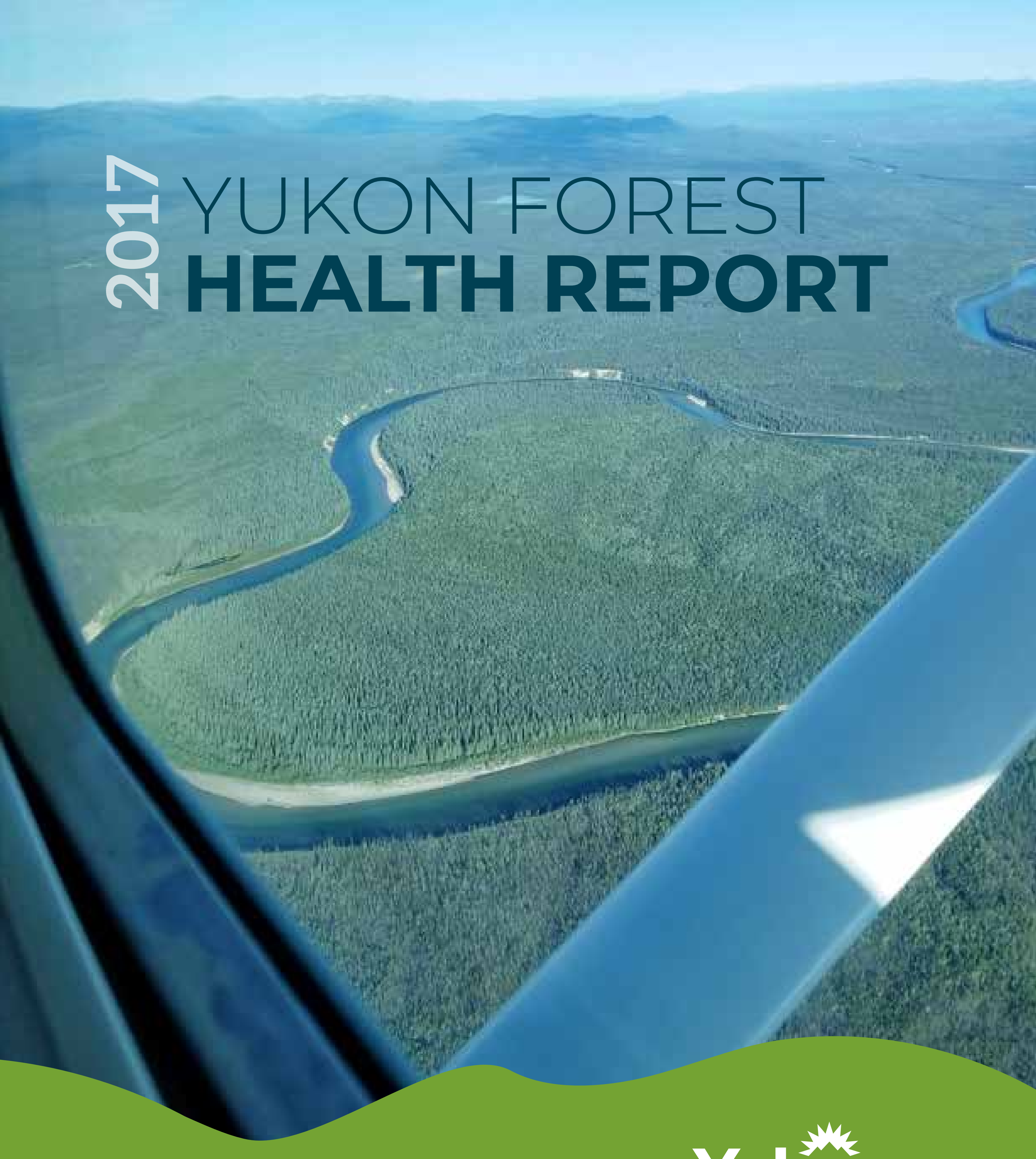
2017 YUKON FOREST HEALTH REPORT



Yukon

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

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

Under section 34-2 of the FRA, the director of the forest branch may develop research and monitoring plans and programs to: a) investigate the spread, effect and control of insects and pests as it relates to the protection of forest resources and b) support the advances in forest resource management. This includes monitoring plans such the risk-based Yukon Forest Health Monitoring Strategy adopted by FMB in 2009.

