area for monitoring (Photo 28). From 2014-2019, aerial surveys were undertaken along the BC border using an east-west grid. The grid was adaptive in that it was based on the MPB risk in BC; initially the grid was 30 km by 300 km (5 km north of border in Yukon, and 25 km south of border in BC). In the last few years, it was reduced to 25 km by 300 km south of the BC border given decreasing MPB populations.

During the northward advance in BC, MPB has encountered what has come to be referred as "naïve" pine. These are lodgepole 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. In the RMT, severe cold winters have killed beetle broods within the trees, reinforcing the lethal effect of harsh cold winters on beetle populations. Combined with declining populations in northern BC, northward movement of MPB populations declined significantly. Hence in 2015, aerial surveys in the RMT were discontinued following two years of insignificant northward movement of MPB in the RMT.

**PHOTO 28.** *Vast expanse of Mature Lodgepole Pine, looking south into BC, southwest of Watson Lake.*

## Border Zone

Following no detection of no MPB in 2019, a decision was made to discontinue aerial surveys following several years of no detection of MPB in the border zone. However, Yukon FMB reviews BC's aerial survey results annually to determine if monitoring will be reinstated. This year's review found four unconfirmed MPB spots, totalling 12 trees in the border zone. Based on this information Yukon FMB will resume monitoring the border zone in 2022 starting with ground truthing the four spots to confirm MPB.

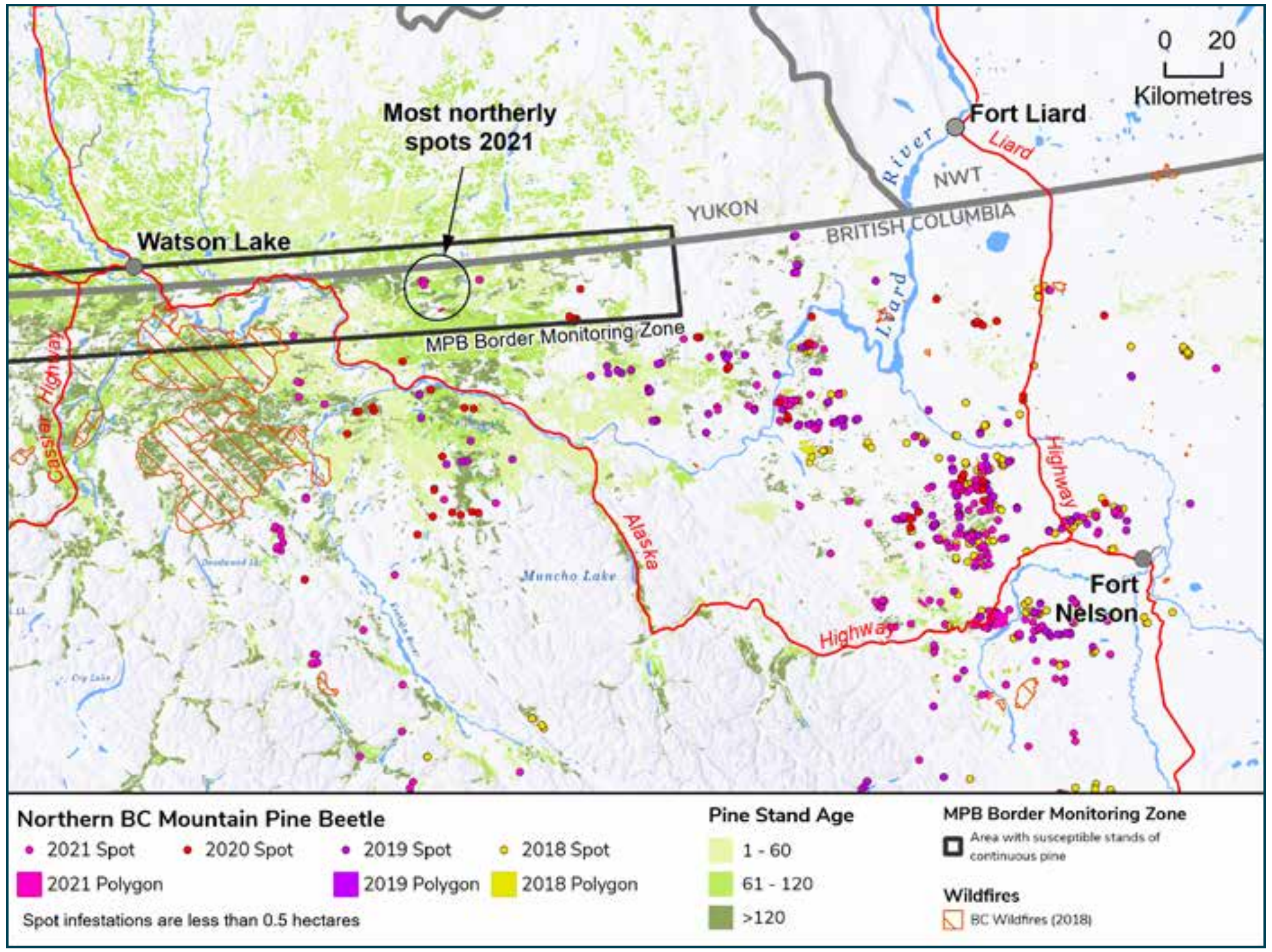
## British Columbia Observations

B.C.'s Ministry of Forests, Lands and Natural Resource Operations conducts aerial surveys in northern BC. These surveys have found that since the peak in 2013, populations in the northern Rocky Mountain Trench (RMT) have retreated with only a few spots noted from 2015-2018. In 2019 spot infestations were noted within 3 km of the border but retreated 10 km south in 2020. Unconfirmed 2021 results show populations in northern BC expanding slightly again, both northward and westward, and into the border zone with only 3 spots totalling 12 trees west of Coal River and within 3 km of the Yukon border (Map 11). There was also one other spot detected in the border zone, east of the 2018 wildfires and with only one tree mapped. The presence of MPB in this area of the border zone warrants further investigation given its proximity to Yukon border, higher hazard host material e.g., older stands (Map 11) and shifting climate suitability (Map 12A, Map12B).

