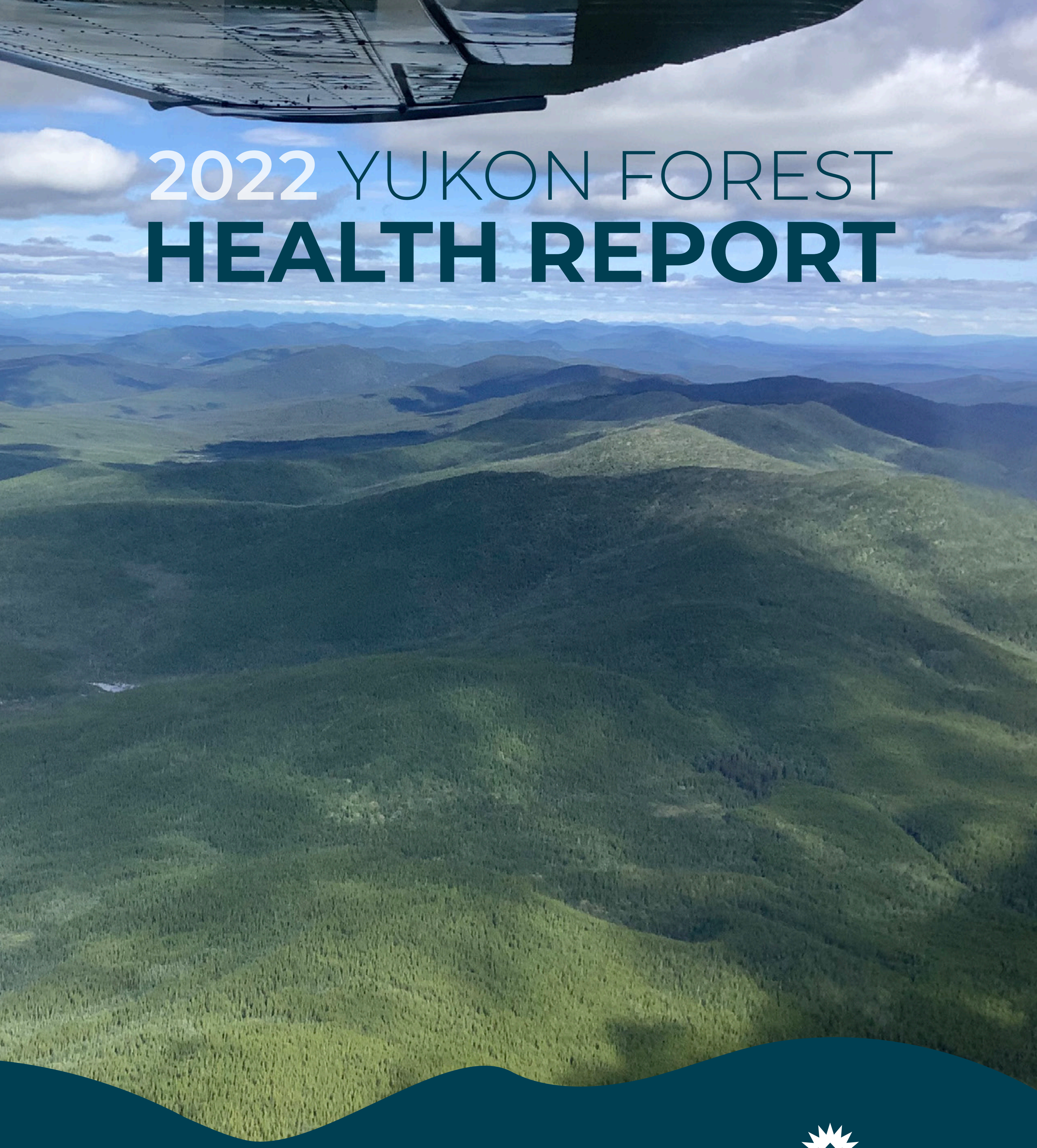
2022 YUKON FOREST HEALTH REPORT



Yukon

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TABLE OF **CONTENTS**

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

The Government of Yukon's Forest Management Branch manages Yukon forests for sustainability. A 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 *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 they relate 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 developed and adopted by the Forest Management Branch in 2009.

Yukon Forest Health Monitoring Strategy

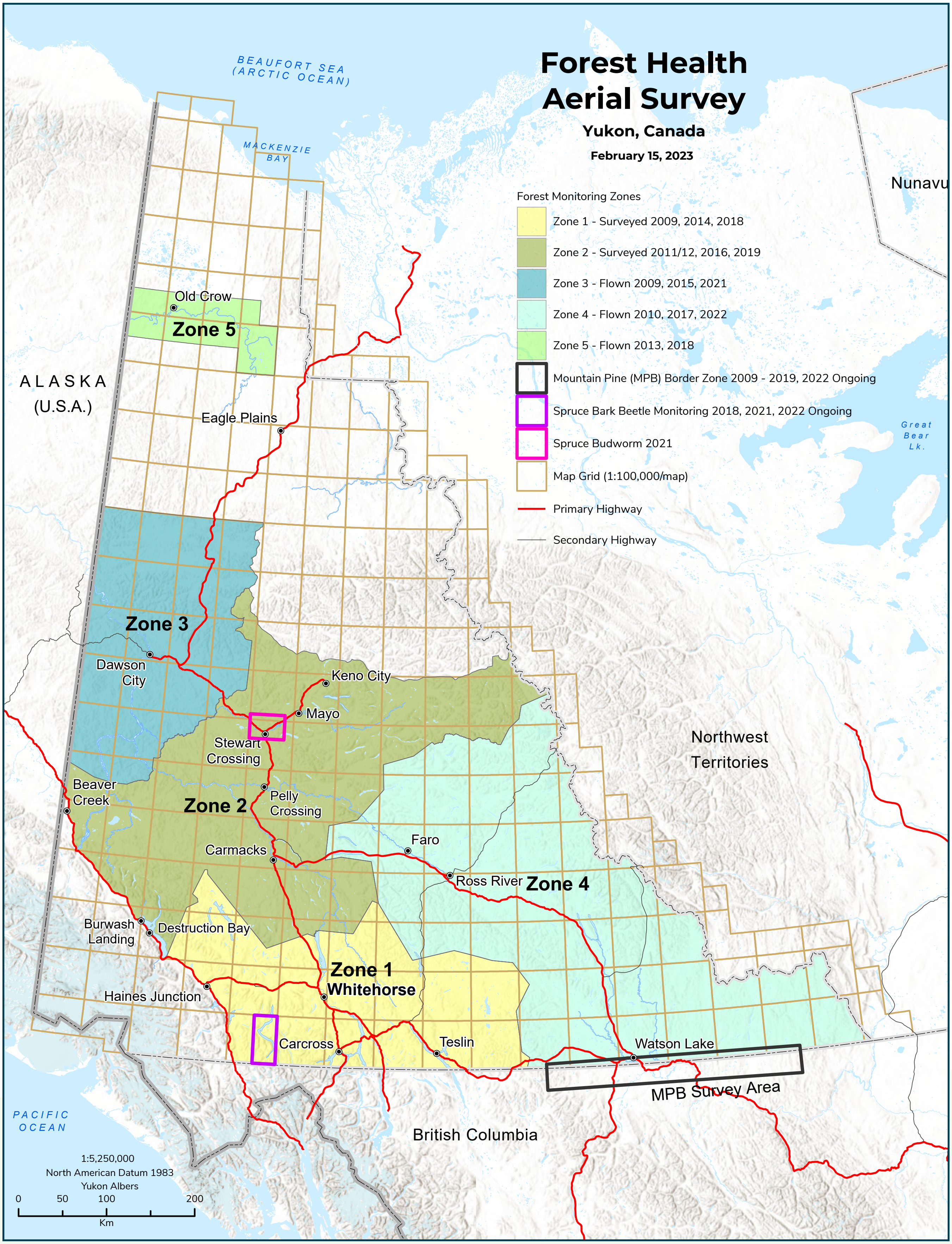
The Yukon Forest Health Monitoring Strategy focuses on forest insects, diseases and abiotic disturbances that pose the greatest risk to resource values of Yukon's forests. Since its implementation in 2009, the strategy has met the following priorities each year:

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 forest health specialists have completed aerial surveys in one of five zones. In 2022, forest health surveys focused on the Southeastern Yukon (FHZ 4).

The Forest Management Branch produces annual forest health reports that summarize the results of monitoring and related activities and draw on historical data to access population trends. This historical data lies in both the health reports and Forest Insect and Disease Survey (FIDS) 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 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.



MAP 1. *Yukon Forest Health aerial surveys by year (2009-2022).*

AERIAL SURVEYS AND GROUND TRUTHING AS THE PRIMARY TOOLS FOR MONITORING

Aerial overview surveys and ground field checks are relatively simple and low-cost method for effectively monitoring forest health over large areas. They are also adequate for regional and provincial summaries, and to meet national requirements for the Forest Health National Forest Pest Strategy.

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 aerial surveys. Forest Management Branch 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 seven kilometre (km) wide corridor (14 km gridlines).
- Fly aerial surveys on clear days with sunny skies.
- Aerial surveyors use digitizing tablets to 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, which is available for viewing here GeoYukon (**gov.yk.ca**).

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

In 2009, the Forest Management Branch determined the top 10 concerns that pose the greatest risk (i.e., extensive mortality or defoliation) to Yukon forests. These are being monitored through our 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 ha.

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

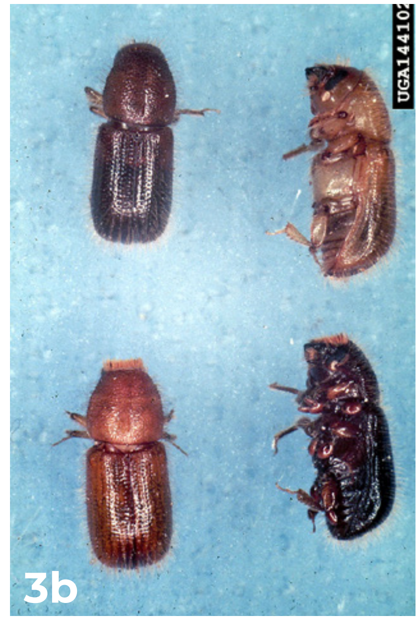
PHOTO 1b. *Adult spruce bark beetle.*

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 ha (Garbutt, 2013).

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, comprised 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 ha in the Yukon, primarily near Stewart Crossing. Historically, eastern spruce budworm damage has been mapped in the extreme southeast portion of the 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 leafmining 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 leafminer, 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 ha (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.*


6a


6b


7a


7b


8a


8b

For further information on these, and other Yukon Forest health disturbances, please refer to the **Yukon.ca/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**.

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 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 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 two-year old attack (red) and previous year attack (yellow-orange fading), Rocky Mountain Trench, British Columbia, 2012..*

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

10 Aspen decline

Aspen decline 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. Abiotic factors are contributing to decline and include drought, extreme weather events and microclimate effects. A retrospective spatial analysis of aspen decline in Yukon found a strong relationship between cumulative defoliation (large aspen tortrix, aspen serpentine leafminer) severity and aspen decline symptoms.

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

SUMMARY OF 2022
FOREST HEALTH INITIATIVES

The Forest Management Branch completed the following four initiatives in 2022:

COMPONENT 1:
Annual Forest Health Aerial and Ground Surveys

In 2022, four separate aerial surveys were undertaken to map Yukon forest disturbances as described in the Yukon Forest Health Monitoring Strategy (Map 1):

1. Six-days in Southeastern Yukon, Forest Health Zone 4 (FHZ 4) for annual monitoring and detection of forest health disturbances.
2. Half day survey of timber harvest areas in Haines Junction to assess presence of spruce bark beetle or northern spruce engraver beetle, and map aspen defoliators.

COMPONENT 2:
Proactive Management of Mountain Pine Beetle

The Forest Management Branch continues to take a proactive approach to monitor 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, the Branch decided to discontinue border monitoring based on the decision matrix in the Monitoring Strategy. Monitoring the border zone resumed in 2022, based on the unconfirmed 2021 British Columbia aerial survey results which were reported in the 2021 Yukon Forest Health Report: four unconfirmed MPB spots were found, totalling 12 trees in the border zone.

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

Forest Management Branch 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). Three special projects were undertaken in 2022, and all 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.
3. Half day aerial survey for the ongoing monitoring of spruce beetle in Kusawa Lake area in Forest Health Zone 1 (FHZ 1).

COMPONENT 4:
Pest Incidence Reporting

The Forest Management Branch 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

Annual Monitoring of Forest Health Zones

In 2022, forest health surveys focused on biotic and abiotic disturbances in the Southeastern Yukon Region (FHZ 4). Six days were required to conduct aerial surveys over FHZ 4: one in mid-July and five in mid-August. A Cessna 206 fixed-wing aircraft was flown in a mostly east-west grid pattern with 14 km between grids, allowing each surveyor to map seven km on either side of the plane (Map 2). The survey was based out of Whitehorse and Watson Lake.

The largest of the forest health zones is FHZ 4. It is bound by two borders: Northwest Territories (NWT) to the east and British Columbia to the south. To the west it is bound by the Cassiar Mountains, heads north to Ings River, west to Quiet Lake/ Salmon River, north to Little Salmon Lake, and then northeast to Hess River and eastward to the NWT border. Its most northerly point is 63° 48'. It falls mostly into the Boreal Cordillera ecozone but also includes Taiga Cordillera ecozone.

Other Proactive Monitoring

1. A half day survey was undertaken to monitor and map spruce beetle in the Kusawa Lake area. In 2018, annual surveys detected over 1,000 ha of spruce beetle attack along the shores of the southern portion of Kusawa Lake. Since then, annual surveys have been undertaken to monitor the progression of the infestation.

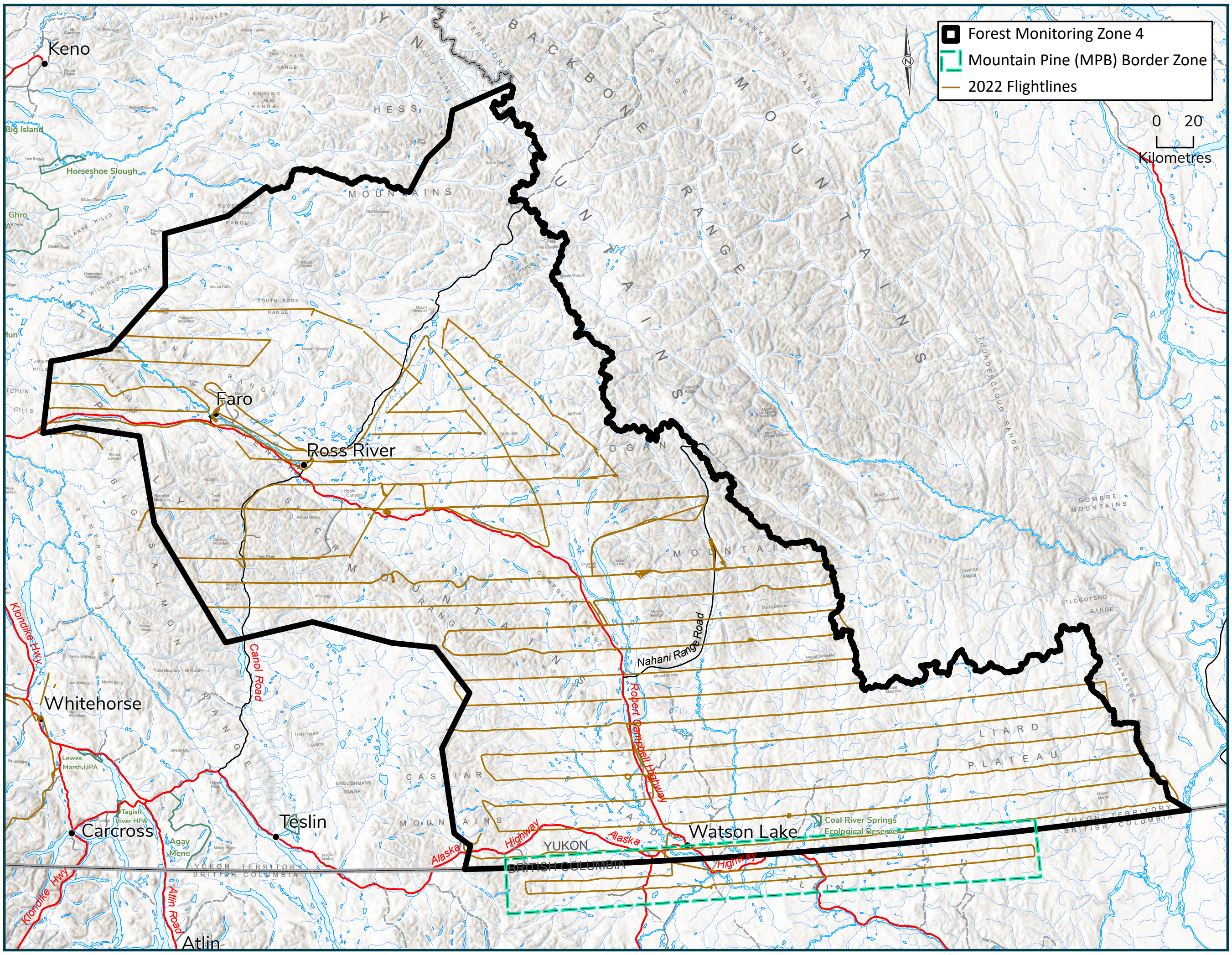
2. A half-day survey was undertaken along the highway corridor from Whitehorse west to Haines Junction, for two purposes:

   1.) monitor for the presence of spruce beetle or northern spruce engraver beetle in the timber harvest areas in Haines Junction, and

   2.) map any aspen defoliators or other disturbances in the highway corridor along the way.

3. A half-day survey to detect and map mountain pine beetle in the BC/Yukon monitoring zone.

Two person aerial survey crew and extended Cessna 206.



MAP 2. *Aerial survey flight lines in 2022 over forest health zone 4.*

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 ratio and hence the incidence, severity and frequency of pest outbreaks. Trees can be impacted by adverse environmental conditions such as flooding and fire. 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.

2022 YUKON WEATHER SUMMARY

The following summarizes Yukon temperature and precipitation for the period October 2021 to August 2022 and is depicted in Figure 1.

October-December 2021 | Fall and early winter: Fall began with temperatures near seasonal normals and dry conditions in southern Yukon. Stormier weather arrived in November and while temperatures remained close to normal, precipitation through much of central and southeast Yukon was well above normal, ranging from 150% - 330%. December was notable both for widespread snowfall across the Yukon (150% - 390%) but also for several intrusions of Arctic air throughout the territory. This cold air was the cause of much of the snowfall, and also dragged temperatures to near 5°C below normals for the month.

January-March 2022 | Late winter and early spring: The new year began with a short-lived Arctic outbreak and a continuation of above normal snowfall in all but south-central Yukon. Heavy snowfall continued in February, accompanied by much warmer southern air that created temperatures as much as 7°C warmer than normal for the month. By the end of March there was four and a half times as much snow as normal, contributing to a record-breaking snowpack in many areas of the territory.

April-June 2022 | Spring and early summer: Spring did not come early in 2022, with the snowfall continuing in southern Yukon, thanks in part to persistent cool Arctic air that kept conditions several degrees colder than normal. Northern and central regions received a reprieve from snowfall while the south continued to accumulate snow until late in April. May and June could best be described as "unsettled" due to frequent showery or rainy conditions. Most of the territory saw above normal rainfall and near-normal temperatures leading into mid-June. The end of June marked seven months of above normal snow and rainfall across almost the entire territory and brought with it hot and dry temperatures to start the climatological summer.