Yukon Forest Health Monitoring Strategy

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

The objectives of the Yukon Forest Health Monitoring Strategy are:

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

In the FRA Regulations (sections 81 and 82), there is a commitment from the director to provide a written report on the status of forest health in Yukon (the annual Forest Health Report) to the Minister of Energy, Mines and Resources (EMR).

Rotational Monitoring of Forest Health Zones

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

In 2013, the fifth and last of the five zones was monitored. This year, being the ninth year of aerial surveys, marks the fourth year that a forest health zone has been resurveyed (resulting in two years of data for four FHZs). Given that baseline data has already been captured in each of the forest health zones, the mapping resolution from 2014 forward will be coarser; moving from 8 km gridlines to 12 km gridlines in 2014-2016 and 14 km gridlines in 2017 due to the large size of the FHZs.

AERIAL SURVEYS AND **GROUND TRUTHING** AS THE **PRIMARY TOOLS** FOR **MONITORING**

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

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

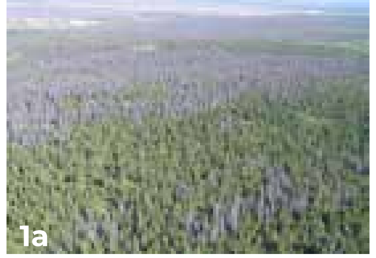
Standards for Conducting Aerial Surveys

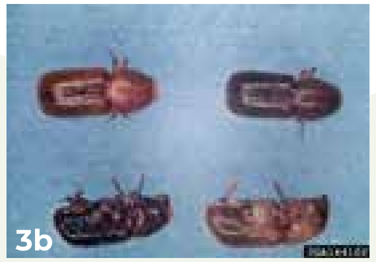
The following standards are used for conducing aerial surveys in Yukon:

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

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

IDENTIFICATION OF **MAJOR FOREST HEALTH CONCERNS** OF YUKON





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

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

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

1. Spruce bark beetle *(Dendroctonus rufipennis)*

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

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

1b Adult spruce bark beetle.

2. Northern spruce engraver *(Ips perturbatus)*

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

2a Single tree attack, Northern spruce engraver.

2b Young adults and larva, Northern spruce engraver.

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

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

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

3b Adults, Western balsam bark beetle.

4. Budworms *(Choristoneura spp.)*

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

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

4b Spruce budworm larva.

5. Larch sawfly *(Pristiphora erichsonii)*

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

5 Larch sawfly larva.

6. Large aspen tortrix *(Choristoneura conflictana)*

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

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

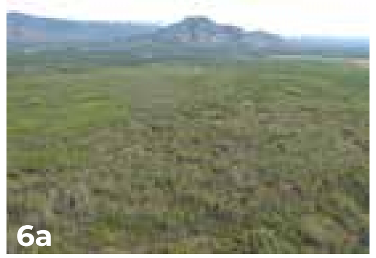
6b Adult moth, Large aspen tortrix.

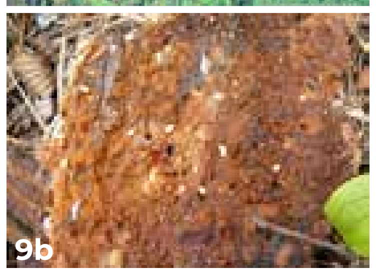
7. Aspen serpentine leafminer *(Phyllocnistis populiella)*

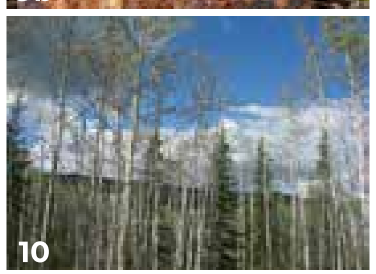
This insect pest occurs throughout the Yukon range of trembling aspen and also defoliates balsam poplar *(Populus balsamifera)*. Starting in the early 1990s, a massive outbreak of aspen serpentine leafminer extended from Alaska through Yukon, and into B.C.

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

7b Leaf mining, Aspen serpentine leafminer.