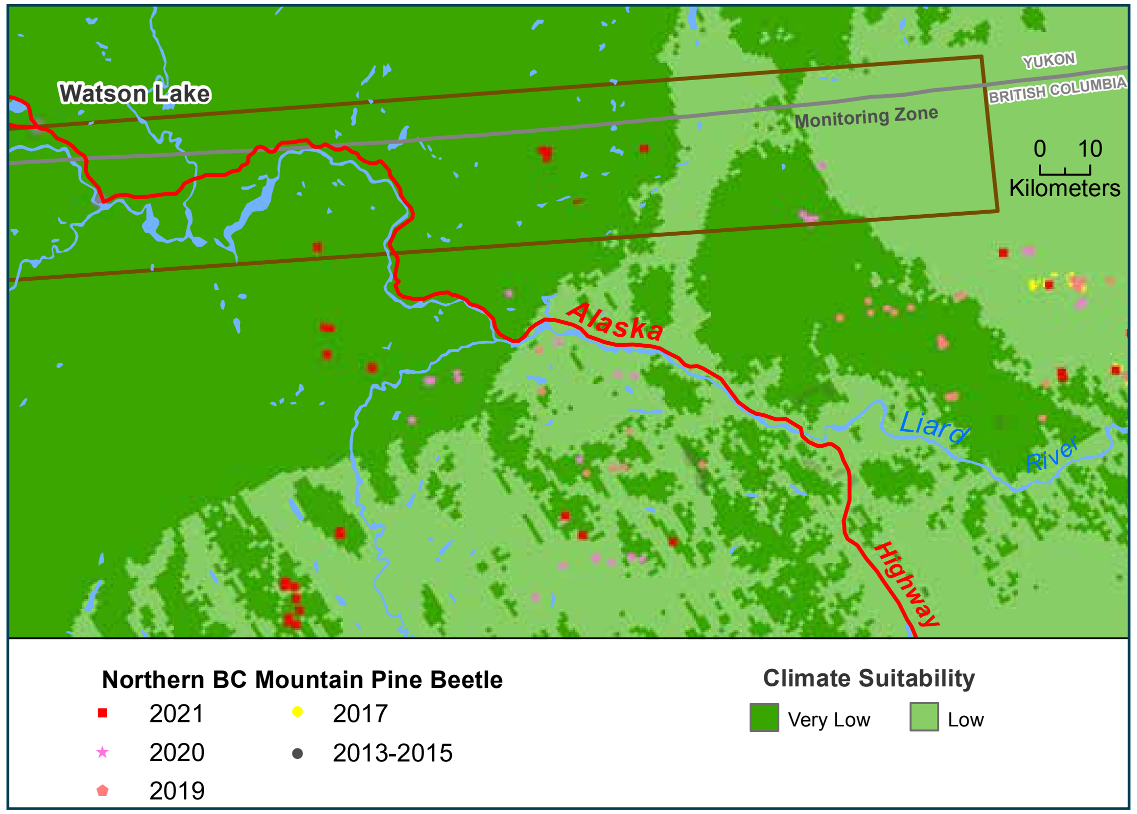
It is anticipated that continued westward migration will likely be halted or significantly slowed by the vast young pine stands that resulted from both the 1982 "Egg Fire" that burned over 100,000 hectares of mature pine, and the more recent 2018 wildfires. Young stands in the "Egg Fire" will act as sinks rather than sources given the smaller diameter and thin bark. Mature lodgepole pine in any refugia (area of unburned forest within the fire) of the 2018 wildfires might support MPB populations depending upon their overall health and the local climate.

The advancing and retreating of MPB along its northern limit aligns with the theory of biological invasions, that years of favorable climate will see populations build and advance, while years with unfavorable weather will see populations retreating. The 2011 MPB Risk Analysis (Hodge, 2011) completed for Yukon Forest Management Branch describes the factors influencing spread and establishment with climatic suitability deemed as one of the limiting factors to northern expansion into southeast Yukon. This is due to higher mortality rates associated with extreme winter weather, especially in two-year cycle populations.

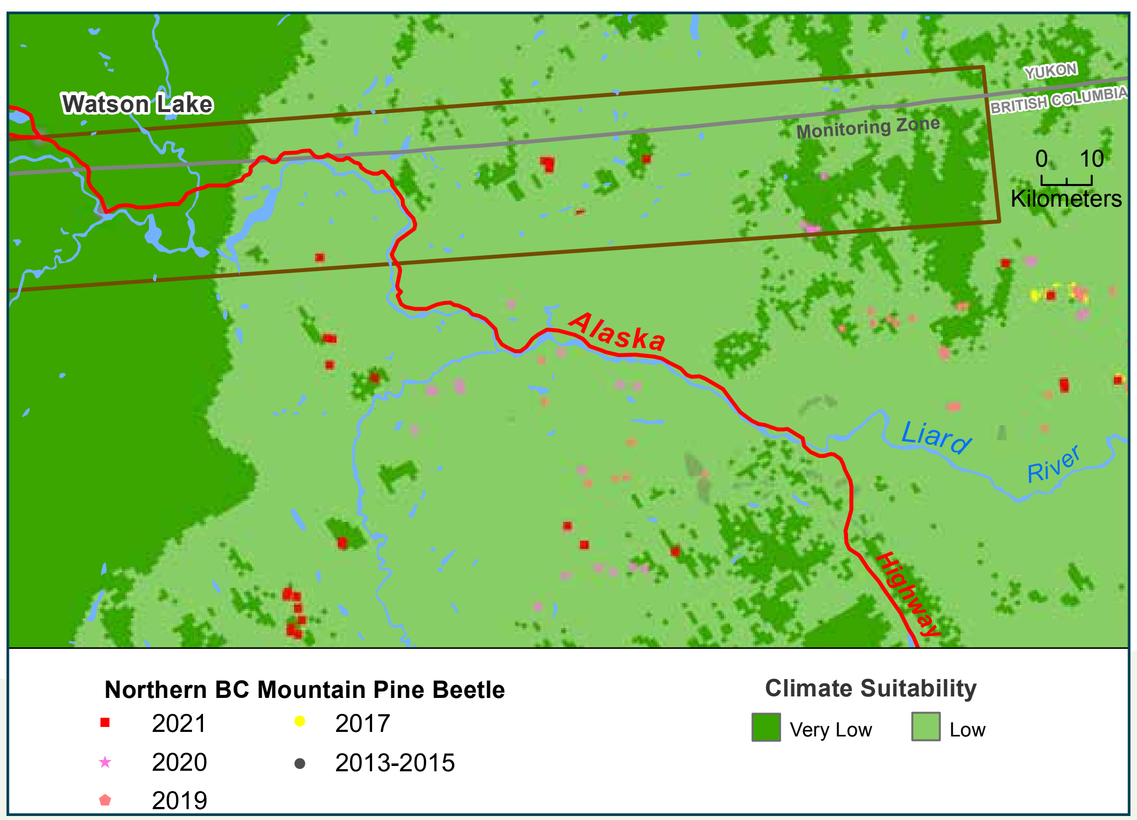
In the years following the 2011 MPB Risk Analysis, this limiting factor has been confirmed. As any expansion into the area with the lowest climate suitability zone generally does not last beyond a year, whereas those in the low climate suitability seem to persist (Map 12A). As the climate warms, there will be a shift northward of the low climate suitability zone (Map 12B). This shift could result in populations persisting in the monitoring zone, as evidenced by the current persistence in the low climatic suitability zone east of the Liard River. As indicated in the 2011 risk analysis (Hodge, 2011), the cycle of endemic/incipient-to-brief eruptive is projected to continue for several decades, until such time that the climate warms sufficiently to provide for consecutive years of univoltine (producing one brood in a season) populations. Given the right climatic conditions, small populations could become established and slowly migrate north within the next decade. This will result in MPB crossing the BC/Yukon border into southeast Yukon and attacking scattered individual trees or small groups of trees.