July-August 2022 | Summer: Warm and dry conditions persisted through mid-July, until a persistent upper ridge was finally knocked out of place by a series of storms pushing in from the coast. While temperatures were unexceptional, most of the Yukon received well above normal rainfall in July and again in August. The exception to this wet trend was southeast Yukon including Watson Lake and Ross River, which remained warm and dry into September.

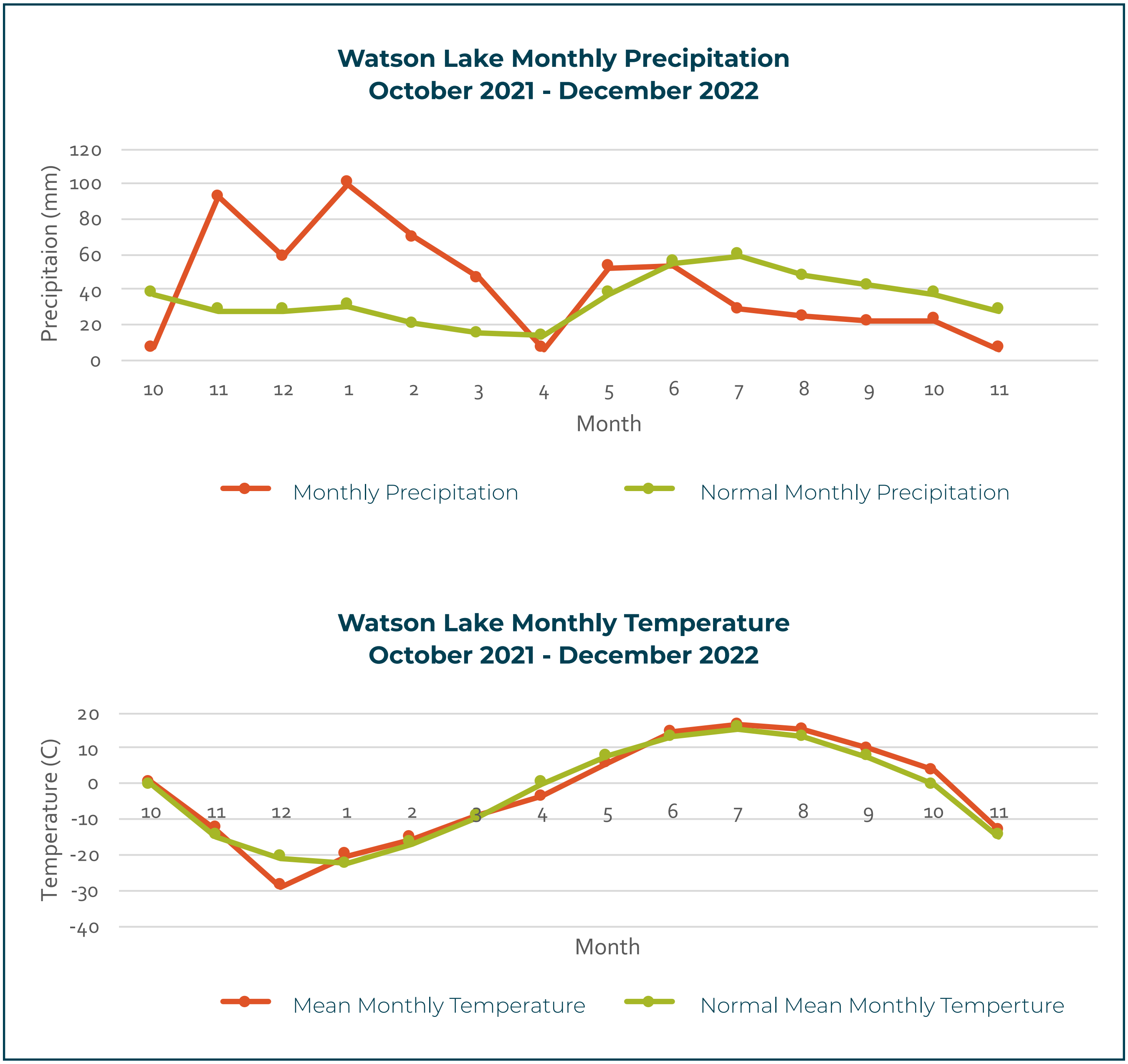


FIGURE 1. *Monthly mean precipitation (top) and temperature (bottom) from October 2021 to November 2022, compared to normals (1981-2019) for Watson Lake.*

SUMMARY OF 2022 **BIOTIC** AND **ABIOTIC DISTURBANCES**

The southeastern Yukon region (FHZ 4) was surveyed in 2010 and 2017, making it possible to assess trends over time by comparing pest activity in these years (Table 1). As noted on page 10, two areas in FHZ 1 were also aerially monitored; the Kusawa Lake area and the highway corridor from Whitehorse west to Quill Creek including timber harvest areas near Haines Junction. This is the third year that the Kusawa drainage has been assessed since spruce beetle was first detected in 2018. The aerial surveys in the Whitehorse/Haines Junction highway corridor have been ongoing for a number of years to assess and map aspen defoliators. In 2022, this survey was extended to include the timber harvest area near Haines Junction to detect and map any bark beetles e.g., spruce beetle or northern spruce engraver beetle. All forest health factors mapped en route to Kusawa Lake or Haines Junction (in FHZ 1) are included in Table 1.

Aerial view of Liard Plateau near NWT border (FHZ 4).

	FHZ 1			FHZ 4		
DISTURBANCE TYPE	**2019**	**2021**	**2022**	**2010**	**2017**	**2022**
Biotic						
Aspen serpentine leafminer		4,705	2,066	53,085	94,390	46,076
Aspen serpentine leafminer/ large aspen tortrix			13,242			
Large aspen tortrix		1,760	760		7,106	335
Large aspen tortrix/ aspen serpentine leafminer						61
Eastern spruce budworm					369	
Spruce beetle	709 (old)	1,394 (old with <1% current attack)	1,677 (<1 % current attack)			344
Northern spruce engraver beetle			0.25			3,097 (<1% current attack)
Western balsam bark beetle				607	10,625	1,145
Cottonwood leaf rust					187	
Willow blotch miner					442	323
Willow leaf rust					1,075	
Abiotic						
Winter wind desiccation				873		200
Slide				278		
Flooding			127	506	238	274
Site-related						0.5
Windthrow		914 (old and new)		51	661	
Lightning				1		
Bear					46	7
Pest Complexes						
Aspen decline				11	62	479
Aspen serpentine leafminer/ aspen decline			6,601			6,109
Large aspen tortrix/aspen decline						875
Porcupine/pine engraver beetle		0.5	1.5	1	18	1,406
Windthrow/pine engraver beetle		118	150 (old)			

TABLE 1. *Hectares affected and history of forest health disturbances recorded in FHZ 4 in 2010/2017/2022, and a small portion of FHZ 1 where special surveys were conducted.*

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. The leafminer's activity was first recorded in the early 1950s along the Alaska Highway. Current outbreaks in Alaska and the Yukon have affected hundreds of thousands of ha 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 the 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 this finding, there is speculation 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). A warmer and drier climate increases vulnerability to defoliators (Woods et. Al. 2022) as it assists in the initiation or 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).

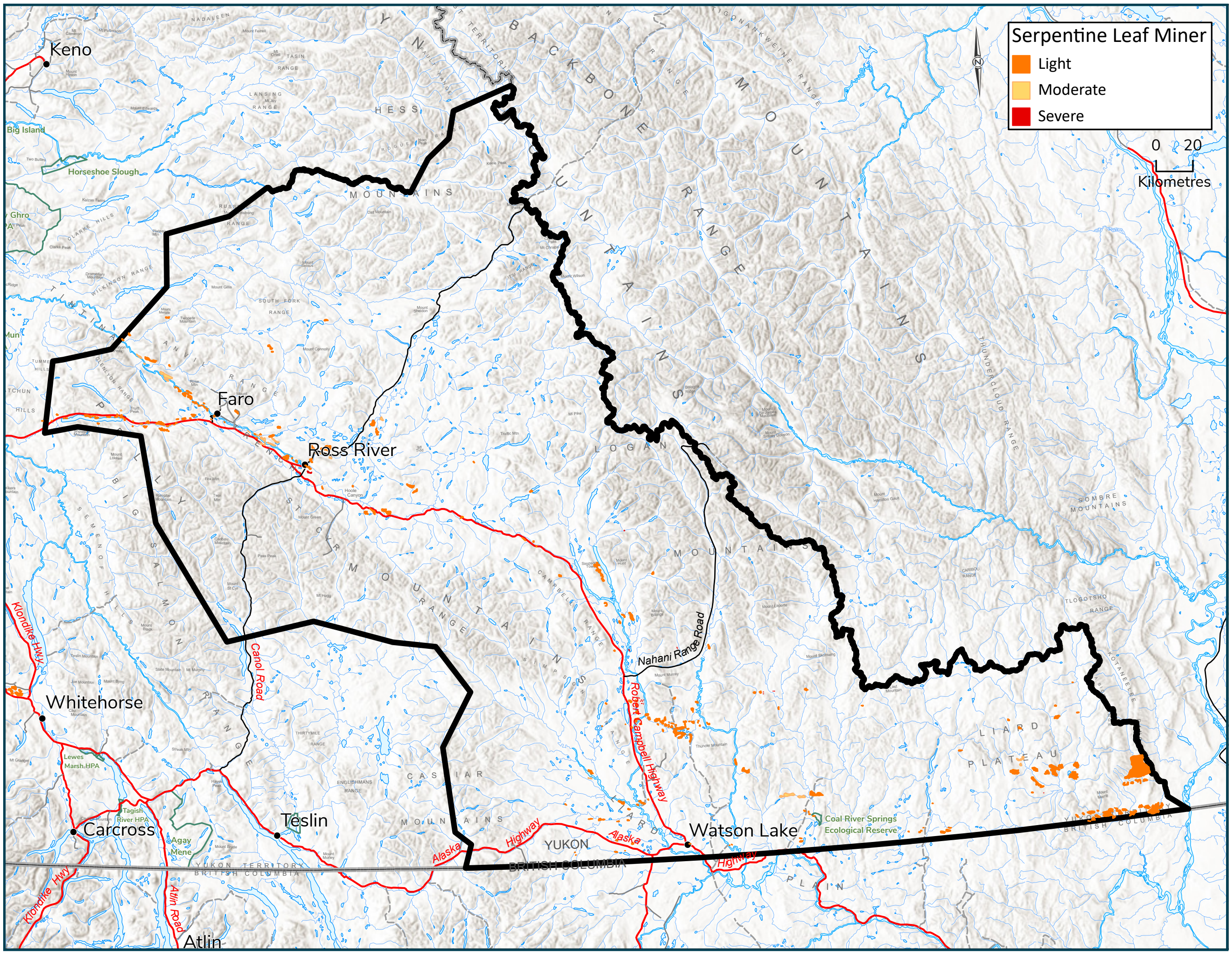
STATUS IN 2022

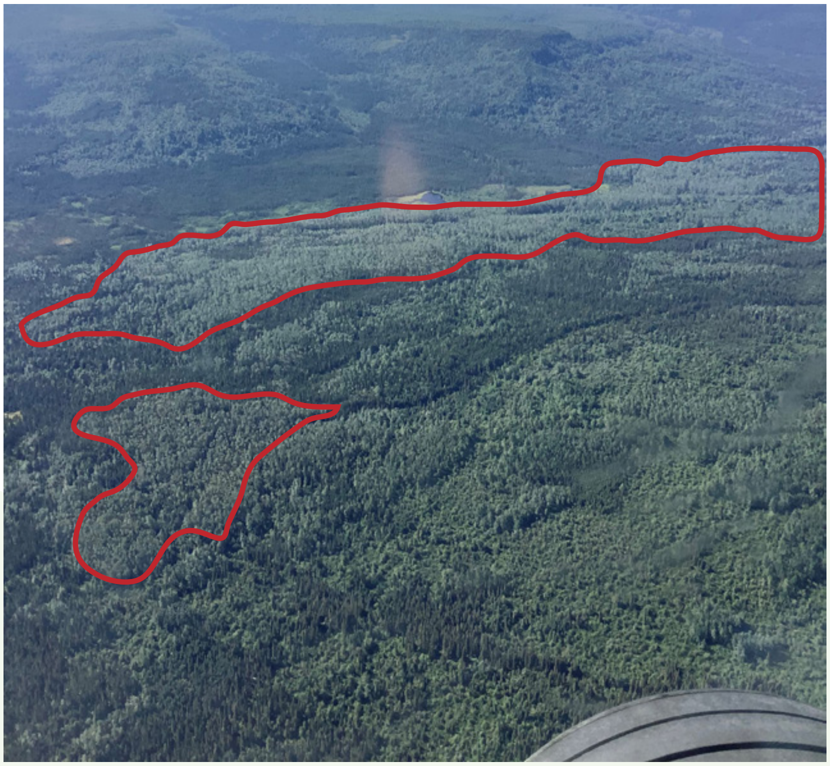
In 2022, in FHZ 4 the area infested with aspen serpentine leafminer, including in combination with aspen decline, decreased by almost half to 52,246 ha from 94,390 ha in 2017, and similar to 2010 when 53,085 ha were mapped (Map 3). Only 12% was associated with aspen decline, down from 2017, when 54% was associated with aspen decline and large aspen tortrix.

The characteristic silvery leaves are indicative of aspen serpentine leafminer (Photo 11). It was noted in the northern portion of FHZ 4 north of Faro along the Pelly River to Ross River and near Little Salmon Lake, in the central portion between Frances Lake and Stewart Lake, and in the south near the NWT and BC border along and near the Beaver River (Map 3). Smaller infestations were mapped between Ross River and Francis Lake, near Rancheria River, Liard River and Albert Creek, and between Hyland River and Coal Creek. The majority of aspen decline in association with aspen serpentine leafminer was mapped near the NWT border, and in the north (near Ross River), in areas with a history of large aspen totrix leafminer damage.

In FHZ 1 there was a significant increase to 21,909 ha from 4,705 ha in 2021, 91% of which was in combination with large aspen tortrix or aspen decline. All areas were mapped along the Whitehorse-Haines Junction corridor.

The Yukon aspen serpentine leafminer has been present every year for the last two decades with variation in annual levels, severity and extent. Given its prevalence and persistence in many stands it is suspected to be contributing to aspen decline.





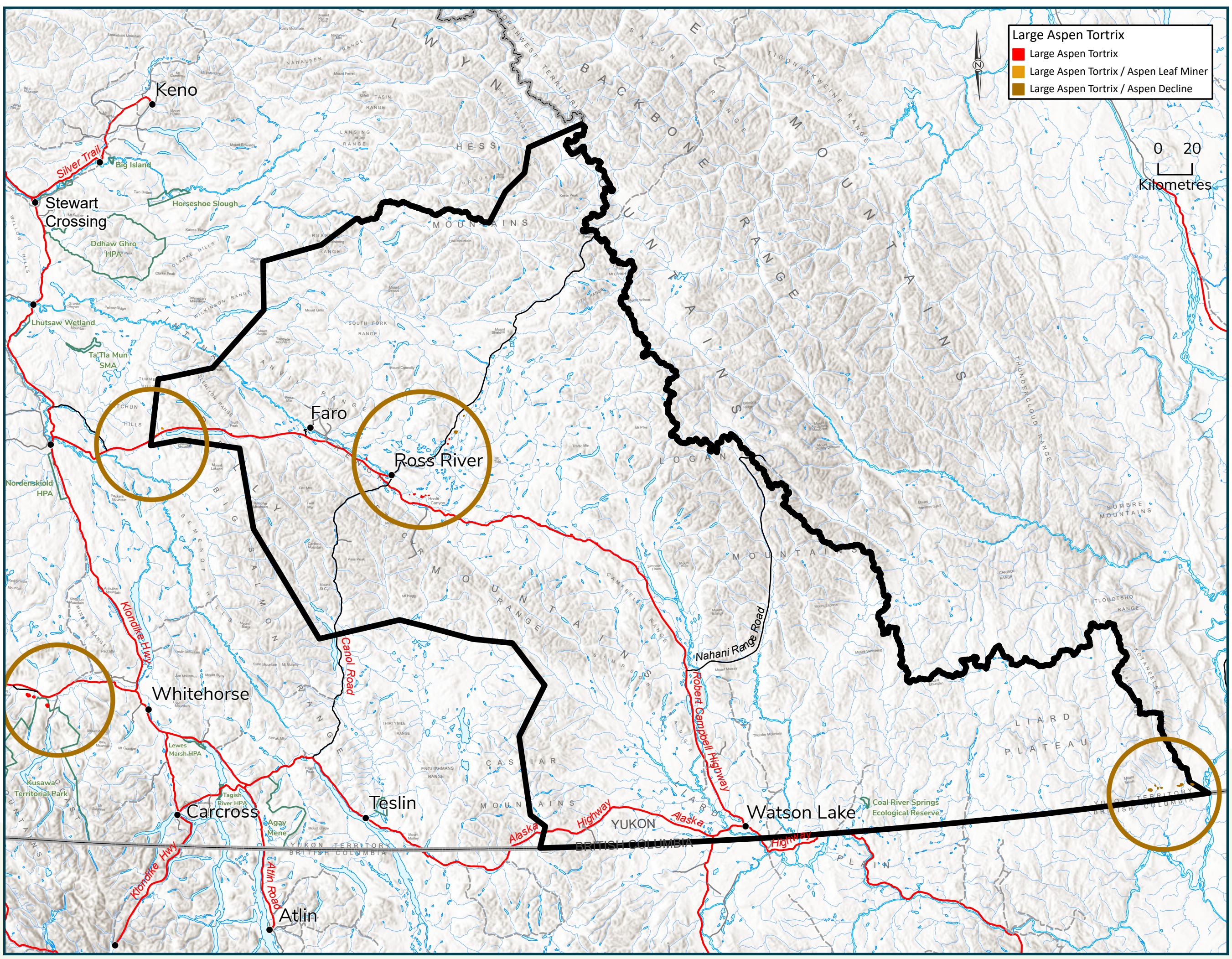
MAP 3. *Extent of aspen serpentine leafminer in FHZ 4, 2022.*

PHOTO 11. *Characteristic silvery leaves caused by aspen serpentine leafminer, Liard Plateau near the NWT border (FHZ 4).*

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 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 and 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 ha of defoliation was recorded in 2018 in the Whitehorse-Haines Junction corridor.



MAP 4. *Extent of large aspen tortrix defoliation in FHZ 4, 2022.*

STATUS IN 2022

Similar to aspen serpentine leafminer, the area defoliated by large aspen tortrix in FHZ 4 decreased significantly to 1,271 ha (Map 4) from 7,106 ha in 2017 (Photo 12). The majority, 68% was in association with aspen decline, and 5% with aspen serpentine leafminer. In the north, defoliation occurred near Little Salmon Lake and Ross River, and in the south near the NWT/BC border.

In FHZ1 the area defoliated decreased to 760 ha from 1,760 ha in 2021, all near Mendenhall.