8. Pine needle cast *(Lophodermella concolor)*

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

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

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

9. Mountain pine beetle *(Dendroctonus ponderosae)*

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

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

9a Mature pine tree attack, Mountain pine beetle, Rocky MountainTrench, BC.

9b Surviving larva at base of tree, Mountain pine beetle, Rocky Mountain Trench, BC.

10. Tree dieback due to drought stress

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

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

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

SUMMARY OF 2017 **FOREST HEALTH INITIATIVES**

The following four initiatives were completed by Forest Management Branch in 2017:

COMPONENT 1:

Annual Forest Health Aerial and Ground Surveys

During 2017, two separate aerial surveys were undertaken in order to map Yukon forest disturbances as described in the Yukon Forest Health Monitoring Strategy (Map 1):

1. Six-day aerial survey to map forest health zone (FHZ) 4 (Southeastern Yukon)
2. A one-day aerial survey of ongoing large aspen tortrix defoliation between Whitehorse and south of Haines Junction.

COMPONENT 2:

Proactive Management of Mountain Pine Beetle (MPB)

FMB continues to take a proactive approach to monitoring the northward expansion of the MPB. A one-day aerial survey was undertaken to monitor the northward movement of the MPB along the Yukon/BC border near Watson Lake, as per the monitoring strategy.

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

COMPONENT 3:

Special Projects: Enhancing Knowledge Base to Inform Risk Management

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

In 2017 one special project was carried forward from 2016, and one new project was initiated:

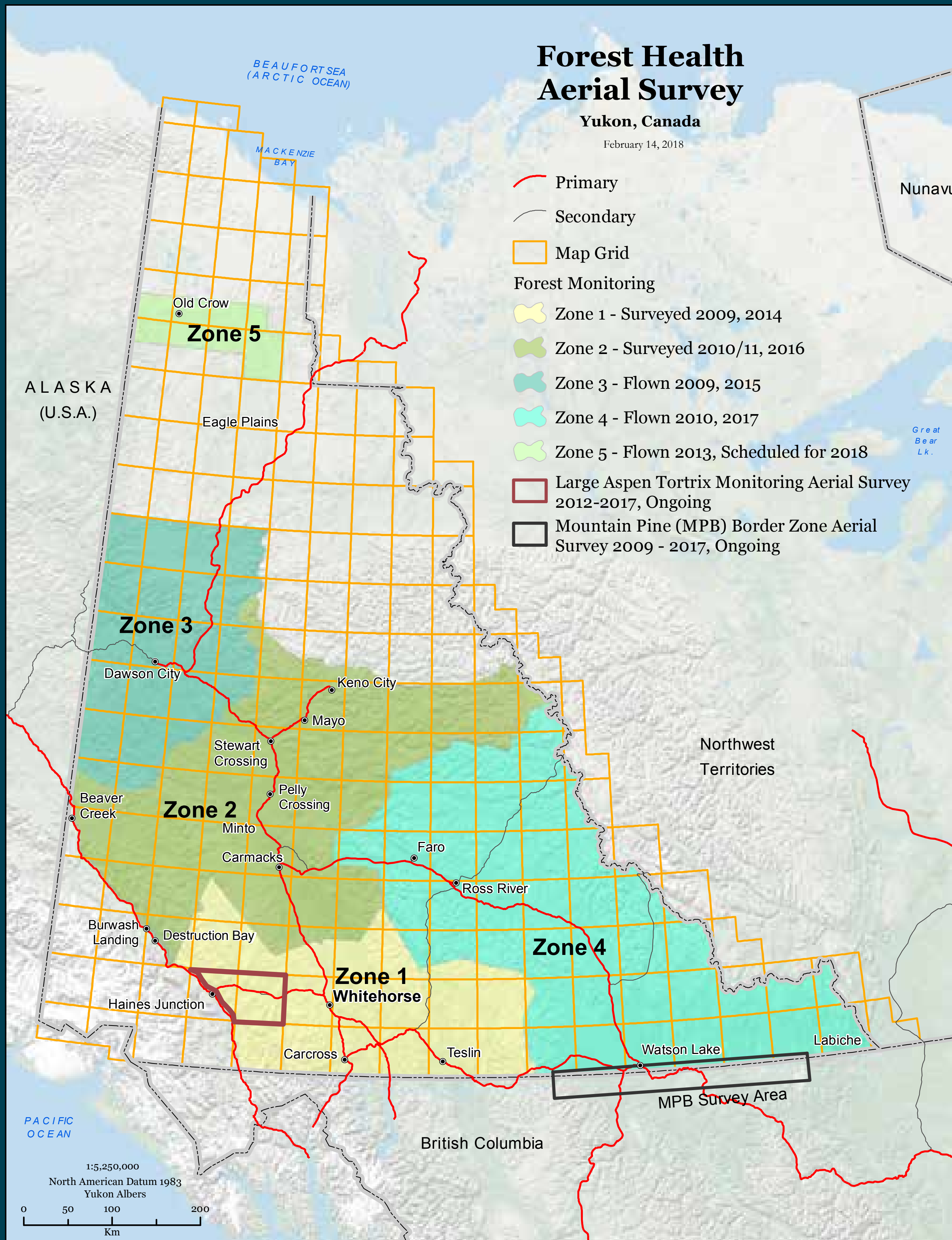
1. Ground checks of areas that sustained wind damage and significant blowdown near Watson Lake to determine if spruce bark beetle was present. Detailed aerial surveys of this blowdown had been completed in 2016.
2. A spruce bark beetle risk assessment of green spruce wood piles along a road right of way near Haines Junction.