**MAP 11.** *British columbia aerial overview survey observations of mountain pine beetle in the border monitoring zone and adjacent area from 2018-2021.*




**MAP 12 A.** *Mountain pine beetle infestations in northern British Columbia with 2011-2030 climate suitability model, Model developed by Carroll et al 2004.*




**MAP 12 B.** *Mountain pine beetle infestations in northern British Columbia with 2011-2040 climate suitability model, model developed by Carroll et al 2004.*

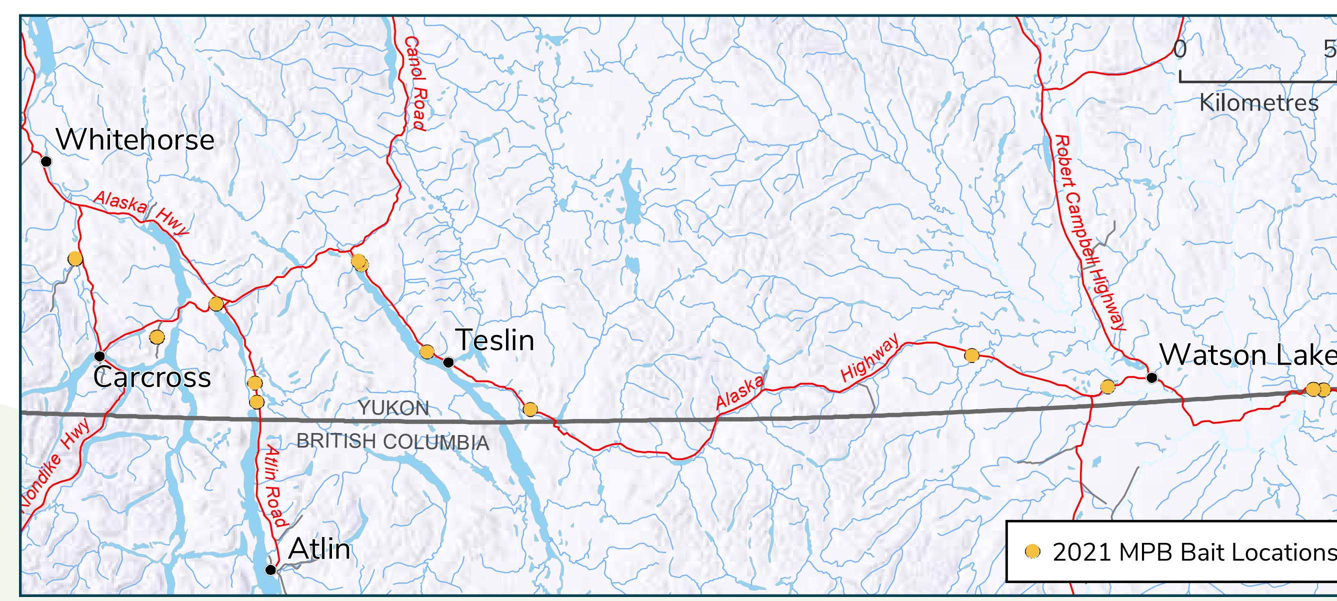


## Using Bait Traps

Since 2009, Forest Management Branch has installed and monitored 15 pheromone bait tree stations in southern Yukon and northern British Columbia to detect the presence of MPB (Map 13, Photo 29, Photo 30). 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 2021 at any of the bait tree stations.

**PHOTO 29.** *Pheromone placed on the north side of the tree.*

**PHOTO 30.** *Mountain Pine Beetle bait tree.*




**MAP 13** *Mountain Pine Beetle monitoring bait trap locations in southern Yukon and BC.*

# SPECIAL PROJECTS

Two special projects were undertaken in 2021, both continuations of previous years projects.

## Bark Beetle Pheromone Trapping

The summer of 2021 marked the fourth consecutive year of data collection for the spruce beetle (*Dendroctonus rufipennis*) monitoring program in the Haines Junction area. This year the project was expanded to include monitoring of northern spruce engraver beetle (Ips perturbatus). The monitoring objectives are:

1. To monitor populations of both beetle species in Haines Junction timber harvest planning areas;
2. To understand the timing of the beetle flight periods in the Haines Junction area;
3. To determine the spatial distribution of beetle populations in the Haines Junction area; and,
4. To detect increases in beetle populations if 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.

### Methodology

Lindgren© funnel traps were used to monitor spruce beetles starting in the spring and summer of 2018. In 2021, additional traps were included to monitor the northern spruce engraver populations. These funnel traps are specifically designed for monitoring and sampling insect populations. Beetle-specific chemical lures are used to attract beetles to the traps. Ten traps were erected for spruce bark beetles, and eight traps for northern spruce bark beetle at various locations surrounding Haines Junction (Map 14). Traps were established in locations with a 30-metre buffer between traps and live spruce trees to reduce the risk of attacks on live trees. Traps were checked weekly during flight periods of each beetle.

### Spruce Bark Beetle Results

The 2021, spruce beetle flight period peaked in mid-June when the average daily maximum temperature was between 19 and 25 degrees (Figure 5). The total number of beetles captured during the sampling period was 43, marking the third consecutive year of decline (Table 2). The bar graph below shows a steady decline of captured beetles since the trapping program started in 2018. For captured beetles by location See Table 2.