PHOTO 12. *Pinkish hue of defoliated trees characteristics large aspen tortrix damage, near Champagne, in FHZ 1.*

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 recently downed trees, green slash from logging and land clearing, decked timber and dying or stressed trees, occasionally causing 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 ha 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 ha) 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 ha of mortality. The beetle then moved into public land and First Nations Settlement Land 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 and Reserve. During the outbreak more than half of the mature spruce were killed over approximately 400,000 ha.

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

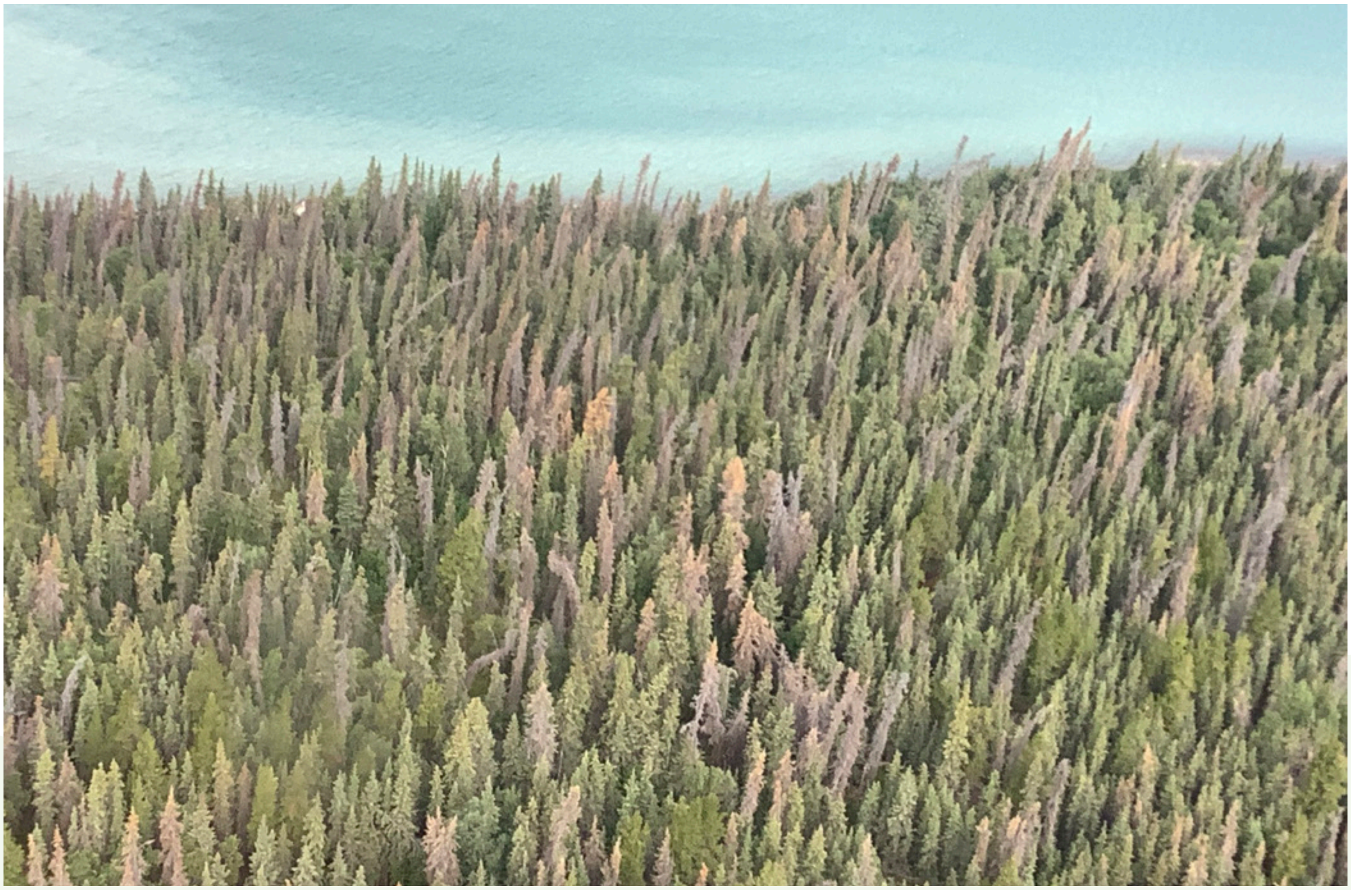


PHOTO 13. *Multiple generations of spruce beetle near Kusawa Lake; yellow-orange trees are 2021 attack, reddish and grey trees are older attack.*

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 (Photo 13, Photo 14). Dull red trees are three-year old attacks 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 2022

In 2022, new infestations totaling 344 ha were mapped in the southern portion of FHZ 4. Six polygons of light* to moderate* levels of mortality were mapped, ranging in size from 28 ha to 97 ha, and 44 spots* of mortality. Five polygons were northwest of Watson Lake (Map 5), and one polygon was near the NWT border along the Labiche River (Map 6). Elsewhere, spots were scattered in the southern portion of the FHZ 4, within 30 km of the BC border.

There is very little history of spruce beetle activity in FHZ 4. Some activity was spotted near Watson Lake/Upper Liard in 1957-1958, Little Salmon and Quiet lakes in 1980, and one observation of scattered light attack in the La Biche River Valley in 1985. In 2017, the Yukon Forest Management Branch conducted ground assessments east of Watson Lake following a wind throw event to assess spruce bark beetle risk. No spruce bark beetle was noted during the ground assessments.

A spruce beetle outbreak has been ongoing since 2014 in northeast BC with ground assessments indicating a portion of the populations completing their cycle in one-year, rather than two. Warming climate could be contributing to longevity of the outbreak. Recent research supports the notion that warming climate is the main factor responsible for spruce beetle outbreaks due to amplified beetle life cycle, and that drought has played a secondary role (Petit et al 2020).

Ongoing monitoring of the spruce beetle infestation at Kusawa Lake (FHZ 1) showed 1,677 ha of mostly old attack (Map 7), up slightly from 1,394 ha in 2021. Only 212 ha had trace levels of new infestation, while the remainder were in previously infested stands (i.e., with red (recent attack,) and grey (older attack) trees). Although the ratio of old to new infestation continues to be low in the Kusawa Lake area, the Forest Management Branch will continue to manage forest health proactively. This will include ongoing monitoring. The Haines Junction region continues to show low levels of spruce beetle infestation.

* light: 1-10% of trees
moderate: 11%- 30% of trees
spot: 1-30 recently killed trees

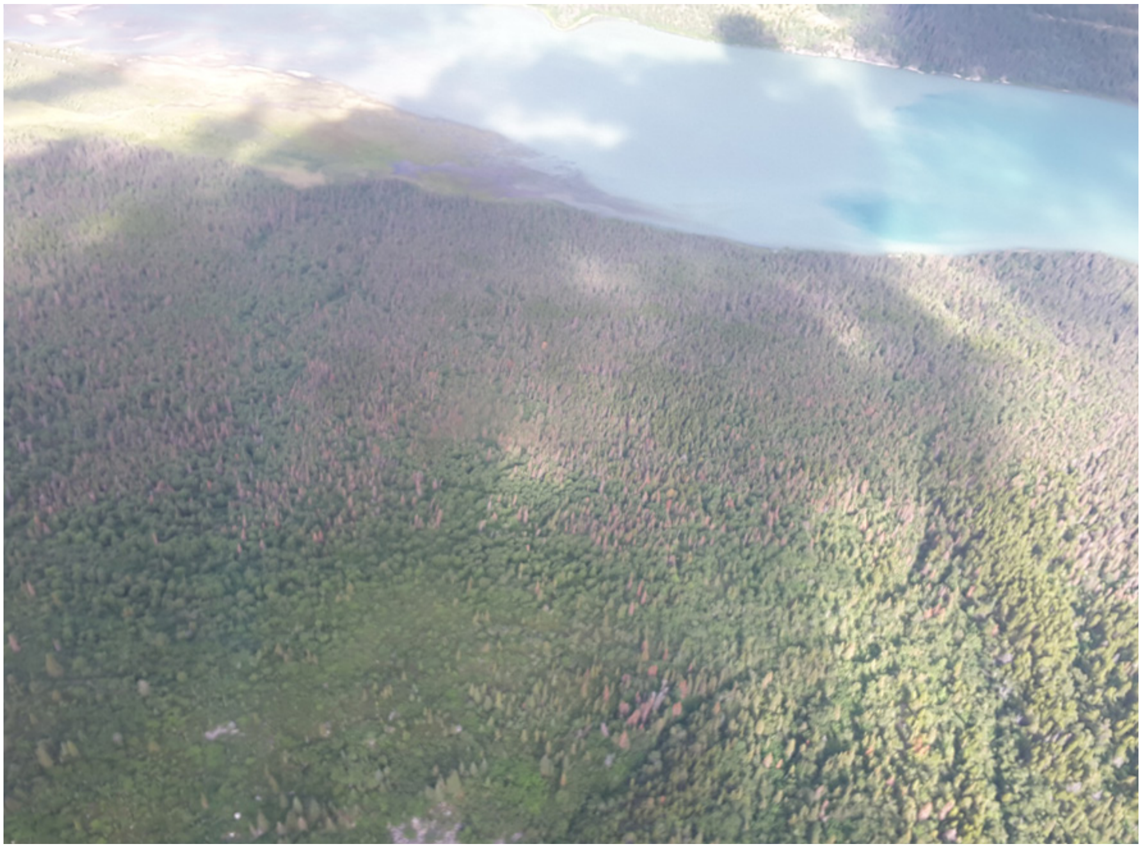
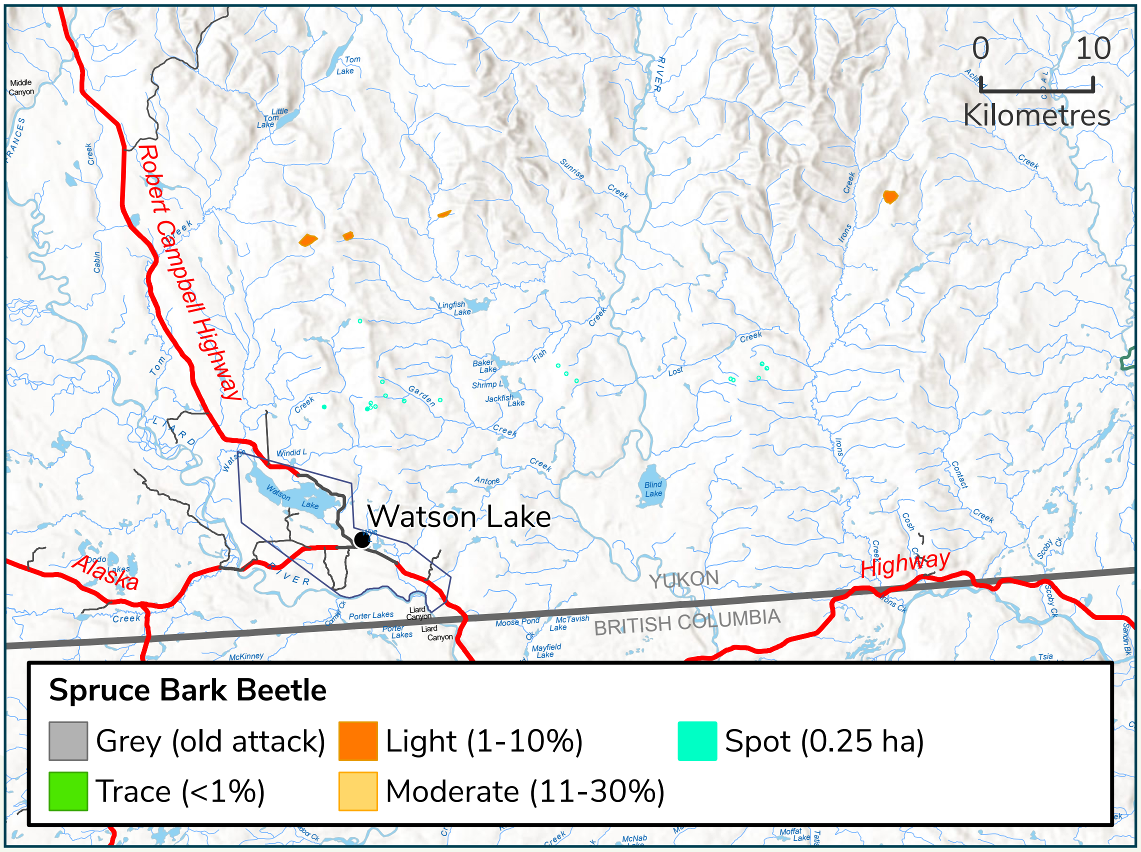
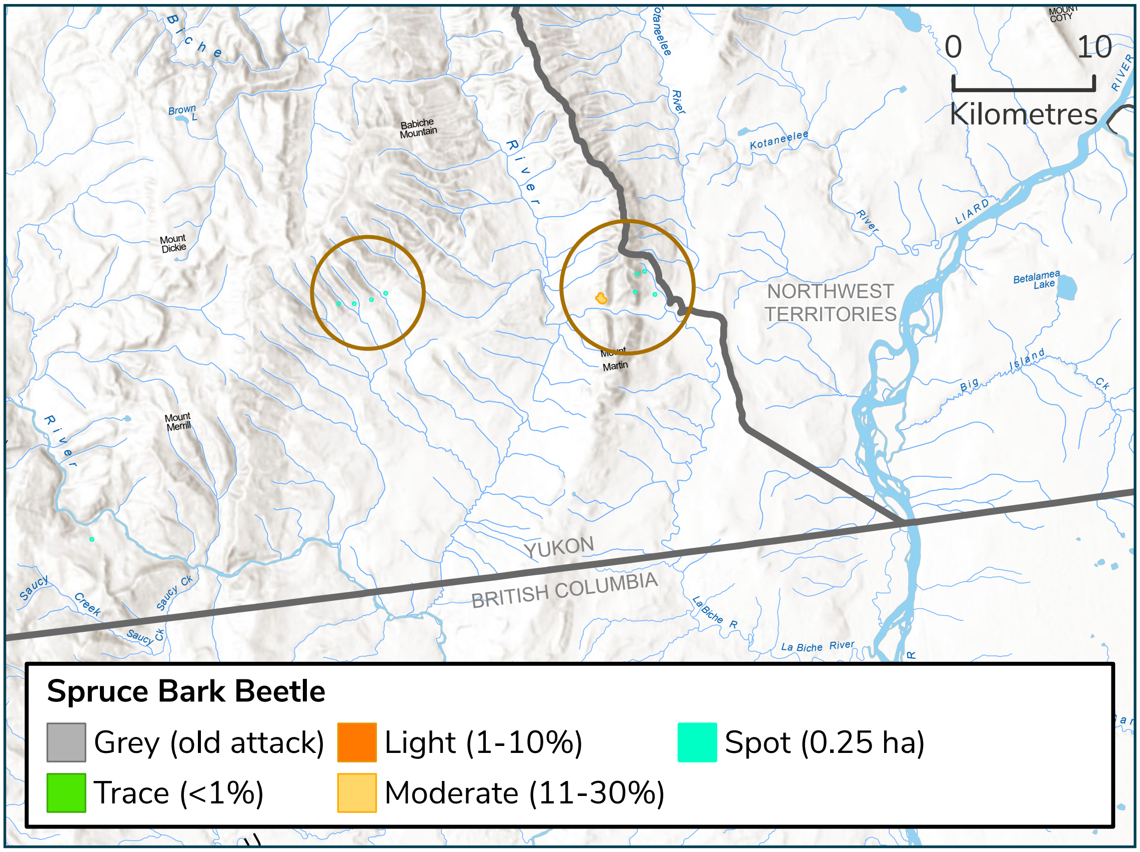


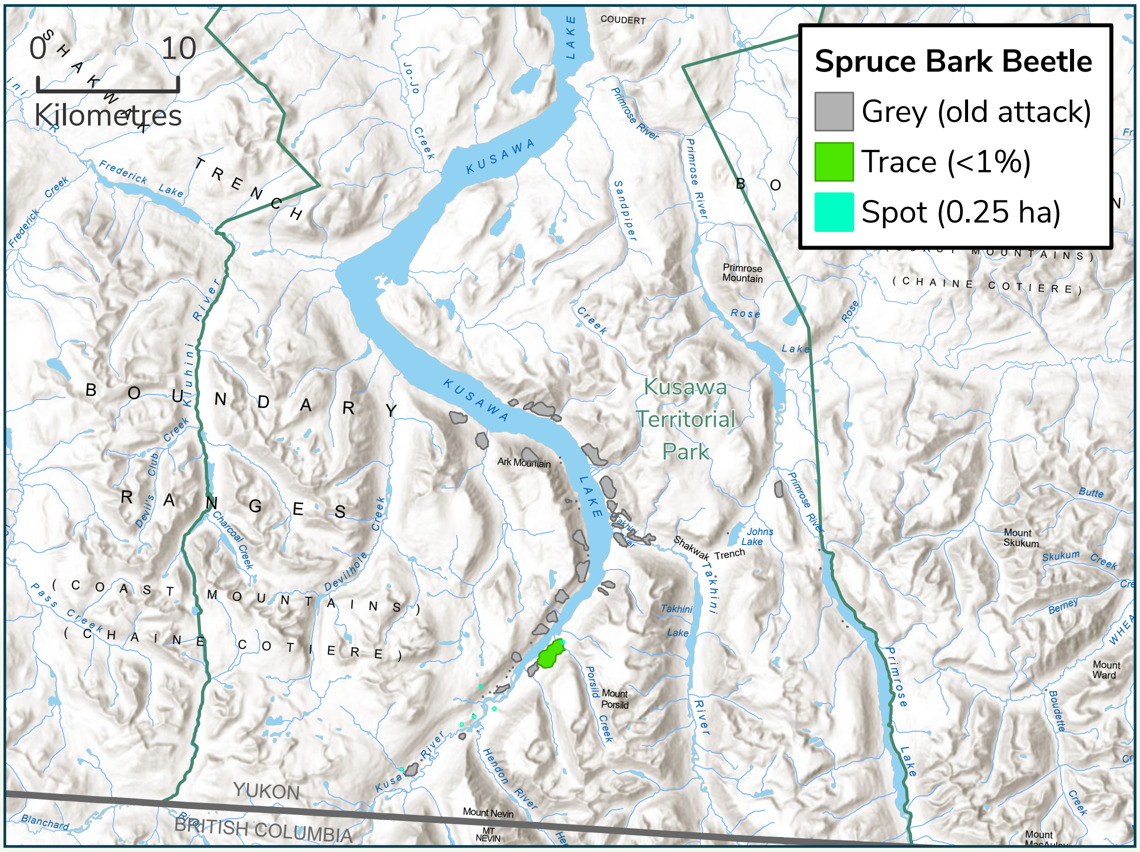
PHOTO 14. *Spruce beetle-caused mortality along Kusawa Lake; mostly reds and greys.*