COMPONENT 4:

Extension – Community Engagement

FMB prepare and deliver presentations regarding forest health, either for special projects (MPB) or for general information. These are conducted upon request or as required to communicate FMB programs.

FMB also responds to general forest health and pest incident reports from the public and from government agencies throughout Yukon. Pest incidence ground checks include those initiated by the public, and are generally regarded as other noteworthy pests. Public calls generally come from urban areas where ornamental trees are common and human influence greatly expands the range of pests and pathogens that may be found as they tend to be more urban.



MAP 1 Yukon Forest Health Aerial Surveys by year (2009 – 2016) and planned Surveys for 2017 and 2018.

Photo 1 Two-person aerial survey crew and pilot with extended Cessna 206.

ANNUAL FOREST HEALTH AERIAL AND GROUND SURVEYS

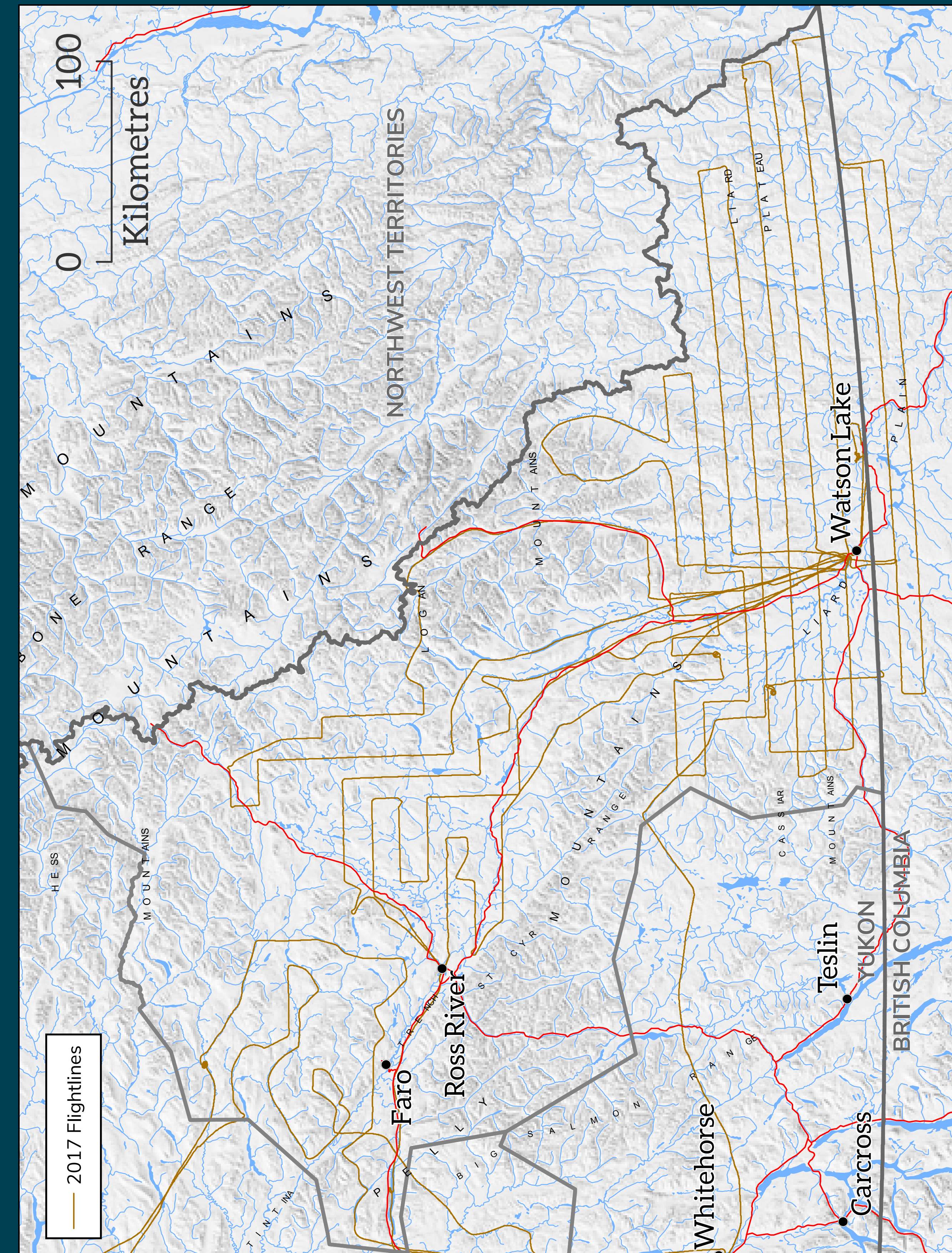
In 2017, forest health surveys were directed at biotic and abiotic disturbances in FHZ 4 and portions of FHZ 1. A six-day aerial survey of the forested area within FHZ 4, and a one-day survey of the area affected by large aspen tortrix in FHZ 1 was flown using an extended Cessna 206 fixed-wing aircraft (Photo 1, Map 2).