### Northern Spruce Engraver Results

Trap catches were very high for northern spruce engraver beetles, the total number of beetles captured during the sampling period was 15,452 (Table 2). Trap catches peaked in the second week of June, and were finished by early July (Figure 6).

| TRAP | SBB COUNT 2021 | IPS COUNT 2021 |
|---|---|---|
| 1 | 1 | 1354 |
| 2 | 6 | 1912 |
| 3 | 0 | 4441 |
| 4 | * | * |
| 5 | 3 | 3084 |
| 6 | 1 | 677 |
| 7 | 6 | 1806 |
| 8 | 6 | * |
| 9 | * | * |
| 10 | 3 | 1630 |
| 11 | 9 | * |
| 12 | 8 | 548 |
| 13 | * | * |
| Total | 43 | 15452 |

*- No Data Collected

**TABLE 2.** *Total number of spruce bark beetle (SBB) captured and northern spruce engraver beetles (IPS) captured in 2021 (per trap). Asterisk indicate no data.*



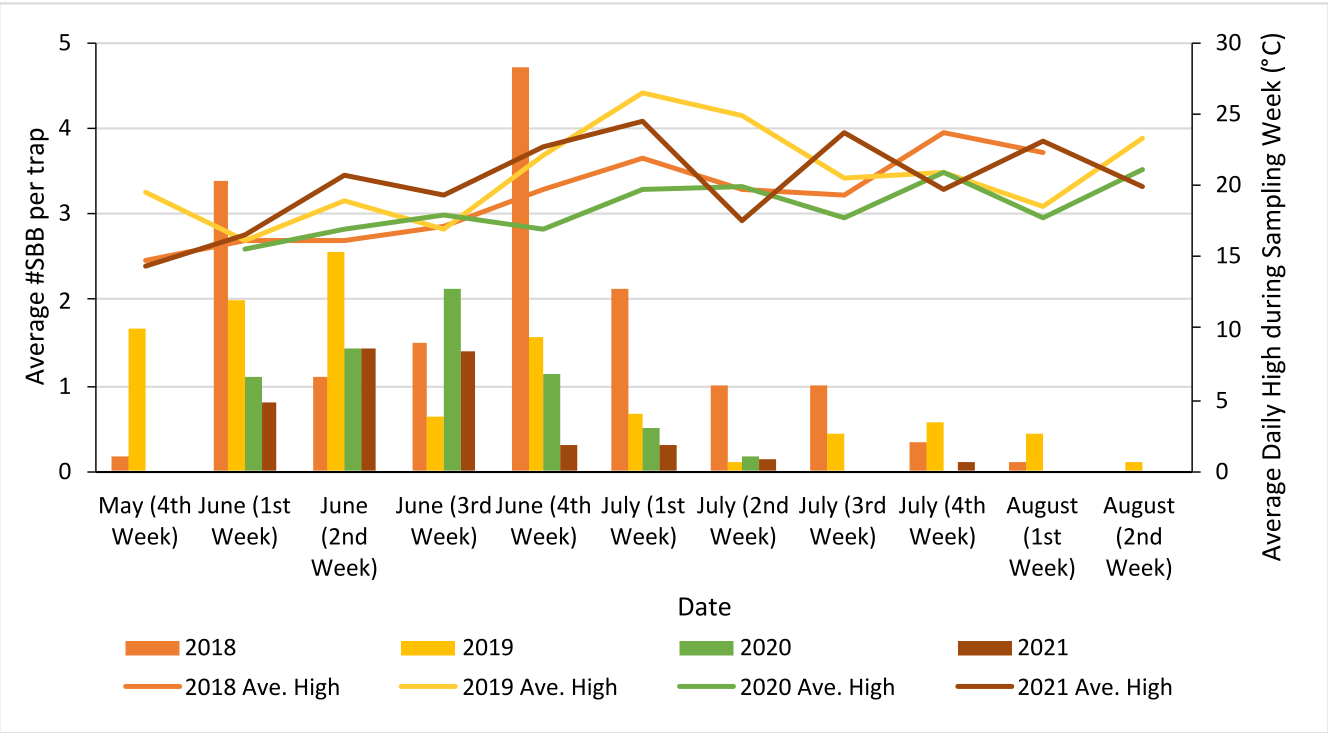



**FIGURE 5.** *The average number of northern spruce engraver beetles (IPS) captured per trap, and the average daily high temperature (°Celsius) during each sampling week in 2021.*