MAP 5. *Spruce beetle infestations, NE of Watson Lake.*



MAP 6. *Spruce beetle near the NWT border, along the Labiche River.*

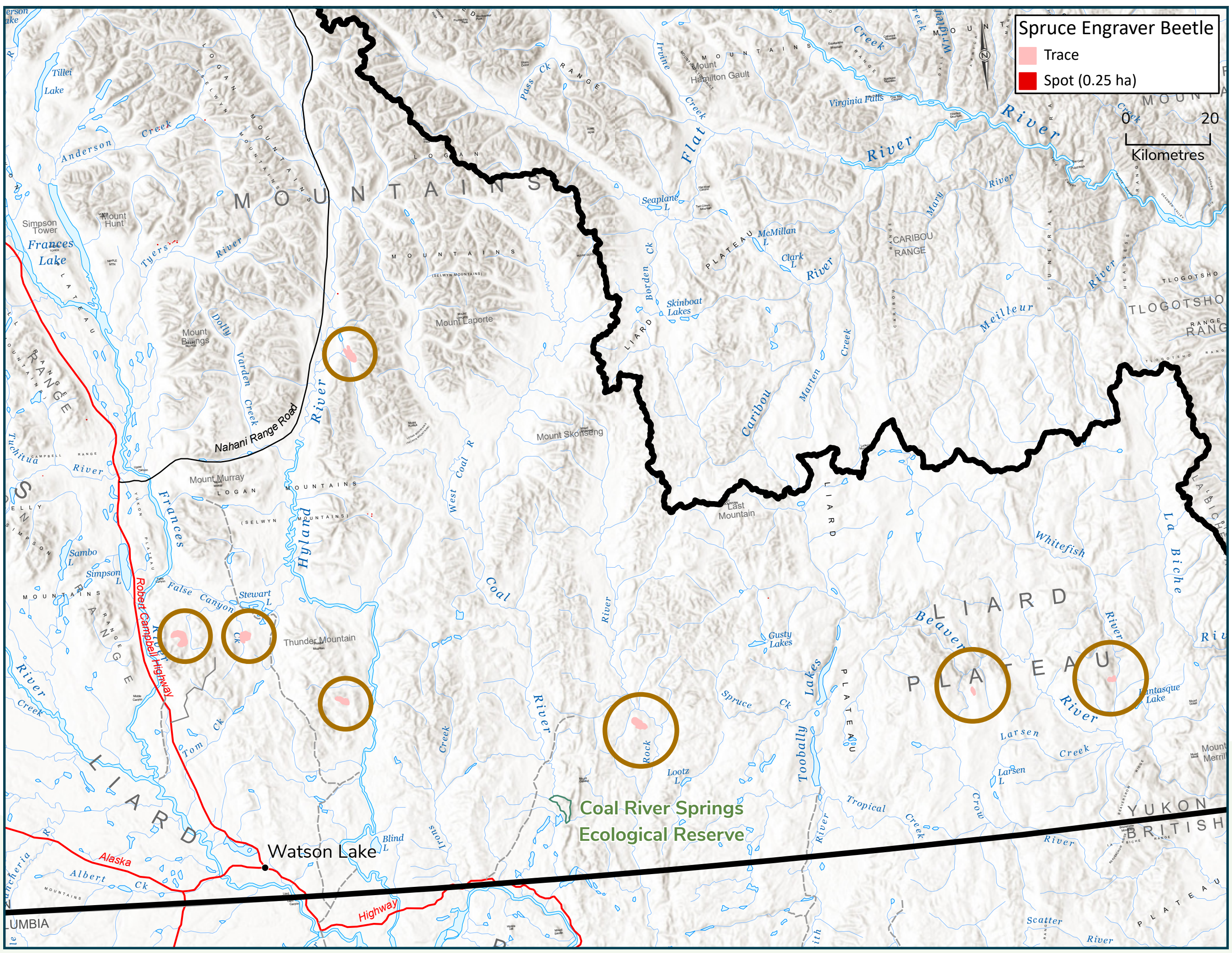


MAP 7. *Spruce beetle in the Kusawa Lake area, 2022.*

Northern Spruce Engraver Beetle (*Ips perturbatus*)

The northern spruce engraver beetle is the second most important bark beetle affecting Yukon forests and is common throughout the range of its white spruce host. In the past they have often been found during outbreaks of spruce beetle attacking the tops of spruce beetle-attacked trees. In the previous Haines Junction infestation, they were observed in spruce beetle-infested trees near the beginning. As the infestation continued engraver beetle populations steadily increased until the year 2000 when they started to kill trees independently. This occurred especially in young stands where the smaller trees were not attractive to the spruce beetle. At its peak in 2008, it infested over 3,000 ha, and by 2010 had collapsed with only scattered roadside mortality noted.

Spruce engravers are successful in smaller trees because they complete their life cycle in a single season instead of the two seasons (normally) required for spruce beetle. In fact, they spend only a few months inside the tree. The reminder of the year, generally from August until late May or early June of the following year, they hibernate in the duff. In the spring they fly between late May and mid-June as soon as the duff warms to 15° C, so they normally fly just before or during the spruce beetle flight period.



MAP 8. *Areas where northern spruce engraver beetle was observed in 2022.*

STATUS IN 2022

In 2022, old and new white spruce mortality attributed to northern spruce engraver beetle (*Ips perturbatus*) was mapped during aerial surveys in seven separate polygons totalling 3,097 ha, a notable increase from 2017 and 2010 when none were recorded (Map 8). These is also a possibility that spruce beetle may be present but given the scattered spot signature it is more than likely northern spruce engraver beetle. The polygons contained trace (<1%) levels of mortality and ranged in size from 120 ha to 802 ha, some in association with high water levels or flooding (Photo 15). The large area infested is an artifact of mapping larger trace (<1% recently killed trees) polygons rather than numerous spots (1-30 recently killed trees).

PHOTO 15. *Suspected northern spruce engraver beetle mortality in association with high water levels or flooding in FHZ 4.*

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

Over the last 30 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 ha of light* 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.

As the climate continues to warm it is anticipated that western balsam bark beetle will continue to move northward and potentially spread throughout the range of sub-alpine fir in Yukon forests.

STATUS IN 2022

In 2022, a significant decrease in the infested area occurred; from 10,265 ha representing 98 locations in 2017 to 1,145 ha over 73 locations, most of which were in the southern portion of FHZ 4. The vast majority were spot infestations (Photo 16), with six trace* polygons ranging in size from 18 ha to 220 ha. Similar to the northern spruce engraver beetle, the large area is likely a result of the practice of lumping spots into a large polygon rather than mapping individual spots. Polygon infestations were noted near McNeil, Hasselberg, Simpson and Stewart lakes, and spots noted in previously infested areas in southwest Yukon. There was no further northward advancement from those previously recorded from 2009-2017.

Willow Blotch Miner (*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 2013).

STATUS IN 2022

In 2022, populations were down slightly from 442 ha to 323 in 2017 with small polygons noted in the north near Big Salmon River and Wolverine Lake, and in the south near Lost Mountain and Coal Creek.

* light: 1-10% of trees
trace: <1% of trees

PHOTO 16. *Spot infestation of western balsam bark beetle in FHZ 4.*

ABIOTIC DISTURBANCES

Winter wind desiccation

Winter wind desiccation also known as winter drying, generally occurs on one side of the affected trees. The physiological mechanisms linked to these environmental effects are not yet understood (Hadley and Smith 1983). One suggested cause is unusually thin needle cuticles (the waxy coating on the surface of the needles), due to the short growing seasons on high elevation sites. Another is cuticle abrasion by wind and blowing snow, both leading to reduced resistance to moisture loss (Hadley and Smith, 1983). Whatever the mechanism, it seems clear that moisture loss on frozen ground is the main cause of needle death.

STATUS IN 2022

In 2022, one trace* polygon totalling 200 ha was mapped on white spruce near the NWT border in the south near Rock and Caribou rivers. In 2010, discolored sub-alpine fir was mapped over 873 ha in high elevation stands in the Pelly Mountains, south of Faro.

Flooding

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).

STATUS IN 2022

In 2022, in FHZ 4 flooding was recorded in 29 different locations totaling 401 ha, up from 238 in 2017. The largest, 147 ha, was observed in a white spruce stand near Coal Creek, east of Watson Lake.

In FHZ 1 flooding occurred in three areas covering 127 ha: two polygons near Dezadeash River and one near Summit Creek.

Site-Related

Two trembling aspen stands (Photo 17) exhibiting signs of chlorosis were mapped west of Francis Lake, totaling under one hectare. No ground assessments were conducted although it is suspected that the chlorosis is due to a nutrient deficiency with certain aspen clones being more vulnerable, given the clonal signature of the symptom.

Bear

Trace* damage suspected to be caused by bears was noted in a seven ha young lodgepole pine stand northwest of Watson Lake, near the headwaters of Contact Creek (Photo 18). Bear damage can be distinguished from porcupine damage by the colour and portion of tree affected; where porcupine damage can cause various colour fades from orange to yellow and affect either the top or portion of a tree, bear damage tends to cause yellowing of the entire tree due to bear scarring at the bole.

* trace: <1% of trees

PHOTO 17. *Yellowing, chlorosis, of a trembling aspen clone west of Francis Lake.*

PHOTO 18. *Single scattered yellow (dying) lodgepole pine characteristic of bear damage on lower bole, in a stand near the headwaters of Contact Creek, northwest of Watson Lake.*

PEST COMPLEXES

Aspen Decline

Aspen decline 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's Forest Insect and Disease 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 NWT, 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, and clonal resistance. 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 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 this 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.

In 2019, the Forest Management Branch 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 (Figure 2 and Figure 3).

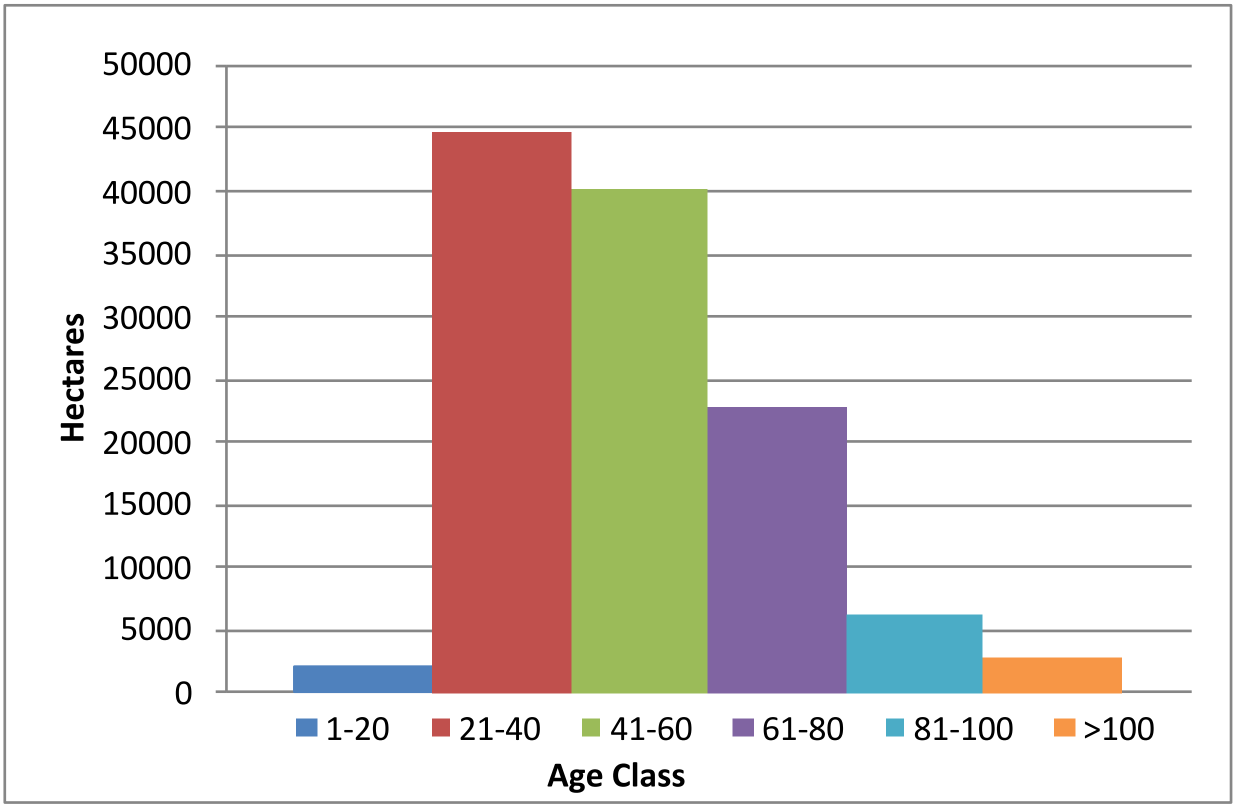


FIGURE 2. *Age class distribution of aspen stands with decline in 2016.*

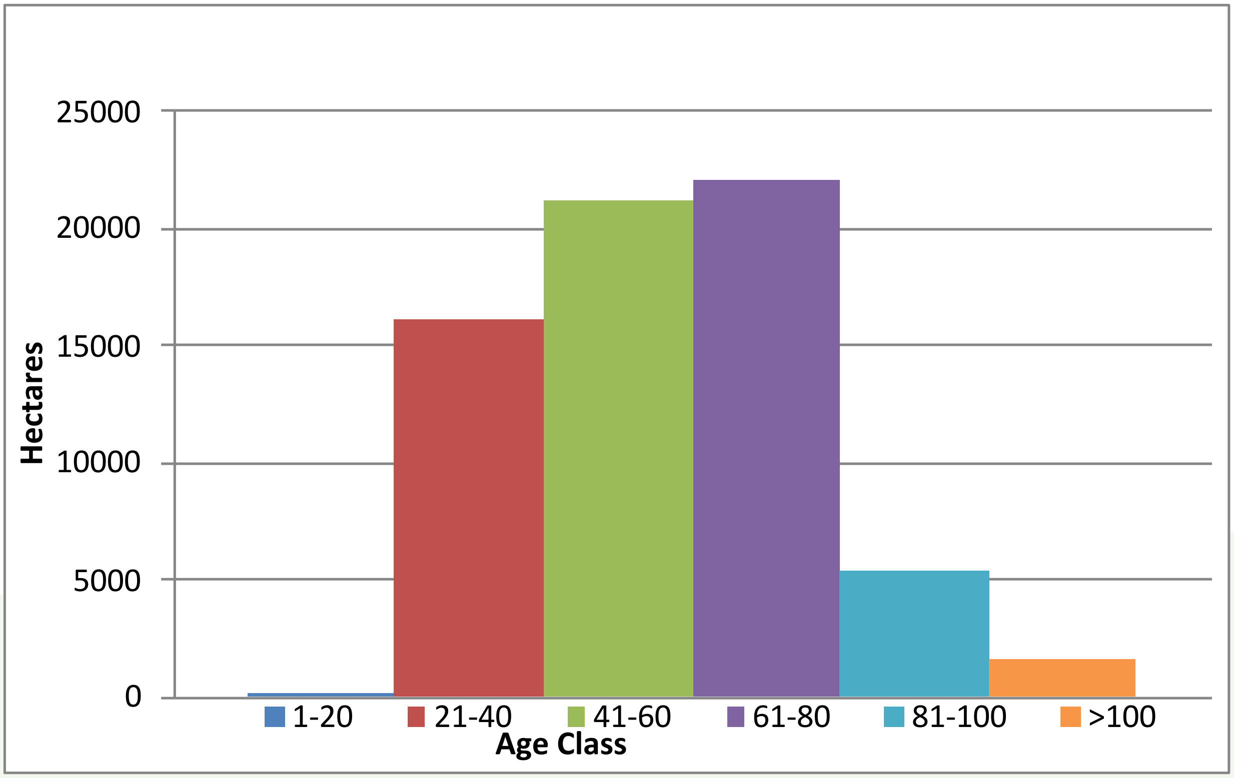
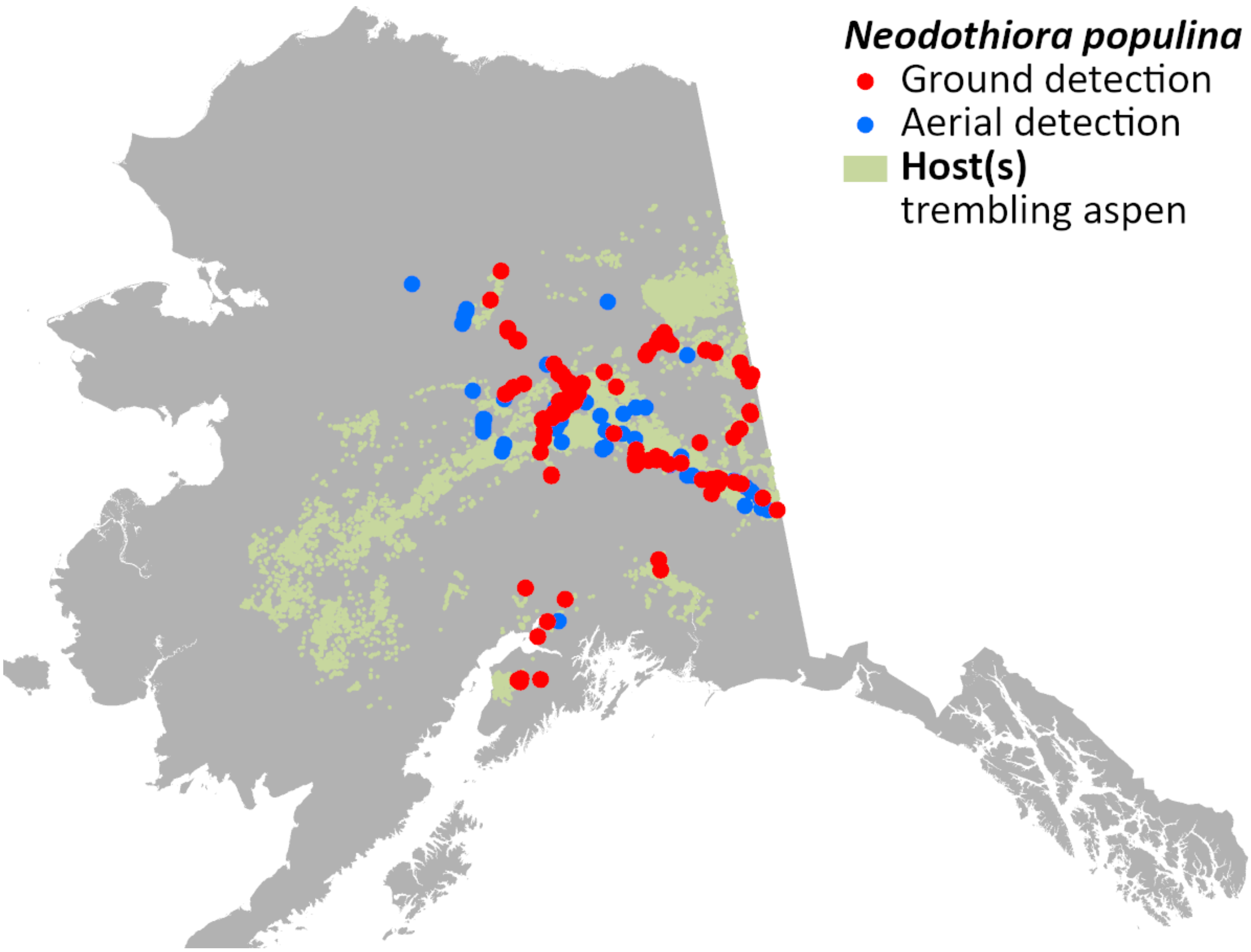


FIGURE 3. *Age class distribution of aspen stands with decline in 2019.*

PHOTO 19. *Running aspen canker on trembling aspen in Alaska boreal forests.*

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. 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 (Photo 19, Photo 20). Positive sites included those adjacent to the Yukon border (Map 9). 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 leafminer infestations are responsible for widespread aspen mortality. This is supported by recent findings that aspen leafminer negatively impacts water relations in trembling aspen (Wagner, Wheeler and Burr, 2019). 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).