FHZ 4 is the largest of the forest health zones. It is bound by two borders; Northwest Territories (NWT) to the east and BC 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 NE 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 (Map 2, Photo 2-4).

FHZ 4 was flown in an east-west grid pattern with 14 km between grids, allowing each surveyor to map seven km on either side of the plane (Map 2). FHZ 1 followed a circuit north and south of the Alaska, and east and west of Haines Road, which captured large aspen tortrix defoliation.

Photo 2 Looking south along the Hyland River near the British Columbia border in the Boreal Cordillera ecozone, east of Watson Lake in FHZ 4.

Photo 3 Selwyn Mountains looking north to Caesar Lakes in the Taiga Cordillera ecozone in the SE portion of FHZ 4 near the NWT border.



MAP 2 Aerial survey flight lines in 2017 over Forest Health Zone 4.

SUMMARY OF 2017 **BIOTIC** AND **ABIOTIC DISTURBANCES**

Given that FHZ 4 south was surveyed in 2010, it is possible to assess trends over time by comparing pest activity in 2010 to 2017 (Table 1). Similarly as the same area has been flown for the last several years in FHZ 1 it is also possible to compare annual trends (Table 1).

Table 1 Summary of recorded forest health disturbances in FHZ 4 in 2010 and 2017, and only areas within the recent large aspen tortrix outbreak in FHZ 1 for 2015-2017. Note: Some stands had a combination of pests – the most dominant pest is noted first.