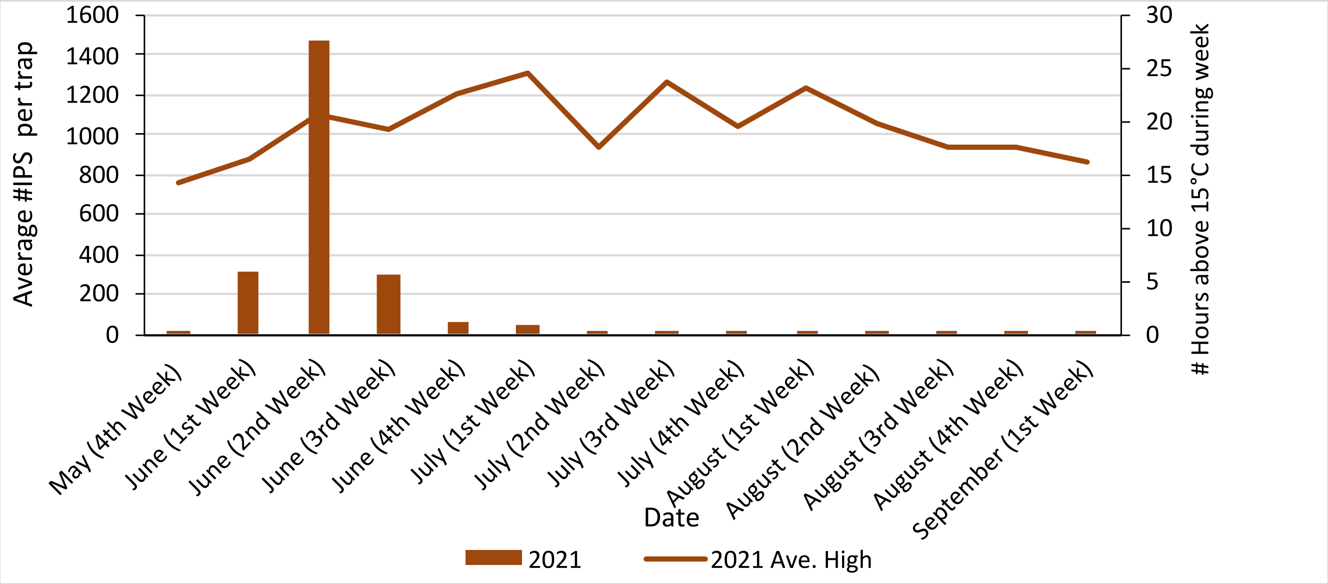
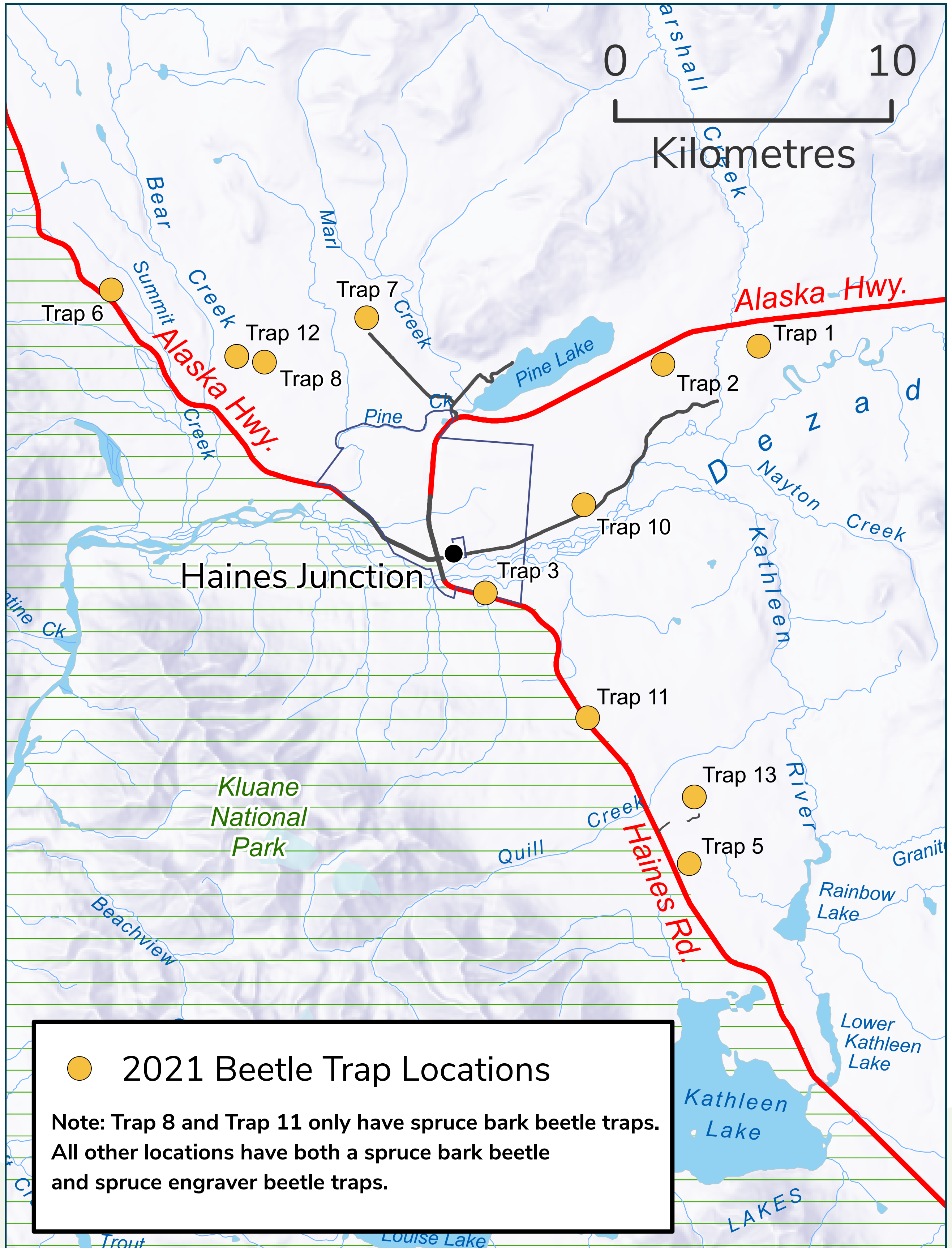



**FIGURE 6.** *The average number of northern spruce engraver beetles (IPS) captured per trap, and the average daily high temperature (°Celsius) during each sampling week in 2021.*




**MAP 14.** *Bark beetle trap locations in the Haines Junction area. Lindgren© Funnel Traps with chemical lures attached to them that attracted specific beetle species.*



# CONCLUSIONS

### Spruce Bark Beetle:

The number of beetles captured from 2018 to 2021 have been steadily declining, and are less than at the end of the last outbreak (1990-2006). This suggests that populations have returned to endemic levels.

### Northern Engraver Beetle:

Trap catches for the northern spruce engraver beetle in 2021 were very high, with over 15,000 adults captured. To date, mortality has not been observed on standing trees, as they are likely attacking slashed down woody material within the recently harvested areas.

### Next Steps

Yukon Forest Management Branch will continue to monitor spruce bark beetle and northern spruce engraver beetle to inform risk management. In addition, given the high number of northern spruce bark beetle trapped in 2021, Forest Management Branch will monitor the Haines Junction area for any signs of attack on standing live trees. Management practices aimed at reducing such risk have been implemented and include limiting the available downed green woody debris via cutting permit terms and conditions.

## Deep Creek/Jack Fish Bay Bark Beetle Monitoring

### Background

In late October 2020, a windthrow event north of Whitehorse in the Deep Creek /Jack Fish bay area, caused a significant disturbance to white spruce and lodgepole pine-leading stands. Given the potential risk to adjacent forests associated with bark beetle populations building in windthrow, Yukon Forest Management Branch (FMB) undertook a proactive approach and completed a pest risk analysis (PRA). The PRA included a pest risk assessment and management response options, including best practices.

### Pest Risk Analysis

The following is the pest risk assessment summary of the risk posed by beetle populations building within the blowdown, and potential to expand into the adjacent stands.

Management response options included a best case scenario, which was to remove all windthrow timber prior to initial beetle flight period in the spring of 2021. As this option was not feasible from a cost perspective due to the scale of the blowdown, the windthrow areas were monitored for beetles throughout the summer of 2021. Monitoring tactics included ground surveys to identify bark beetle species, and aerial surveys to identify level of disturbance within windthrow and adjacent stands.

| PEST | LIKELIHOOD OF EXPANSION | CONSEQUENCES OF EXPANSION | OVERALL RISK |
|---|---|---|---|
| Spruce Beetle | Low-Medium | Medium | Medium |
| Northern spruce engraver beetle | Low-Medium | Medium | Medium |
| Lodgepole pine beetle | Low | Low | Low |
| Pine engraver beetle | Low-Medium | Low | Medium |