PHOTO 20. *Crown dieback and stem mortality associated with running aspen canker on trembling aspen in Alaska boreal forests.*



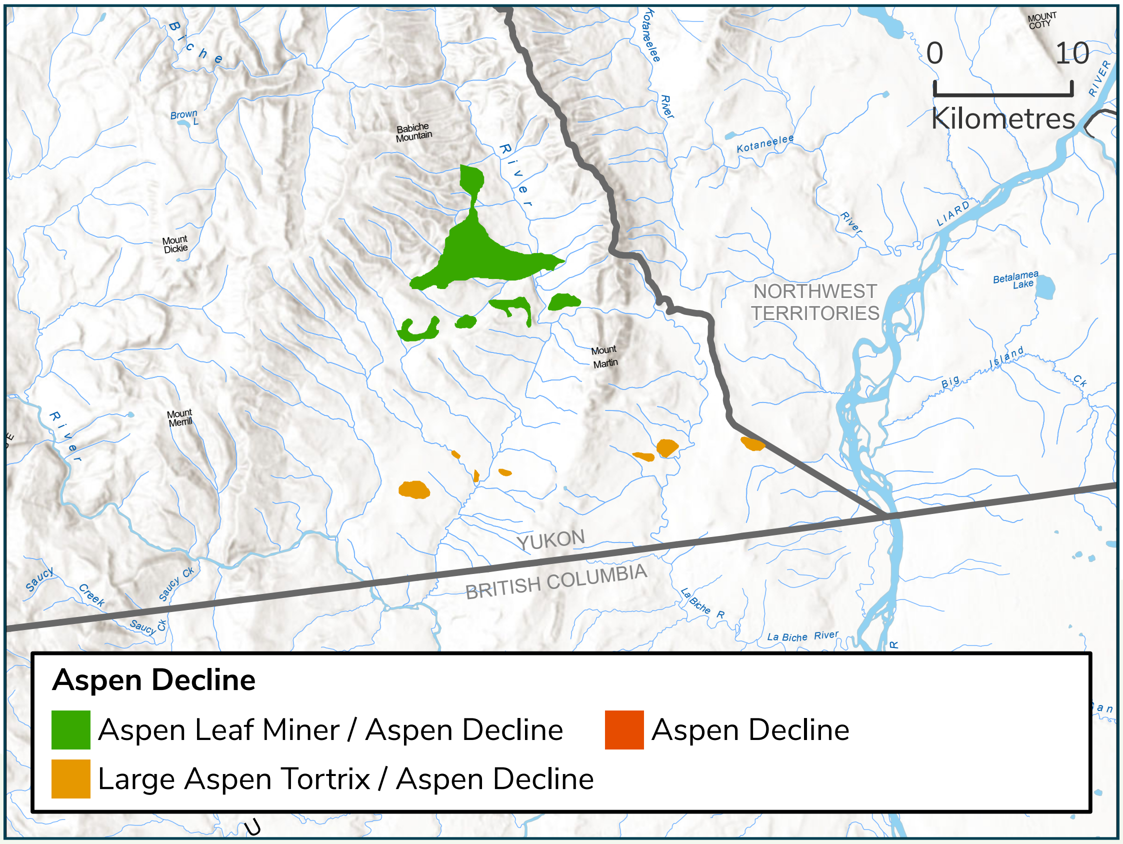
MAP 9. *Distribution of running aspen canker in Alaska, based on ground and aerial surveys (Source: Region 10 - Forest & Grassland Health (usda.gov))*

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 will continue to work to gain a better understanding of potential contributing factors.

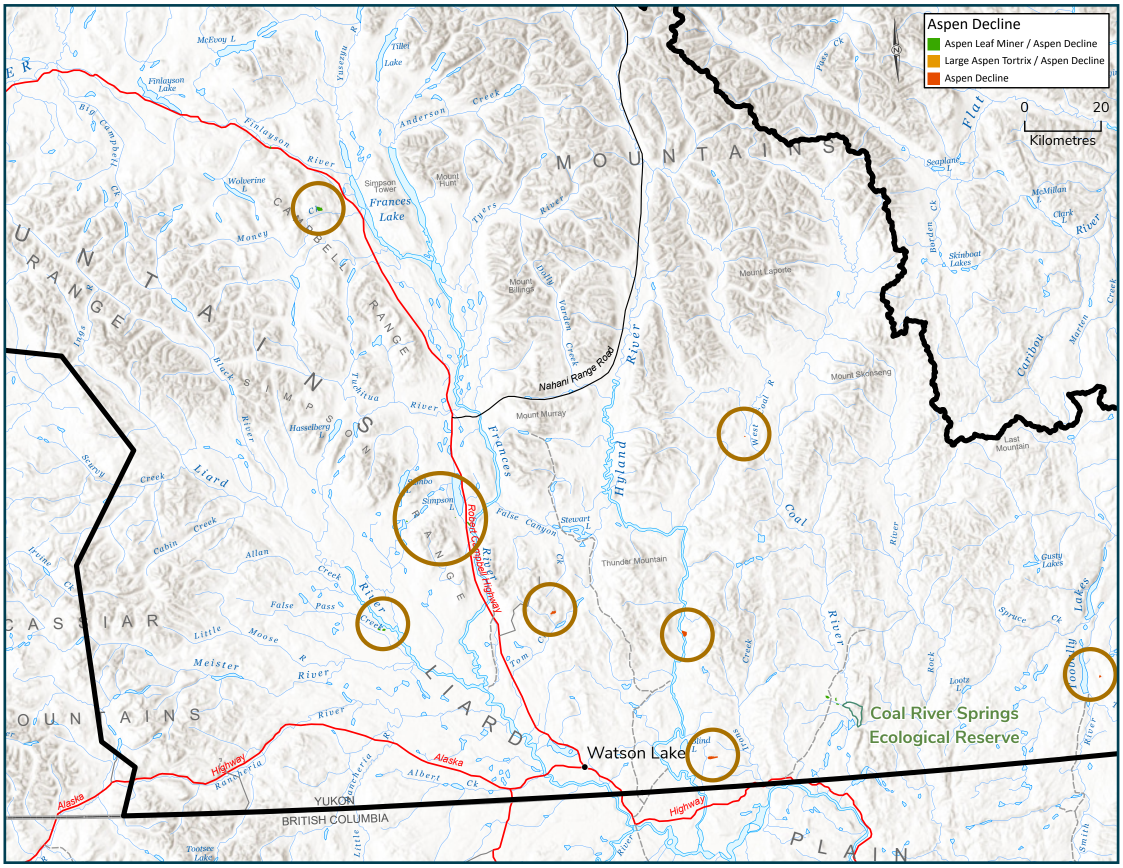
STATUS IN 2022

In FHZ 4 in 2022, the area affected with aspen decline increased significantly to 7,463 ha, from 62 ha mapped in 2017, and 11 ha in 2010 (Map 10, Map 11, Map 12) (Photo 21, Photo 22). This increase is likely due to consecutive years of aspen serpentine leafminer populations combined with a few years of above normal summer temperatures, and low precipitation, including snowfall, since 2017. The majority (81%) of the decline occurred in stands where aspen serpentine leafminer was the primary disturbance factor, 12% with large aspen tortrix, and 7% with no other disturbance factors.

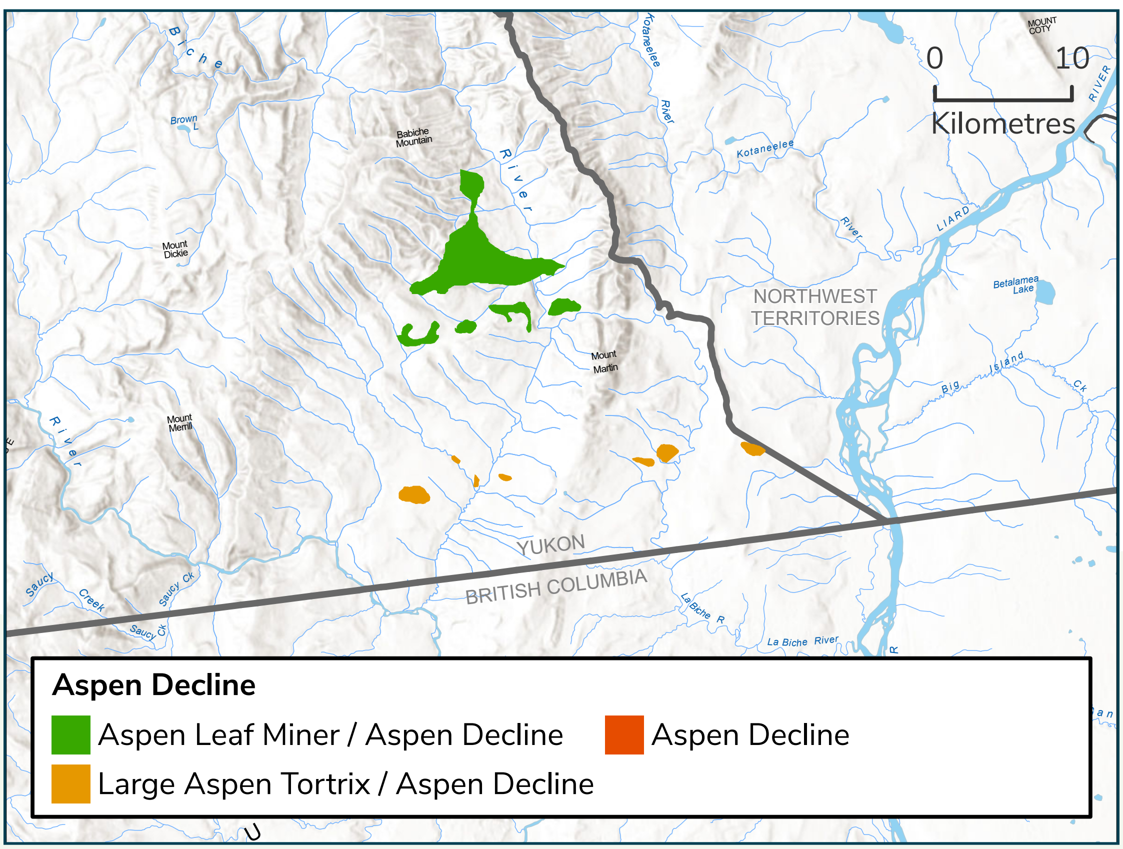
In FHZ 1, 6,601 ha of trembling aspen infested with aspen serpentine leafminer were also affected by aspen decline. These are mostly in stands previously defoliated by large aspen tortrix along the Whitehorse-Haines Junction corridor (Map 13), where large aspen infestations peaked in 2015 when over 15,000 ha were infested.



MAP 10. *Location of stands with aspen decline in the Ross River area in FHZ 4.*



MAP 11. *Location of stands with aspen decline symptoms in Watson Lake area in FHZ 4.*



MAP 12. *Location of stands with aspen decline near the NWT/BC border in FHZ 4.*

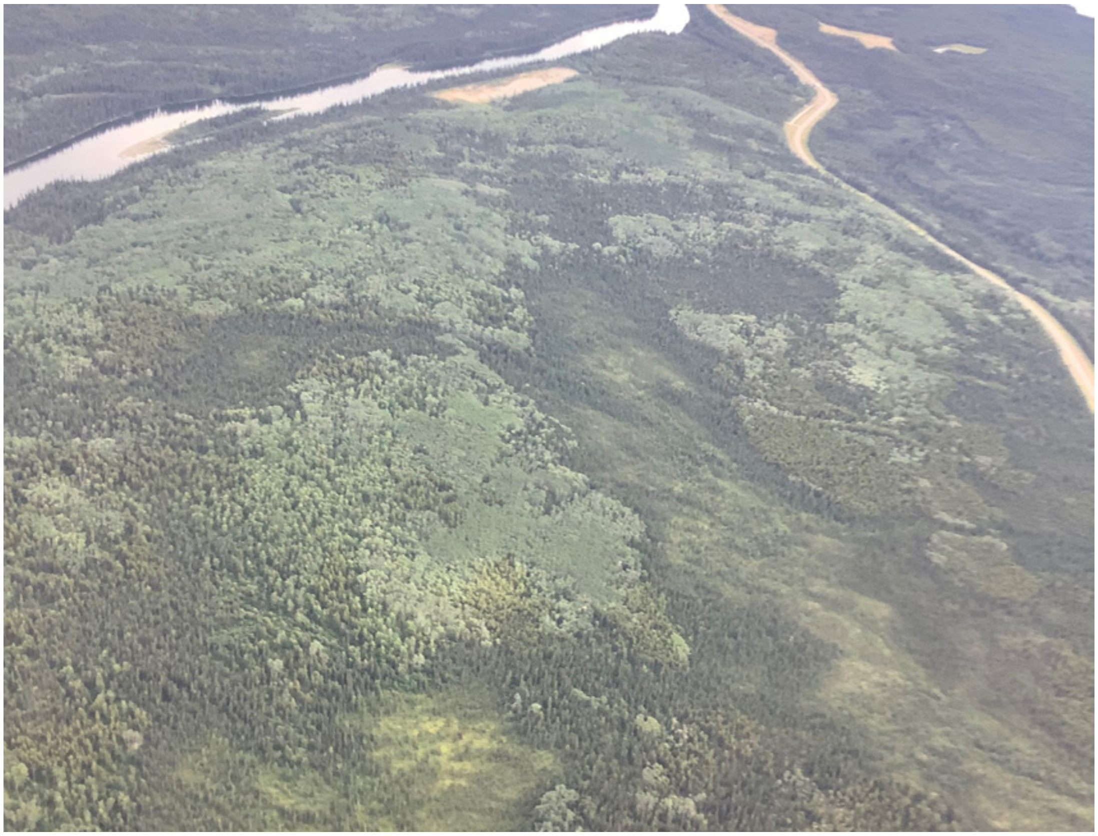


PHOTO 21. *Light aspen decline intermixed with healthier trembling aspen and aspen serpentine leafminer, south of Simpson Lake, in FHZ 4.*

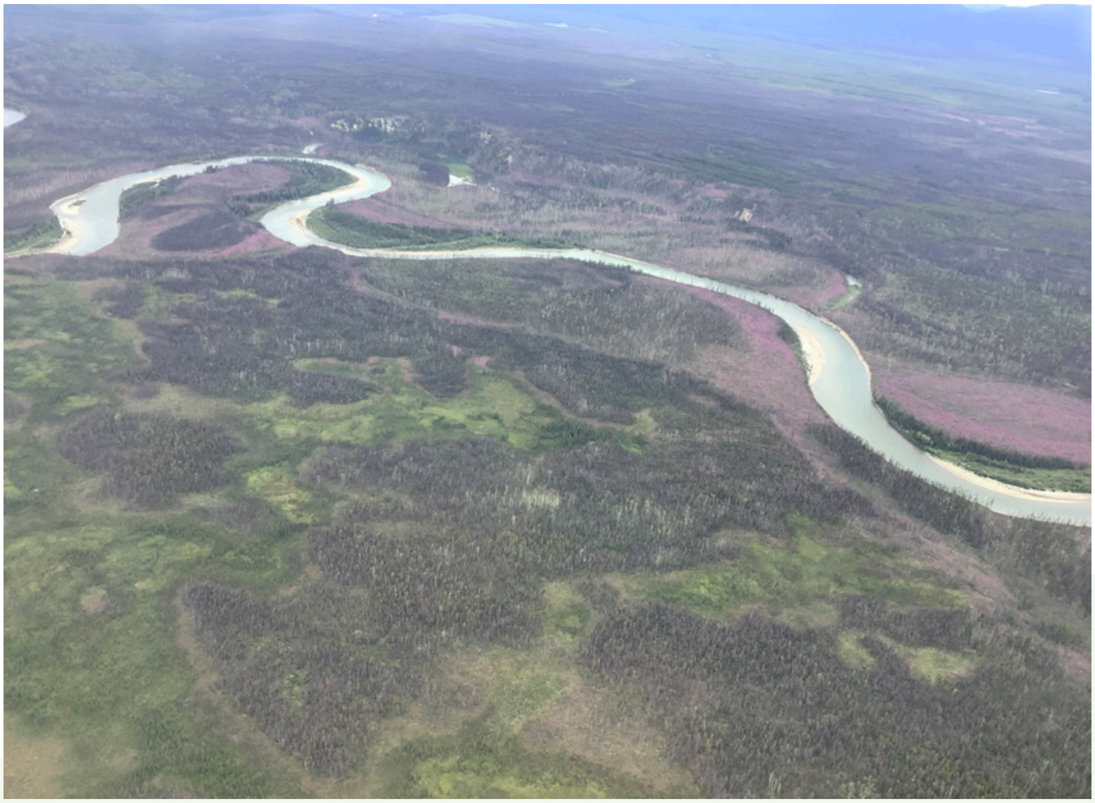
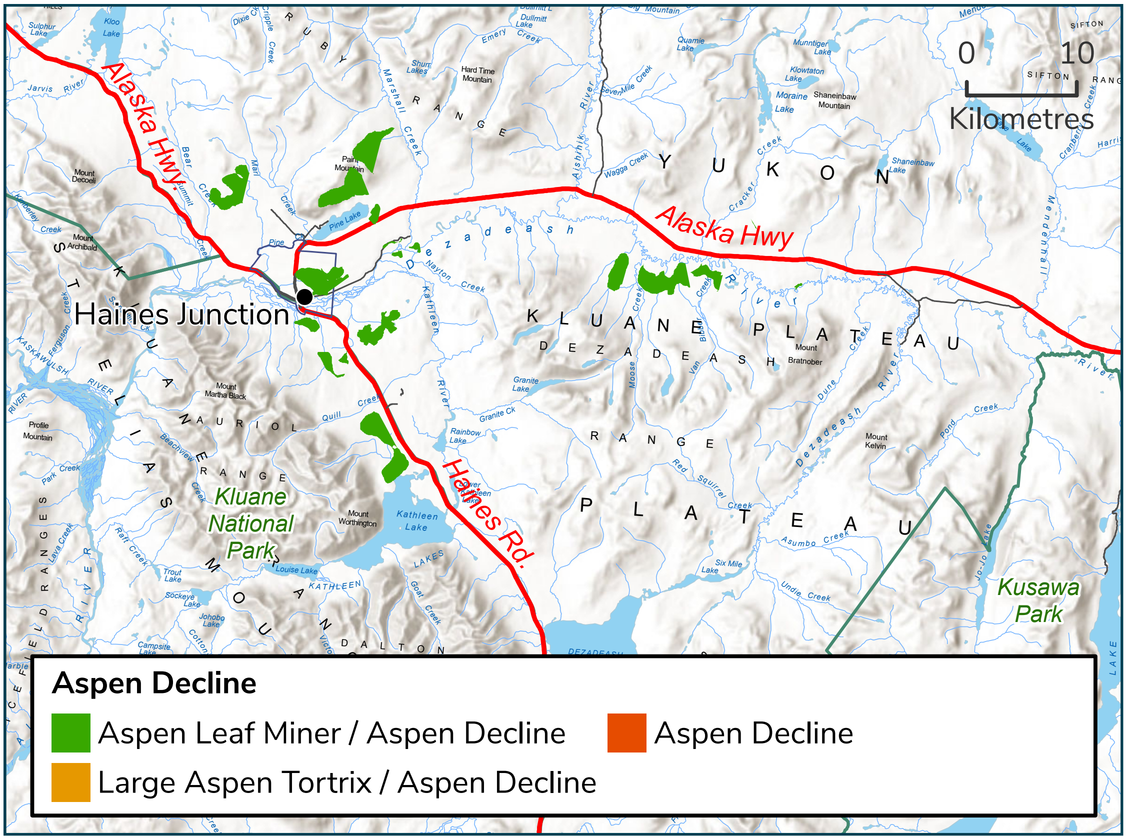


PHOTO 22. *Scattered severe aspen decline in mixed conifer stands along the Liard River, southwest of Simpson Lake in FHZ 4.*



MAP 13. *Location of stands with aspen decline in the Haines Junction corridor in FHZ 1.*

Porcupine and Bark Beetles

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

In 2014, ground checks were conducted on pockets of lodgepole pine which had a signature similar to mountain pine beetle (Photo 23). Closer aerial examination revealed top-kill rather than whole tree mortality (Photo 24). Subsequent ground checks confirmed mortality or damage due to porcupine solely, or porcupine and lodgepole pine beetle and in some cases pine engraver beetle. Hence similar damage is now deemed affected by this pest complex.