	FHZ 4		FHZ 1		
DISTURBANCE TYPE	**2010**	**2017**	**2015**	**2016**	**2017**
Biotic	(ha)	(ha)	(ha)	(ha)	(ha)
Western Balsam Bark Beetle	607	10,265	-	-	-
Eastern Spruce Budworm	-	369	-	-	-
Aspen Leaf Miner	53,085	94,390	-	172	135
Large Aspen Tortrix	-	7,106	15,690	1,237	452
Large Aspen Tortrix/Aspen Decline	-		-	1,792	-
Cottonwood Leaf Rust	-	187	-		-
Willow Leaf Rust	-	1,075	-		-
Willow Leafminer	-	442	-	13	-
Abiotic					
Winter wind desiccation	873	-	-	-	1,320
Fire scorch and secondary beetles	469	322	-	-	-
Slide	278	-	-	-	-
Flooding	506	238	-	-	399
Aspen Decline	11	62	-	588	4,618
Windthrow	51	661	-	-	-
Porcupine	1	18	-	-	-
Lightning	1	-	-	-	-
Bear	-	46	-	-	-

BIOTIC DISTURBANCES

Aspen Serpentine Leafminer *(Phyllocnistis populiella)*

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

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

Area infested by this leafminer in 2017 was highly variable, with increases in some areas and decline in others.

In FHZ 4, aspen serpentine leaf miner was noted throughout the host range, in the south along the Liard, Hyland, Coal, and Beaver rivers (Map 3 and Map 4). In the central part of FHZ 4 from Francis Lake NW to Ross River and NE along Canol Road (Map 5), and in the northern section along Pelly, Tay, MacMillan, and Riddell rivers. (Map 6).

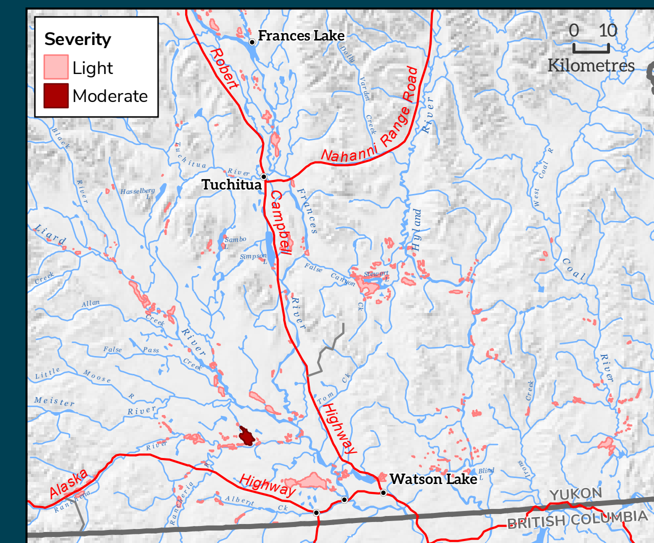
Population levels increased significantly since 2010 when 53,085 ha were recorded to 94,390 ha in 2017. The majority of the defoliation in 2017 was light, accounting for 96% of the defoliation, whereas in 2010 67% was severe, 10% moderate and 23% light. The moderate defoliation which did occur in 2017 was near Rancheria River in the south, and adjacent to the Pelly River near Ross River in the north.

In FHZ 1, aspen serpentine leafminer was mapped over 135 ha along Aishihik River and Kathleen Lake; down slightly from 172 ha mapped in 2016.

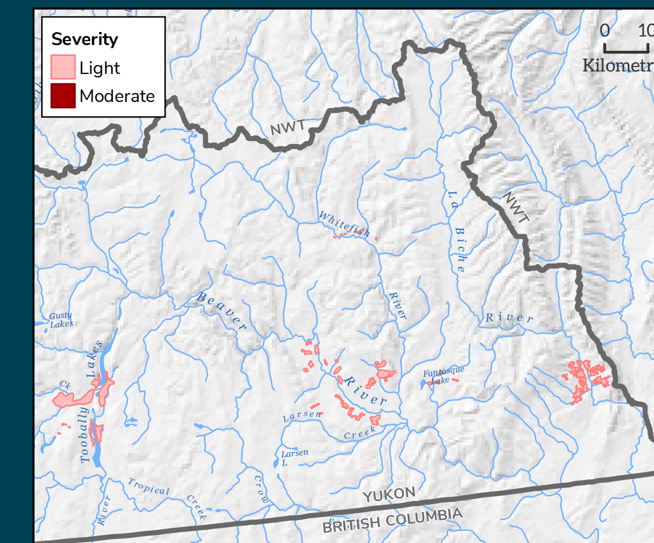
Photo 4 Light to moderate aspen serpentine leafminer SW of Ross River along the Robert Campbell Highway and Pelly River.