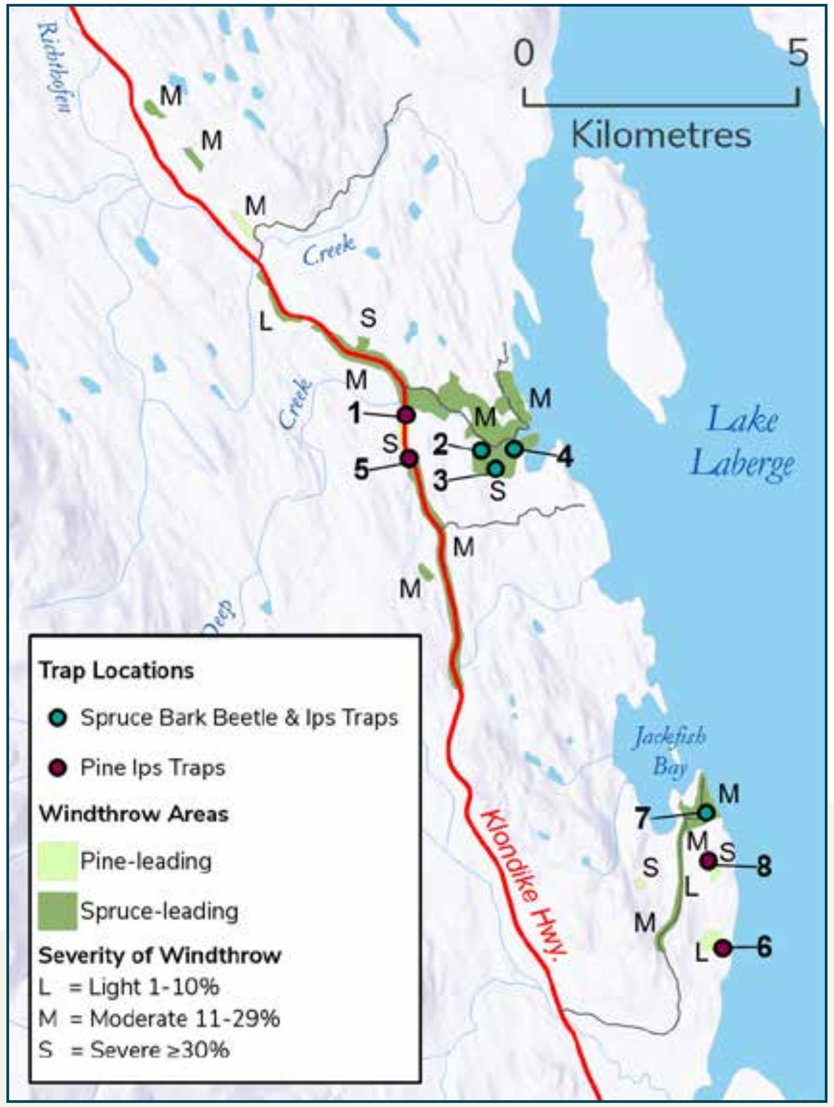
**TABLE 3.** *Pest risk assessment summary*

Ground surveys utilized Lindgren© funnel traps and beetle probing within windthrow and adjacent stands. Lindgren© funnel traps with specific chemical lures were set up based on leading species in the moderate and severe blowdown polygons (Photo 31). Spruce-leading areas had chemical lures to attract spruce beetles and northern engraver beetles, while lodgepole pine-leading strands had lures to attract pine engraver beetles (Map 15). The traps were checked weekly and trap catches recorded. These results provided FMB with a better understanding of the flight period, and population levels within the area. Aerial surveys using a helicopter assessed the level of windthrow as light (1-10% of trees recently killed), moderate (11-29% of trees recently killed, and severe (>30% of trees recently killed) (Map 15).

Next steps are the development of treatment plans based on 2021 monitoring observations.

**PHOTO 31.** *Lindgren© Funnel Trap at trap location #2.*

**MAP 15.** *Windthrow areas by leading species and severity with bark beetle trap locations in the Deep Creek/Jack Fish Bay. Lindgren© Funnel Traps with chemical lures attached to them that attract specific beetle species.*






## Risk Response Approach and Results

### Trap Observations

- Spruce bark beetle: Total capture was 5 beetles (Table 4). Due to such low catchment, it is difficult to determine peak flight period.
- Northern spruce engraver beetle: Total capture was 223 beetles (Table 4), with an average of 4 beetles per trap per week. The peak flight occurred from the third week in June to the first week in August (Figure 7).
- Pine engraver beetle: Total capture was 1274 beetles (Table 4), with an average of 24 beetles per trap per week. The peak flight occurred in the first 2 weeks of August. (Figure 8).

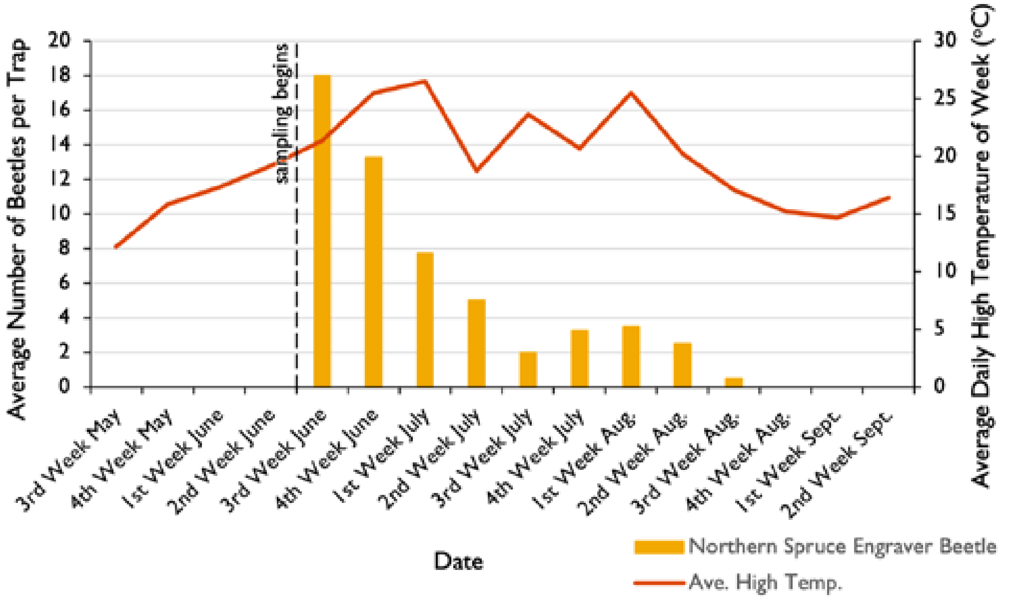



**FIGURE 7.** *The average number of northern spruce engraver beetles (IPS perturbatus) captured and the average daily high temperature, in degrees Celsius, during each sampling week.*