STATUS IN 2022

In 2022, symptoms resembling those of the porcupine/bark beetle complex were observed over 7,747 ha in FHZ 4. The largest polygons were northwest of Watson Lake near False Pass Creek, and NE of Watson Lake between Coal and Rock creeks. The apparent large size of the area is a result of lumping of spots, rather than mapping individual spots. Nonetheless it represents a significant increase from 18 ha mapped in 2017.

Windthrow and Pine Engraver Beetle

A 150-hectare pocket of older windthrow in lodgepole pine was recorded near Mount Vanier in FHZ 1. Based on ground assessments conducted nearby in 2021 of a similar area, it is suspected that pine engraver beetle (*Ips pini*) is likely attacking downed and standing susceptible trees.

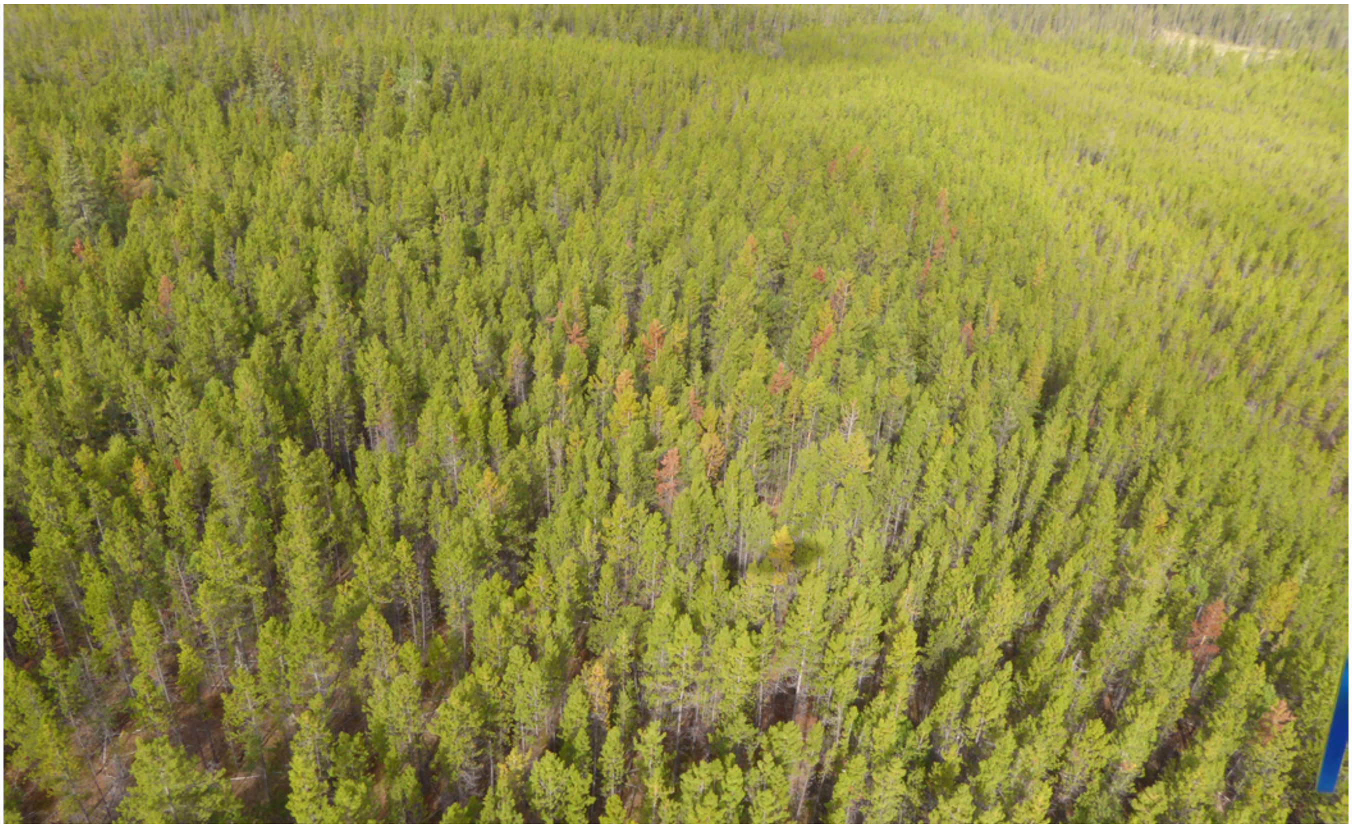


PHOTO 23. *Stand- level signature of porcupine/bark beetle pest complex.*

PHOTO 24. *Top-kill associated with bark removal by porcupines.*

PROACTIVE MANAGEMENT OF MOUNTAIN PINE BEETLE

Background

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 lures in southern Yukon to detect presence of MPB. (To date, no presence of MPB has been detected.)
- The Government of Yukon's Interdepartmental Mountain Pine Beetle Committee formed in 2011, provided direction and developed strategies to monitor and manage MPB.
- In 2012, Government of Yukon hosted a MPB workshop in Whitehorse to inform Yukon First Nations and other stake holders of the threat of the northern expansion of MPB to Yukon.
- 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, an 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).

Key messages from the 2012 Mountain Pine Beetle Risk Analysis for Yukon Lodgepole pine forests were:

1. It is highly likely that MPB will expand into YT by 2020. However populations will likely remain low until suitable weather conditions for several consecutive years help synchronize populations and promote univoltine (one year cycle) populations. That combined with higher brood productivity in naïve* pine could lead to an outbreak, but it would be short-lived due to a return to average climatic conditions. One cold snap is all that is required to reduce populations.
2. Based on current climate suitability and host susceptibility models, this cycle of endemic/incipient-to-brief-eruptive will continue to occur through to 2070 and may be the signature of MPB in YT unless new models indicate otherwise. New models may elucidate when and where suppression activities are warranted.
3. Impacts will be low in the short-term and moderate-to-high in the long-term, with the highest impacts in the short-term to sociocultural values, and in the long-term to environmental and economic values.
4. Annual aerial surveys covering potential entry corridors along the border, and highly susceptible forest types are integral components of risk response. Therefore, they should be regarded as the highest priority monitoring activity, followed by ground assessments.

* Naïve pine 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.

Monitoring Rationale

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 ha of lodgepole pine forest in BC. 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. The 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. Under suitable climatic conditions the RMT represents a potential pathway of MPB into the Yukon, given the availability of susceptible host and lack of geographic barriers.

Climate plays an important role in the population dynamics 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 geographic expansion of the beetle, possibly allowing for earlier emergence and mating in the spring and summer (Mitton and Ferrenberg, 2012).

PHOTO 25. *Mosaic of lodgepole pine age resulting from 2018 wildfires in northern BC, southwest of Watson Lake.*

MONITORING MOUNTAIN PINE BEETLE IN 2022

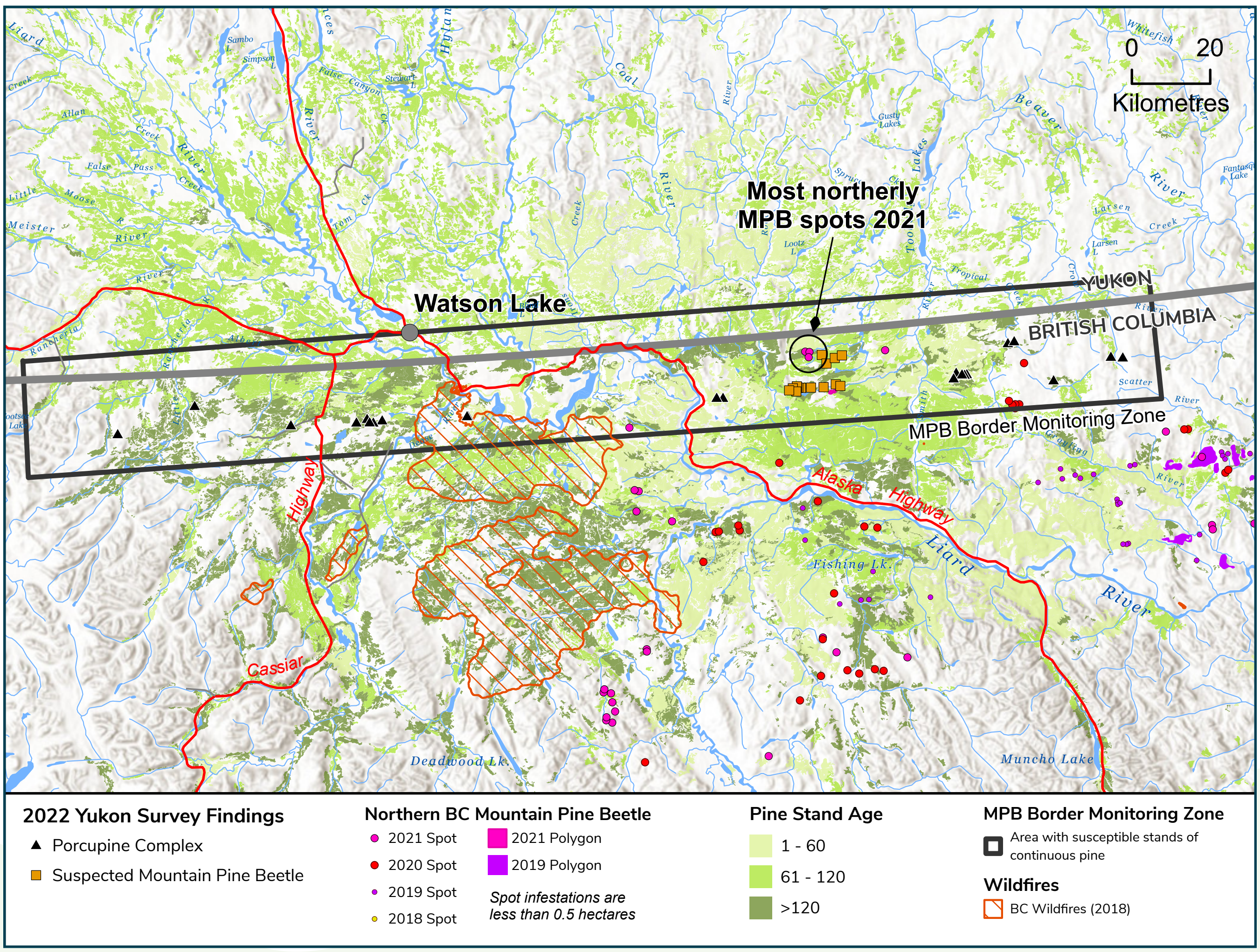
In 2010 when aerial surveys were initiated, mountain pine beetle (MPB) populations and subsequent pine mortality within the RMT in British Columbia were very high, within 150 km of the Yukon border. Given the beetle pressure and risk associated with active MPB populations in the RMT, aerial surveys were 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.

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. 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. Wildfires in BC in 2018 have reduced some of the contiguous hazard and created more heterogeneity in the previous expanse of mature pine (Photo 25).

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 encountered 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.

PHOTO 26a-c. *Suspect MPB in the border monitoring zone, within 15 km of the Yukon border. The typical signature of MPB is small groups of attacked trees that are similar to the three images shown.*



MAP 14. *Location of porcupine complex and suspect mountain pine beetle spots as mapped by Yukon FMB in 2022 in the border zone, and history of observations by BC from 2018-2021, including the 3 spots mapped in 2021.*

Border Zone

STATUS IN 2022

Following no detection of MPB for several years, a decision was made in 2019 to discontinue aerial surveys. Forest Management Branch reinstated the border zone surveys in 2022 given the proximity of the 3 MPB spots (12 trees total) observed in BC's 2021 aerial survey results.

The Forest Management Branch conducted aerial surveys in the border zone in 2022 and observed 16 single and small groups of fading yellowish-orange lodgepole pine which are suspected to be caused by MPB (Photo 26a-c). These are in the vicinity of the spots identified as MPB in 2021 by BC (Map 14). Should they be confirmed as MPB it could indicate successful in situ overwintering populations rather than long-distance dispersal, given the proximity to the MPB spots mapped by BC in 2021.

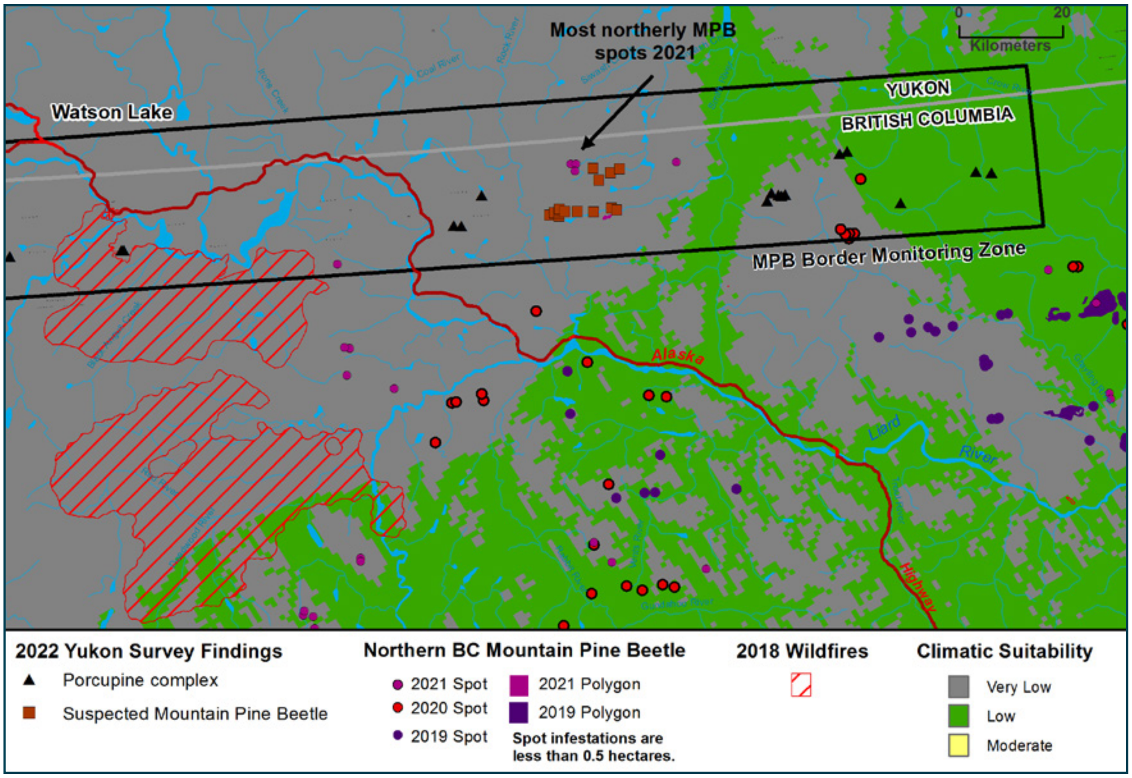
British Columbia Observations

BC's Ministry of Forests, Lands and Natural Resource Operations conducts forest health aerial surveys in northern BC. 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 three km of the border but retreated 10 km south in 2020. Unconfirmed 2021 reports indicated that populations in northern BC expanded slightly, both northward and westward, and into the border zone with three spots totaling 12 trees west of Coal River and within three km of the Yukon border (Map 14). At the time of writing this report, 2022 aerial survey results from BC were not available.

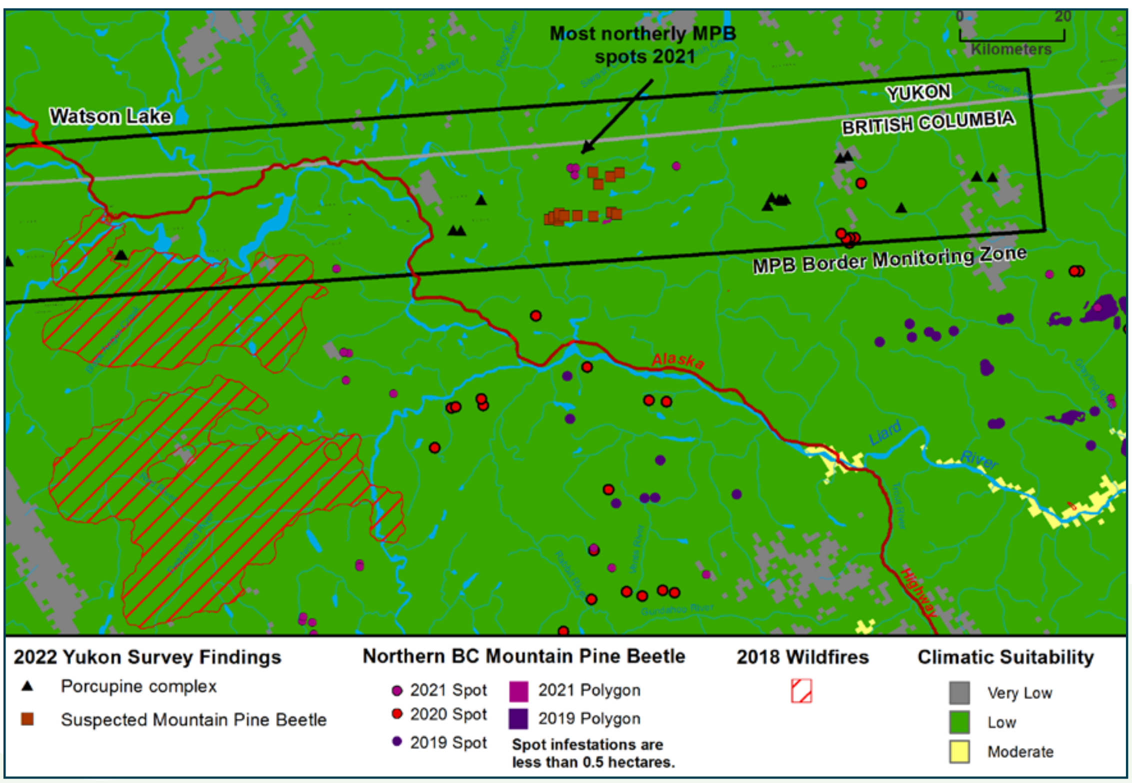
It is anticipated that continued westward migration will likely be halted or significantly slowed by the vast young pine stands that resulted from the 2018 wildfires, as well as the 1982 Egg Fire (which burned over 100,000 ha of mature pine). Young stands in the Egg Fire area act as sinks rather than sources, given the smaller diameter and thin bark. Mature lodgepole pine in any unburned area (refugia) within the wildfire areas 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. Years of favourable climate will see populations build and advance, while years with unfavorable weather will see populations retreating. The 2012 MPB Risk Analysis (Hodge, 2012) 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.