Photo 5 Moderate aspen leaf miner east of Watson Lake near Iron Creek.

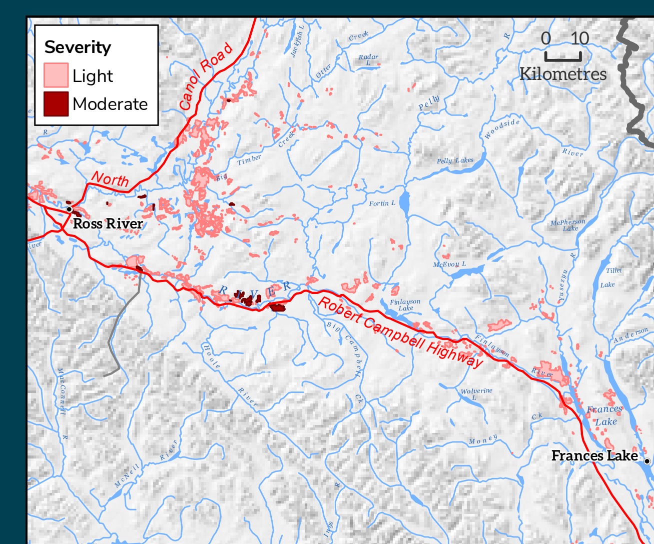
Photo 6 Contrast between healthy aspen stands (center) and currently infested stands (top) along Robert Campbell Highway near Ross River.



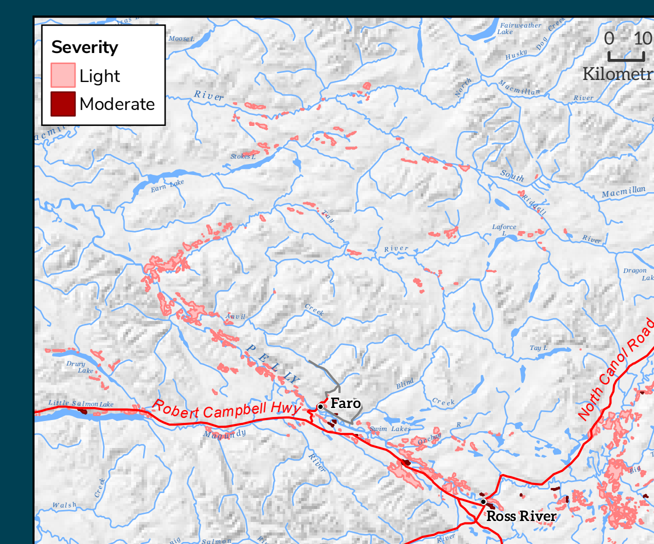
MAP 3



MAP 4



MAP 5



MAP 6

MAPS 3-6 Aspen serpentine leaf miner light to moderate defoliation in FHZ 4 in 2017.

Large Aspen Tortrix *(Choristoneura conflictana)*

Native to North America, the large aspen tortrix is found throughout the trembling aspen's range. Before 1990 and the onset of the spruce bark beetle infestation in the southwest Yukon, it was the single most common cause of insect-based disturbance in Yukon forests. In FHZ 1 the last outbreak was prior to 1990, and occurred in 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.

This insect completes its life cycle in a single year. During that time, larvae pass through five developmental stages, known as instars, before reaching maturity. At the end of each instar, larvae shed their skins and re-emerge as the next larger stage. Small second instar larvae emerge from the tents they have spun for winter quarters in late May or early June. They then feed on the emerging buds and leaves of the aspen trees. In some instances, initial feeding damages the buds to the extent that they fail to flush. At the third instar stage of larval development, they roll the leaves and continue until they complete larval development. Pupation occurs normally at the leaf edge in late June. Adults emerge after about ten days and mate. Then, females lay eggs in small masses on the upper surfaces of leaves. Eggs hatch in early August. After hatching, early instar larvae feed on leaf surfaces until late August. Then at the second instar stage, they hide in the bark crevices. Here they spin webs (hibernacula) for overwinter shelter and enter a hibernation stage known as diapause. At this stage, the water in their cells is replaced with glycol (antifreeze) which allows them to withstand winter temperatures as cold as -27°C.