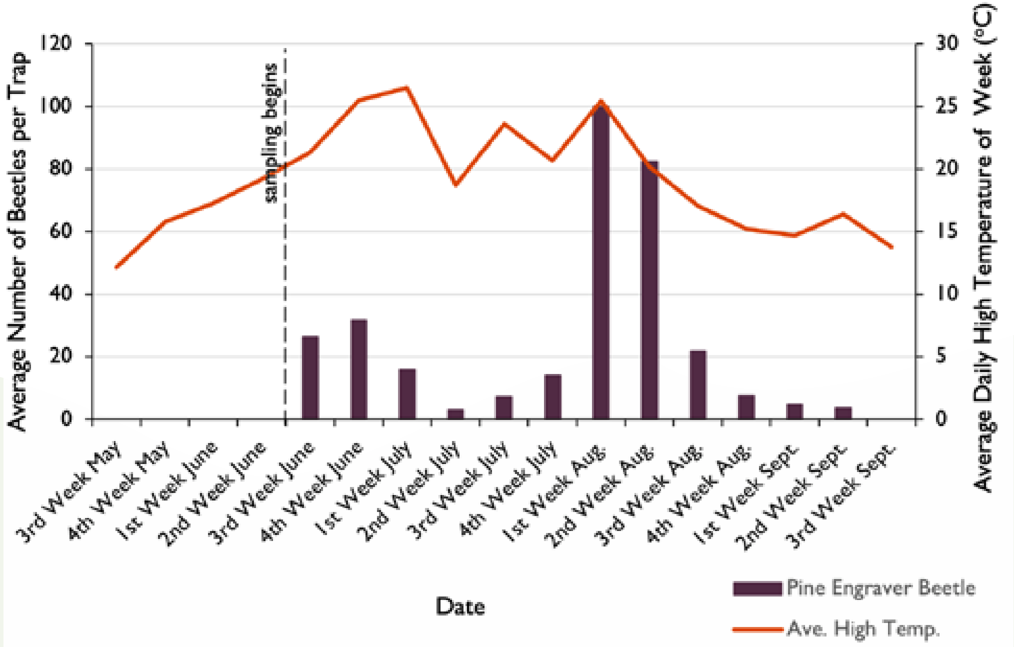



**FIGURE 8.** *The average number of pine engraver beetles (IPS PINI) captured and the average daily high temperature, in degrees Celsius, during each sampling week.*

| TRAP | LOCATION DESCRIPTION | LEADING SPECIES | WINDTHROW SEVERITY | TOTAL # NORTHERN SPRUCE ENGRAVERS | TOTAL # SPRUCE BARK BEETLES | TOTAL # PINE ENGRAVERS |
|---|---|---|---|---|---|---|
| **1** | North Klondike Highway km 224 | Lodgepole Pine | severe (>= 30%) | N/A | N/A | 406 |
| **2** | Deep Creek South Road near creek | White Spruce | severe (11-29%) | 55 | 3 | N/A |
| **3** | Deep Creek South Road field | White Spruce | light (1-10%) | 72 | 1 | N/A |
| **4** | Deep Creek South Road east end | White Spruce | mod. (11-29%) | 3 | 1 | N/A |
| **5** | North Klondike Highway km 223 | Lodgepole Pine | severe (>/= 30%) | N/A | N/A | 181 |
| **6** | Jackfish Bay powerline south | Lodgepole Pine | light (1-10%) | N/A | N/A | 366 |
| **7** | Jackfish Bay near point | White Spruce | mod. (11-29%) | 93 | 0 | N/A |
| **8** | Jackfish Bay powerline north | Lodgepole Pine | severe (>/= 30%) | N/A | N/A | 321 |
| | | | **TOTAL** | 223 | 5 | 1274 |

**TABLE 4.** *Trap location and observations.*

### Beetle Probing

Windthrow trees were inspected for any signs of beetle attack (i.e. boring dust on bark), and brood development was assessed by checking beneath the bark. Observations of attack severity and stages of development were recorded and are as follows:

- Spruce bark beetle: No evidence of attack was observed in the wind throw area.
- Northern spruce engraver beetle: One mass attacked windthrow spruce tree was observed (Photo 32, 33). Examinations beneath the bark revealed mostly adults with one adult per attack site and no associated larval galleries. A few pupae and teneral adults (Photo 34) were observed and a pitch out e.g. failed attack, was observed on a single standing spruce tree (Photo 35). Teneral adults are young adults that have not formed their hard exoskeleton, hence are more vulnerable to the elements.
- Pine engraver beetle: No evidence of attack was observed within the wind throw area.

**PHOTO 32.** *Boring dust on a windthrown white spruce attacked by northern spruce beetle, near trap 7 location.*



**PHOTO 33.** *Ground crews assessing spruce windthrow.*

**PHOTO 35.** *Northern spruce engraver pitch out on standing spruce tree.*

**PHOTO 34**. *Northern spruce engraver newly emerged beetle e.g., Teneral adult (light brown) on a windthrown white spruce.*

## CONCLUSIONS

**Spruce–leading windthrow:** Given that there was only one wind thrown tree that was mass attacked by northern spruce engraver beetle, the immediate risk of significant population increase is considered low. This area has an abundance of suitable host material and it is likely that there are more attacks than observed.

**Pine-leading windthrow;** There was no evidence of pine engraver beetle within the windthrow. This area has an abundance of suitable host material and it is likely that there are more attacks than that observed.

### Next Steps

Monitoring of windthrow utilizing traps and beetle probing will continue for 2022. In addition, the forests adjacent to the windthrow areaswill be monitored for 'faders' to identify any attack which may have occurred on standing trees. Affected trees generally fade to yellow/orange within 12 to 18 months after attack.

# OTHER NOTEWORTHY DISTURBANCES IN 2021

As part of the forest health program, Forest Management Branch assists both the public and other government agencies in the identification of forest pests. This section includes those pests which are either mostly urban in their occurrence, or those observed on the ground. The reports cover pests and diseases that were not detected by aerial overview surveys, either because the disturbance was too small to be detected, or they were not within the Forest Health Zone monitored this year.

## Ambermarked birch leafminer
*(Profenusa thomsoni)*

This leafminer sawfly was introduced into the eastern United States and was first identified in 1923. Since then, populations have spread throughout North America. Most of the recorded outbreaks have occurred on ornamental plantings in urban settings with only light attacks on native birch within municipalities. Amber birch leafminer damage can be detected via aerial overview surveys with no detection recorded to date.

In 2021, outbreak levels of this leafmining sawfly were seen on native and ornamental birch throughout Whitehorse and Dawson City. The damage is caused by larvae feeding within the leaf (Photo 36) resulting in the formation of characteristic blotches (Photo 37). In the Yukon this leafminer was first recorded in 2003 in Dawson, where it was found infesting the leaves of native white birch, and on ornamental birch in Whitehorse and Watson Lake. Since that time, it has continued to cause light damage to birch at all three of these locations.