Ground assessments in the northern Rocky Mountain Trench in BC in the summer of 2012 found very poor overwinter survival of MPB. This combined with the lack of northward progression since then confirms that cold winters have been a limiting factor, as any expansion into the area with the very lowest (Map 15A) climate suitability zone generally does not last beyond a year, whereas those in the low climate suitability seem to persist (Map 15A). As the climate warms, there will be a shift northward of the low climate suitability zone (Map 15B). This shift could result in populations persisting in the monitoring zone, as shown by the current persistence in the low climatic suitability zone east of the Liard River (Map 15A). As indicated in the 2012 risk analysis (Hodge, 2012), 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 this 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 15A. *MPB infestations in northern British Columbia with 2011-2030 climate suitability model: model developed by Carroll et al 2004. Note suspect MPB spots are within the Very Low Climatic Suitability Zone.*



MAP 15B. *MPB infestations in northern British Columbia with 2021-2050 climate suitability model: model developed by Carroll et al 2004. Note the shift northward from Very Low to Low Climatic Suitability Zone*

Using Bait Traps

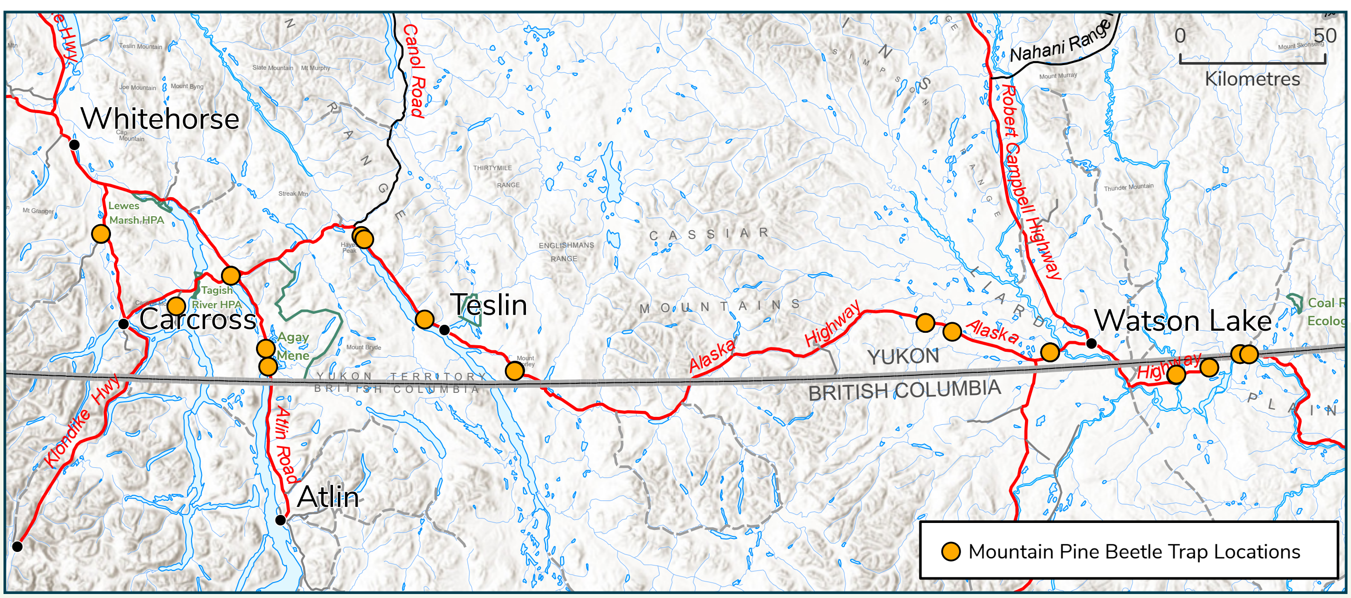
Since 2009, Forest Management Branch has installed and monitored 15 pheromone bait tree stations in southern Yukon to detect the presence of MPB (Map 16, Photo 27, Photo 28). These pheromone baits do not attract MPB over long distances, but will draw them to the baits if they are already in the area. They also do not attract other species of bark beetles. No presence of MPB was found in 2022 at any of the bait tree stations.

Next Steps

As part of a proactive management approach Forest Management Branch will conduct surveys in early summer 2023 to verify the presence and extent of MPB in the border zone. First, reconnaissance aerial surveys will be conducted to further delineate suspect MPB, followed by ground surveys in helicopter accessible areas to determine causal factor of suspect trees. Further steps will be determined based upon the outcome of the surveys.

PHOTO 27. *MPB bait tree.*

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



MAP 16. *MPB monitoring bait trap locations in southern Yukon and BC.*

SPECIAL PROJECTS

Two special projects were undertaken in 2022, both continuations of previous years projects.

Bark Beetle Pheromone Trapping

The summer of 2022 marked the fifth consecutive year of data collection for the spruce bark beetle (*Dendroctonus rufipennis*) monitoring program in the Haines Junction area. It was the second year of data collection for the northern spruce engraver beetle (*Ips perturbatus*). The monitoring objectives are:

1. To monitor populations of both bark 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 2004 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 beetle 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 engraver beetle at various locations surrounding Haines Junction (Map 17). 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

Summer 2022 traps were deployed on May 24th with weekly monitoring starting the following week. In 2022, spruce beetle flight period peaked in mid-July when the average daily maximum temperature was between 25°C and 27°C (Figure 4). The total number of beetles captured during the sampling period was 44, an increase of one individual from 2021 (Table 2).

The average number of beetles captured has remained similar since the program started in 2018. Levels fluctuate somewhat between years, but not by a significant amount. Both 2021 and 2022 monitoring seasons extended into September while 2018 ended the first week of August, and 2019 and 2020 ended the second week of August.

Northern Spruce Engraver Results

Northern spruce engraver beetle trap catches decreased starting in 2021. The total number of beetles caught during the 2022 sampling period was 4,935, with Trap 6 having the highest total count (Table 2). Trap catches peaked in the first week of June and tapered off by early July (Figure 5).

FIGURE 4. *Average number of spruce bark beetle (SBB) caught per trap, and the average daily high temperature (°Celsius) by sampling period, from 2018-2022.*

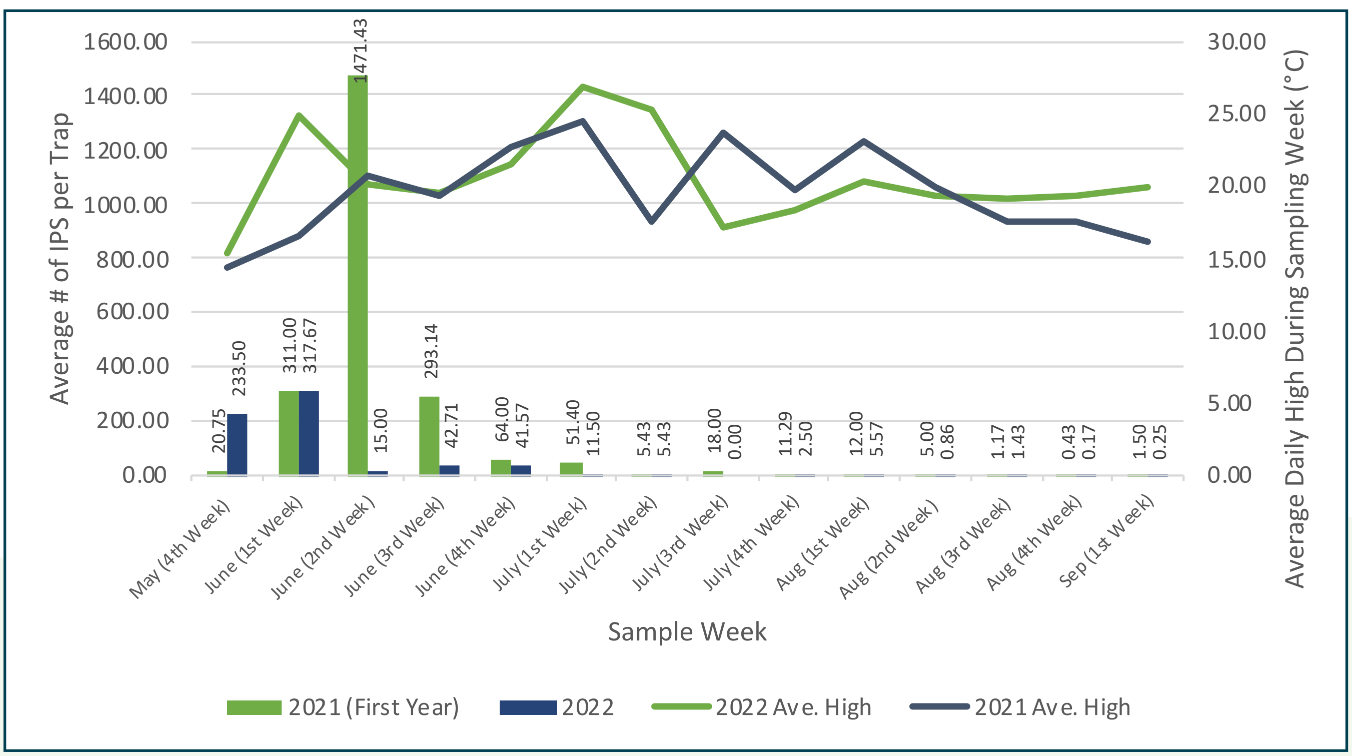


FIGURE 5. *Average number of northern spruce engraver beetles (IPS) caught per trap, and the average daily high temperature (°Celsius) by sampling period by sampling period in 2021 and 2022.*

TRAP #	LOCATION DESCRIPTION	SBB COUNT 2021	IPS COUNT 2021	SBB COUNT 2022	IPS COUNT 2022
1	Pine Canyon 15	1	1354	7	309
2	Pine Canyon 18	6	1912	5	660
3	Fuel Abatement 00	0	4441	4	818
4	Fuel Abatement 00	*	*	*	*
5	Quill Creek 6-B	3	3084	4	422
6	Bear Creek 9	1	677	6	1301
7	Pine Canyon 22	6	1806	10	817
8	Mac East 2-5	6	*	4	*
9	Pine Canyon 16	*	*	*	*
10	Pine Canyon 16	3	1630	4	449
11	Haines Road km 237	9	*	1	*
12	Mac East 3	8	548	1	159
13	Quill Creek 6-G	*	*	*	*
Total		**43**	**15452**	**44**	**4935**

TABLE 2. *Spruce bark beetle (SBB) and northern spruce engraver beetle (IPS) total adult trap catches in 2021 and 2022. Asterisk indicates no trap.*

CONCLUSIONS

Spruce Bark Beetle

The number of bark beetles caught from 2018 to 2022 has been generally stable with natural variation. Populations continue to be lower than at the end of the last outbreak (1990-2006), suggesting that populations have returned to endemic levels.

Northern Spruce Engraver Beetle

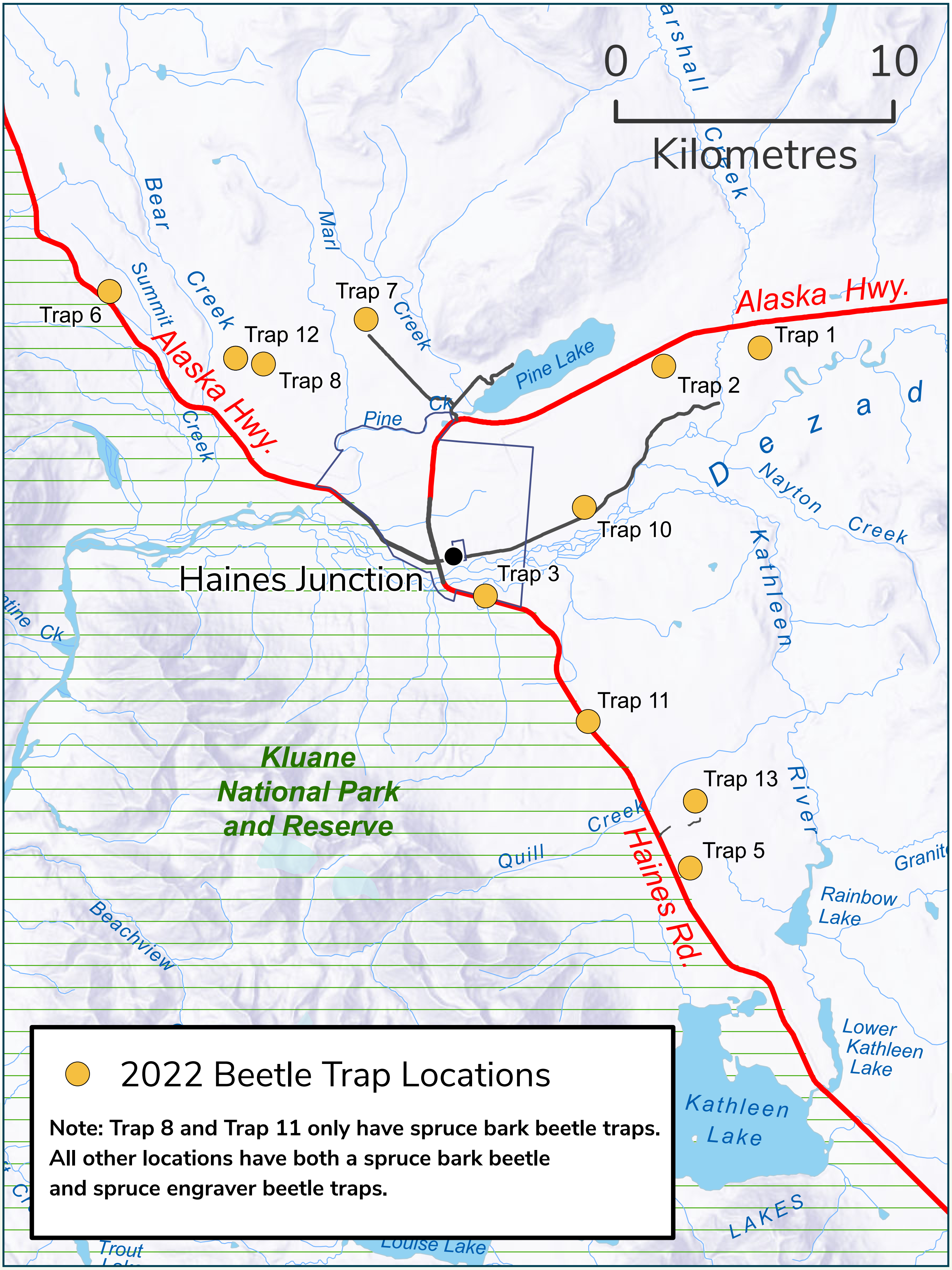
Trap catches for the northern spruce engraver beetle in 2021 were very high, with over 15,000 adults recorded. In 2022, populations declined, with just under 5,000 adults recorded. This trend is typical of northern spruce engraver beetle in that populations increase substantially as fresh downed material becomes available and decrease once the downed wood starts to dry out or has been fully occupied by previous attacks.

To date, mortality of standing trees has not been observed as northern spruce engraver beetles is preferentially attacking slash and down woody material within the recently harvested areas. Northern spruce engraver beetle numbers are generally higher than spruce bark beetle as they have a one year life cycle with adults boring out of the tree in late August and overwintering in the duff. However, high overwinter mortality is common due to cold temperatures which help to maintain endemic populations.

Additionally, there was a special aerial overview survey of the Haines Junction planned areas in 2022. No beetle activity from the air was observed as determined by the lack of fading trees.

Next Steps

The Forest Management Branch will continue to monitor spruce bark beetle and northern spruce engraver beetle to inform risk management. Management practices aimed at reducing such risk have been implemented and include limiting the availability of downed green woody debris via cutting permit terms and harvesting sanitation protocols.



MAP 17. *Bark beetle trap locations in the Haines Junction area.*

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 growing in windthrow, Forest Management Branch undertook a pest risk analysis (PRA). The PRA included a pest risk assessment and management response options, including best practices.

During the summer of 2022, the Forest Management Branch and Ta'an Kwäch'än Council monitored the presence of spruce bark beetle, norther spruce engraver beetle, and pine engraver beetle in the Deep Creek and Jackfish Bay area. Traps were monitored from the third week of June until the first week of September. Presence of beetles was detected in 2021, therefore continued monitoring was recommended.

PHOTO 29. *Lindgren© Funnel Trap at trap location #2.*

Pest Risk Analysis

Table 3 summarizes the pest risk assessment of beetle populations building within the blowdown, and potential to expand into the adjacent stands.

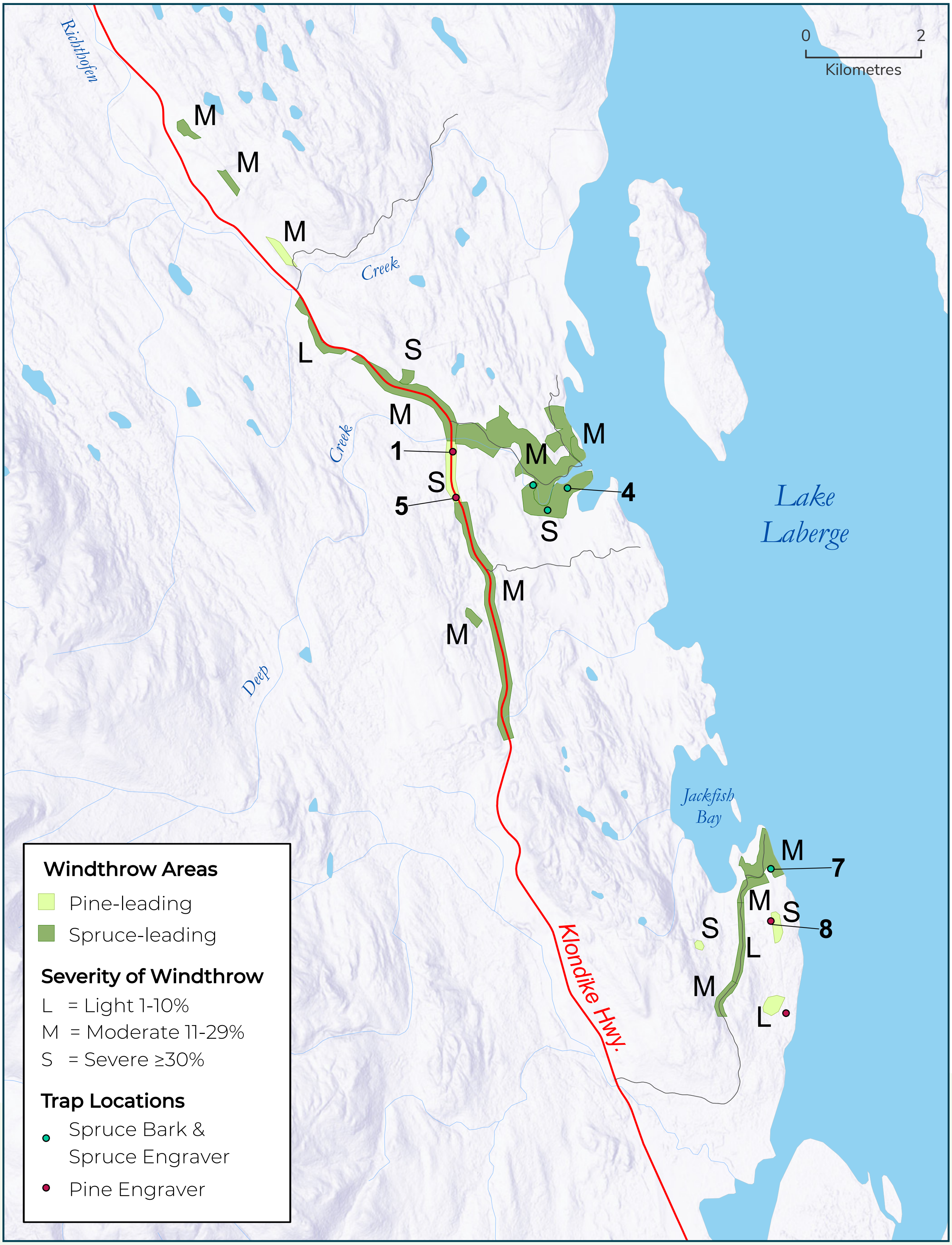
Management response options following the year of the windthrow event included a best-case scenario, which was to remove all windthrow timber prior to initial beetle flight period in the spring of 2021. As this option was not economically feasible due to the scale of the blowdown, the windthrow areas were monitored for beetles throughout the summer of 2021 and 2022. Monitoring tactics included initial aerial surveys to identify levels of disturbance in windthrown stands, followed by ground surveys to assess presence of bark beetle species and levels of attack.