**PHOTO 36.** *Ambermarked birch leafminer leaf blotch and larva.*

**PHOTO 37.** *Light to moderate defoliation by ambermarked birch leafminer in Whitehorse.*



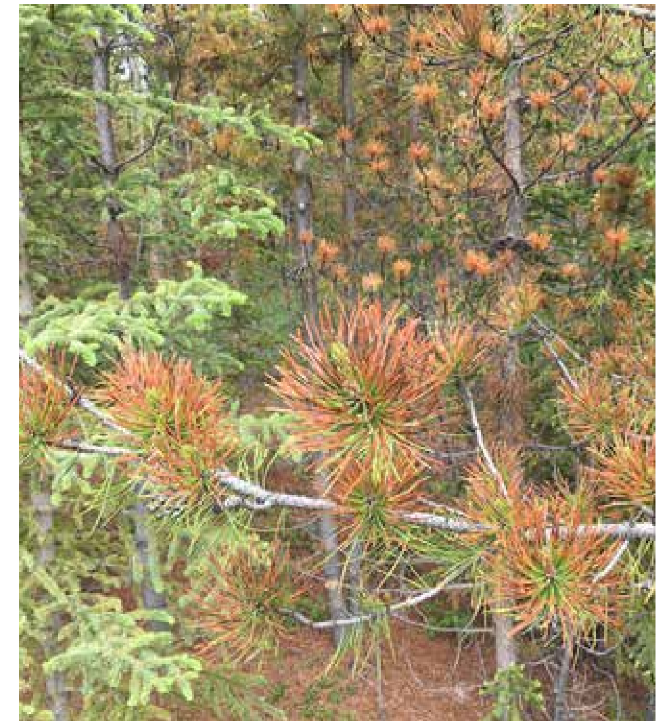


**PHOTO 38.** *Year-old red needles on pine cast infected tree(s).*

**PHOTO 39.** *Majority of the lodgepole pine stand is infected, displaying characteristic year-old red needles.*

## Pine needle cast
*(Lophodermella concolor)*

Pine needle cast is a common fungal disease of lodgepole pine. The disease infects the needles shortly after the spring flush. The following year the needles die and turn red. This characteristic feature is often masked by the new growth, thus challenging for aerial detection. A tell-tale sign of pine needle cast is the red year-old needles, prior to the current year's needles being fully flushed (Photo 38). 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. When pine needle cast outbreaks are severe, the entire stand is likely to exhibit symptoms (Photo 39 ). In most cases, the trees will recover and survive. However, repeated severe infections can reduce height and growth, and can cause some mortality.

In the spring of 2021, pine needle cast was noted throughout much of the host range in Yukon forests, however it was not mapped during aerial surveys as they occurred north of the range of lodgepole pine. No mortality has been noted as a result of these infections. The Forest Management Branch will continue to monitor this foliar disease as part of its risk-based approach to forest management.

## Flagging of Lodgepole Pine and Spruce

A common environmental effect on trees is branch "flagging", often associated with drought stress. These symptoms are commonly seen throughout Yukon affecting lodgepole pine and, to a lesser degree, white spruce. Flagging is a natural phenomenon associated with trees shedding their oldest needles to reduce the crown volume. Branch flagging is a natural response to drought, as trees lose moisture by the process of transpiration through the needles. This process is how trees draw water from the soil by capillary action to feed its living tissues. When moisture becomes limited, the tree sheds the older needles first in favour of new ones, which gather and process light energy more efficiently from the sun. Discolored foliage e.g. red, yellowish, orangish depending on species, is generally visible in the latter part of the summer prior to the needles being shed.

Trees affected by flagging and pine needle cast both exhibit reddening foliage. Examining the age of affected needles is used to properly diagnose the causal agent. Trees exhibiting flagging will exhibit red old needles (closest to the trunk); conversely, trees affected by pine needle cast will display red new needles (furthest from the trunk).

In 2021, flagging was seen on both pine (Photo 40) and white spruce (Photo 41). Public reports of spruce flagging were observed in the later part of August. No mortality was associated with flagging; these trees typically recover from this stress condition.

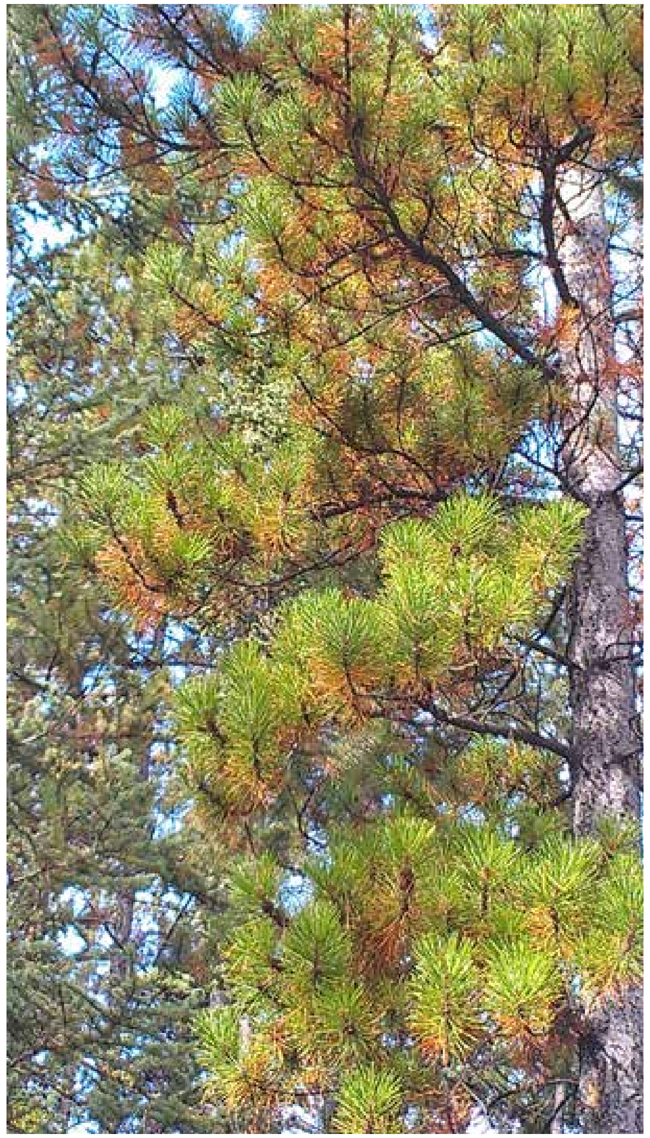


**PHOTO 40.** *Typical late summer "flagging" in lodgepole pine. Note similar to pine needle cast, however the red needles are the oldest needles on the branch closest to the tree stem.*

**PHOTO 41.** *Branch flagging on spruce.*

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