Ground surveys utilized Lindgren© funnel traps and beetle probing within windthrow and adjacent stands. These Lindgren© funnel traps with specific chemical lures were set up based on leading species in the moderate and severe blowdown polygons (Photo 29). Spruce-leading areas had chemical lures to attract spruce beetles and northern engraver beetles, while lodgepole pine-leading stands had lures to attract pine engraver beetles (Map 17). The traps were checked weekly and trap catches recorded. These results provided 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*, moderate*, and severe* (Map 18).

* light: 1-10% of trees recently killed
moderate: 11%- 29% of trees recently killed
severe: >30% of trees recently killed

PEST	LIKELIHOOD OF EXPANSION	CONSEQUENCES OF EXPANSION	OVERALL RISK
Spruce bark 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*



MAP 18. *Windthrow areas by leading species and severity with bark beetle trap locations in the Deep Creek/Jack Fish Bay.*

2022 Risk Response Approach and Results

Trap and Host Observations

- Spruce bark beetle: Total capture was three beetles (Table 4). Due to such low trap catches, it is difficult to determine peak flight period.
- Northern spruce engraver beetle: Total capture was 338 beetles (Table 4), with an average of four beetles per trap per week. The peak flight occurred in the fourth week of June (Figure 7).
- Pine engraver beetle: Total capture was 1,640 beetles (Table 4), with an average of 41 beetles per trap per week. The peak flight occurred during the month of August (Figure 6).
- Note that data was not collected the fifth week of July and the third week of August.
- No new windthrow noted in lodgepole pine or spruce since initial disturbance in 2019.

TRAP	LOCATION DESCRIPTION	LEADING SPECIES	WINDTHROW SEVERITY	TOTAL # SPRUCE BARK	TOTAL # NORTHERN SPRUCE ENGRAVERS	TOTAL # PINE ENGRAVERS
1	North Klondike Highway km 224	Lodgepole Pine	severe (>= 30%)	N/A	N/A	1153
4	Deep Creek South Road east end	White Spruce	mod. (11-29%)	0	157	N/A
5	North Klondike Highway km 223	Lodgepole Pine	severe (>/= 30%)	N/A	N/A	487
7	Jackfish Bay near point	White Spruce	mod. (11-29%)	2	81	N/A
8	Jackfish Bay powerline north	Lodgepole Pine	severe (>/= 30%)	1	100	N/A
			TOTAL	3	338	1640

TABLE 4. *Trap location and observations.*

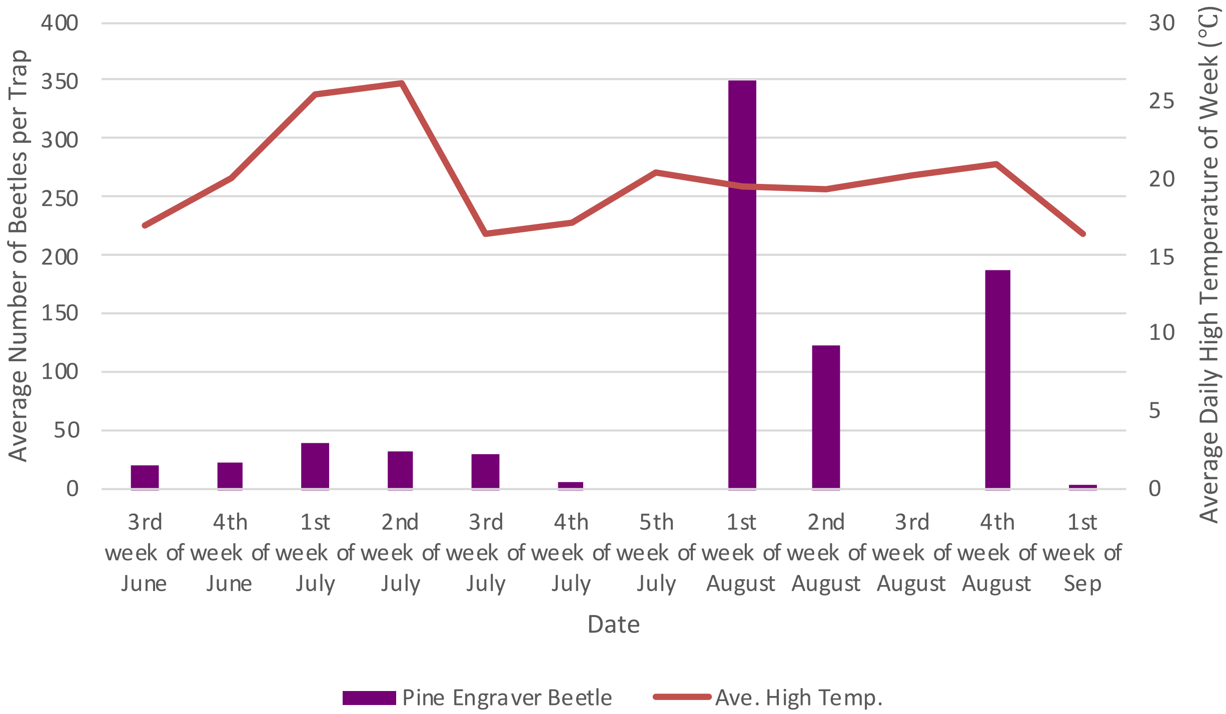


FIGURE 6. *Average number of trap catches of pine engraver beetle (Ips pini), and the average daily high temperature, in degrees Celsius, during each sampling period. Note that the fifth week of July and the third week of August were not sampled.*

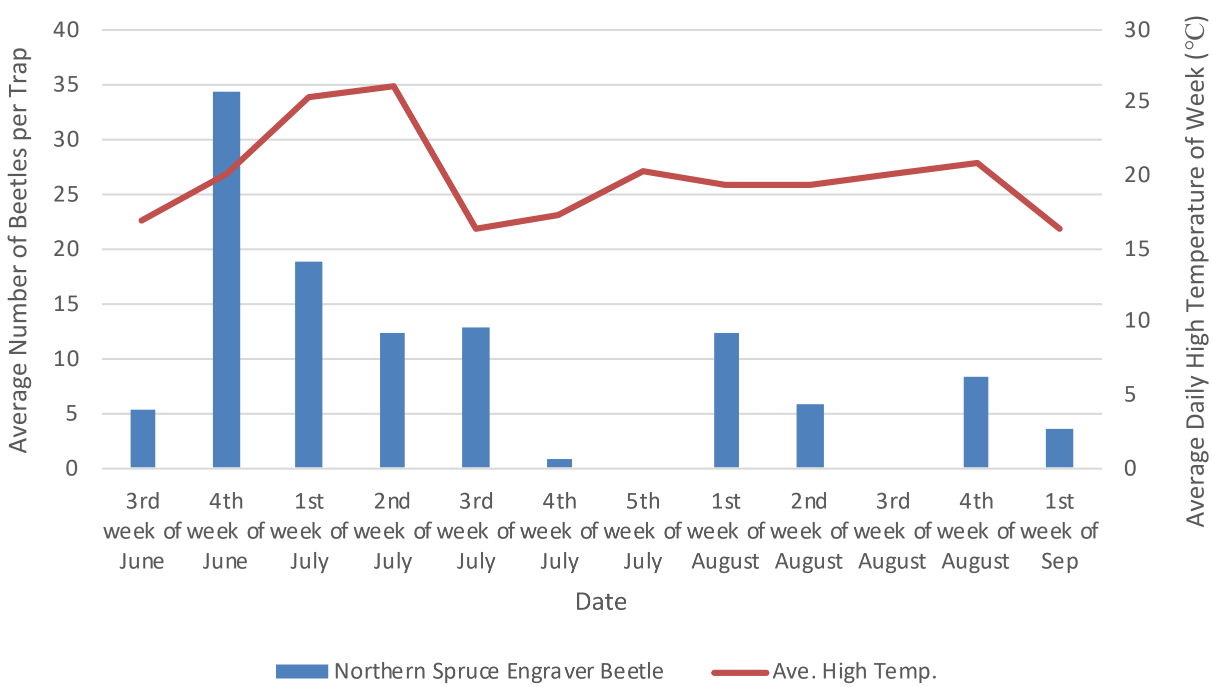


FIGURE 7. *Average number of trap catches of northern spruce engraver beetle (Ips perturbatus), and the average daily high temperature, in degrees Celsius, during each sampling period. Note that the fifth week of July and the third week of August were not sampled.*

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: There was minimal evidence of attack observed in windthrow. During the 2022 monitoring period, there was only one windthrown tree that had the signature of spruce bark beetle galleries, e.g., frass-filled gallery, with no signs of brood development (Photo 30).
- Northern spruce engraver beetle: Minimal presence of beetle larvae was detected in the windthrow (Photo 31). No evidence of young adults was observed, likely due to the timing of assessments.
- Pine engraver beetle: Presence in windthrow was detected during several weeks of monitoring, with fully developed adult galleries (Photo 32).

PHOTO 31. *Frass-free, and deeply etched, northern spruce engraver beetle adult gallery with larvae and pupa visible.*

PHOTO 30. *Spruce bark beetle frass-packed gallery on a windthrown spruce. Also, some woodborer activity.*

PHOTO 32. *Pine engraver adult beetles in windthrown lodgepole pine.*

CONCLUSIONS

Spruce–leading windthrow

Minimal signs of bark beetle development was observed. It should be noted that the blowdown is now three years old, and it is likely that the host material is becoming less suitable for brood development for both spruce bark beetle and northern spruce engraver beetle.

Pine-leading windthrow

There was evidence of pine engraver beetles in the windthrow. It should be noted that in 2021, no beetles were observed. Similar to the spruce beetles it is likely that the windthrow has dried out and therefore less desirable to pine engraver beetle.

Next Steps

Spruce Bark beetle and Northern Spruce Engraver beetle: Risk of any significant development of populations is poor to nil. It should be noted that in 2023, the blowdown will be four years old and will likely be too dry for suitable host material. For the spruce-leading windthrow, monitoring should continue to ensure that populations and resultant risk remain nil to low.

Pine Engraver beetle: Given the presence of pine engraver beetle in the windthrow in 2022, a low risk still exists. Hence, in 2023, monitoring will continue. In addition, the forests adjacent to the windthrown areas will 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 2022

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 was introduced into the eastern United States in 1923 and has since spread throughout North America. In 2022, outbreak levels of this leafmining sawfly were once again noted on native and ornamental birch in Whitehorse. Characteristic brown blotches on the leaves are caused by larvae feeding within the leaf (Photo 33). In the Yukon, this insect was first found infesting the leaves of native white birch in Dawson City in 2003 and ornamental birch in Whitehorse and Watson Lake the same year. Since then, light infestations have been reported annually.

PHOTO 33. *Light to moderate defoliation by ambermarked birch leafminer in Whitehorse.*

Larch Sawfly (*Pristiphora erichsonii*)

This defoliator of larch caused light defoliation on a residential tree in Whitehorse (Photo 34). In the Yukon, small populations of this defoliator typically feed on both ornamental and native trees. Outbreaks tend to be cyclical and are not necessarily linked to specific environmental, climatic or stand conditions.

Direct control can be effective for small quantities of young trees or ornamental trees in urban settings. Methods include removal of needles and litter containing overwintering larvae, frequent spraying of affected branches with high pressure water, shaking infested branches, and removing larvae by hand.

In the Yukon, larch sawfly is widely distributed throughout the host range, *Larix laricina*, from the LaBiche River in the extreme southeast as far north as the Arctic Circle. In North America, various strains of the species have been found; two of these were introduced from Europe and two are native (Furniss and Carolin, 1977).

In the mid 1990's, a severe outbreak on the slopes of Mt. Martin in the LaBiche River area killed most of the mature larch (Garbutt, 1995). A forest health survey in 2005 found 14 dead mature eastern larch in a stand adjacent to the Miner River, a tributary of the Porcupine River south of Old Crow (Garbutt, 2005), likely a result of severe larch sawfly defoliation given their presence on immature larch. Outbreaks of larch sawfly have historically occurred simultaneously in widely scattered locations. It is likely that the Miner River larch were killed in the same outbreak that caused the mortality in the southeast.

PHOTO 34. *Larch sawfly larvae on Siberian Larch in Whitehorse.*

PHOTO 35. *Flat headed woodborer found in firewood Haines Junction.*

PHOTO 36. *Black army cutworms observed at the 2019 Ethel Lake fire, Mayo.*

Flatheaded Wood Borer
(*Buprestidae sp.*)

Flatheaded wood borer larvae (Photo 35) were observed in a residential wood pile in Haines Junction. Flatheaded wood borer larvae are generally found in the wood of dying e.g. stressed, or dead trees and are recognizable by their flat heads and meandering frass-filled galleries. Adults are typically shiny and metallic-looking and belong to a family of wood boring beetles known as buprestids. Round headed borer larvae on the other hand have a head similar to the size of their body and adults have long antennae which exceed the size of their body. These are part of the cerambycid family with white-spotted sawyer beetle, *Monochamus scutellatus*, being the most frequently reported due to the tell-tale white spot.

While wood borers are generally not a concern to seasoned structural lumber or healthy trees it is a good practice to avoid moving firewood from distant places to avoid potential invasive species introductions. For more information on wood borers, including round headed borers (e.g. sawyer beetles) refer to the following brochure distributed by the USDA Forest Service in Alaska https://www.fs.usda.gov/detail/r10/forest-grasslandhealth/?cid=fsbdev2_038421.

Black Army Cutworm
(*Actebia fennica*)

For the second consecutive year black army cutworm larvae were observed feeding on young willow saplings in the 2019 Ethel Lake fire (Photo 36). This defoliator of young saplings, including recently planted seedlings, are known to occur on recently burned sites. In fact, it was a major pest in British Columbia in the 1980s when prescribed burning was used for site preparation. Once prescribed burning stopped the impacts of the black army cutworm became less severe.

Black army cutworm feeds on a range of plants and conifer seedlings growing on recently burned sites. Damage becomes most apparent two to threes years following a late season (July to October) wildfire, or one year after an early season wildfire (before July). Seedlings planted on recently burned sites with little or no vegetation are more likely to be damaged by cutworm larvae.

ABIOTIC

Extreme Weather

Examples of environmental damage due to extreme weather can be found throughout the Yukon in both coniferous and deciduous trees and have been documented in previous forest health reports. It is anticipated that more frequent extreme weather will lead to more instances of forest damage due to heat, cold, snow or wind. Changes in shoulder season patterns are also considered as extreme weather. For example, a warmer than normal spring could lead to premature bud flushing and a subsequent frost could lead to bud damage and potential tree mortality due to a return to normal conditions. Similarly, normal bud flushing could be impacted by abnormal late season frosts or drying winds, as was the case in the summer of 2022, when spruce trees died after such exposure (Photo 37). Open grown and smaller trees are most prone to damage due to their higher exposure to drying winds or frost.

Tree symptoms are highly variable and it is often challenging to determine the causal factor as tree physiology and its interaction with the environment is complex. An example of this can be found on the spruce trees at the Wild Land Fire air tanker base in Mayo, where many of the trees are in poor health with deep cracks, pitching and loose bark. (Photos 38). No fruiting bodies were observed on the trees, and rust or disease would not cause such extensive cracks. It likely that the damage of the spruce trees is a combination of weather extremes, quite possibly extreme cold, and physical damage caused by machinery.

Pine Needle Cast Recovery

In 2018, severe pine needle cast (*Lophodermella concolor*) was reported in a young lodgepole pine stand along the Nahanni road (Photo 39). This foliar disease relies on rainfall in the spring to coincide with the maturation of the spore-laden fruiting bodies from the previous year's infections. The released spores are transferred by rain splash from the old needles to the newly-flushed needles. Through this process, the disease intensifies, especially if similar high moisture conditions prevail two or more years in succession.

Examination of the stand in 2022 found that most of the lodgepole pine had recovered (Photo 40), with characteristic lions-tailing (needle loss) resulting from the severity of the infection (Photo 41).

PHOTO 37. *White spruce seedling killed by frost in Whitehorse.*

PHOTO 38. *Damage to spruce trees caused by extreme cold weather and physical damage from machinery. At air tanker base, Mayo.*

PHOTO 39. *Young lodgepole pine stand with severe pine needle cast infection leading to the loss of this year's needles, Nahanni Road, 2018.*

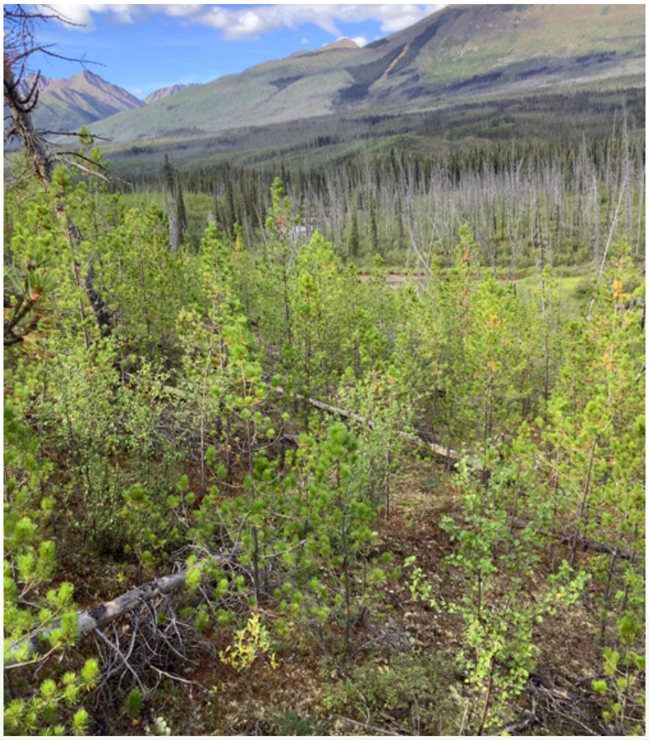


PHOTO 40. *Post needle cast infection recovery of young lodgepole pine in 2022 along Nahanni Road.*

PHOTO 41. *Lions tailing resulting from previous (2018) severe infections of pine needle cast in a young pine stand in 2022, Nahanni Road. Note scar near the top of foreground tree due to Petrova pitch moth.*

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