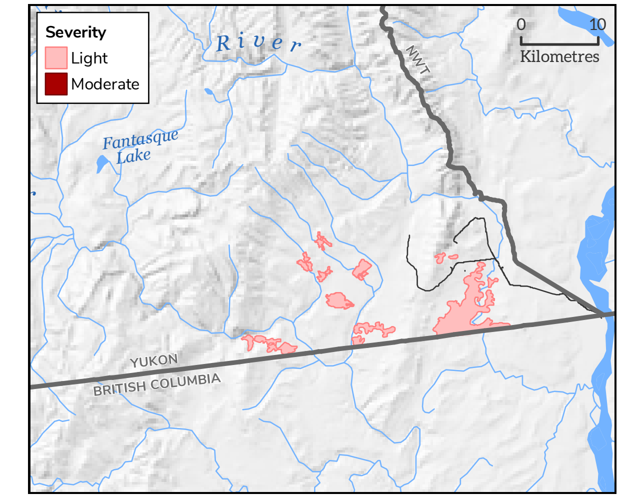
The life history of this insect places it in direct competition with the aspen serpentine leafminer, such that in years when aspen serpentine leafminer populations are low large aspen tortrix feeding is more significant.

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

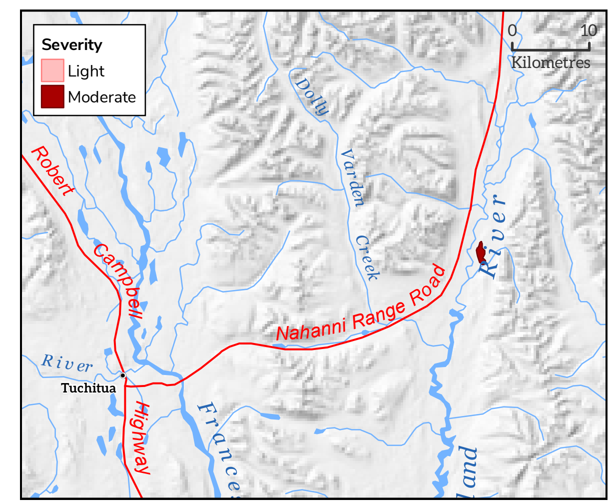
Photo 7 Moderate large aspen tortrix defoliation west of Hyland River NE of Tuchitua.

In FHZ 4 large aspen tortrix caused light defoliation over approximately 6,900 ha, and moderate defoliation over 206 ha, over four separate geographic areas. The majority was in the Liard River drainage in the most southeasterly portion of the zone, along the BC and NWT border (Map 7) with a smaller pocket NE of Tuchitua along the Hyland River (Map 8, Photo 7), Coal Creek (Map 9), and near Faro.

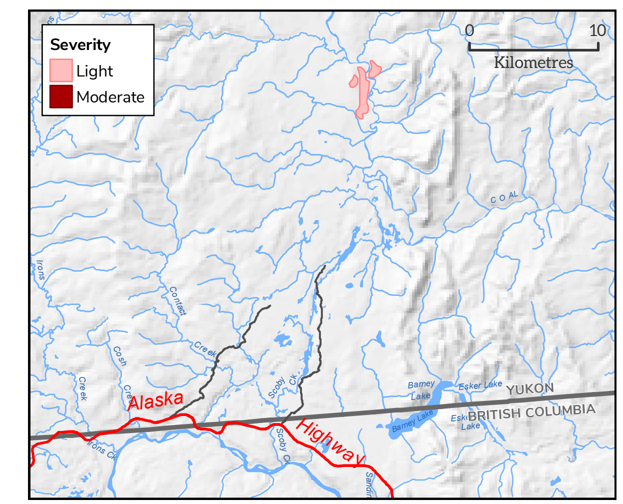
Based on the historical records landscape level events have not been previously recorded in this part of Yukon. However, several outbreaks have been recorded in close proximity to the Yukon border; west and east of the Liard River drainage in BC. The most recent outbreak in British Columbia ended in 2014.



MAP 7 Extensive light large aspen defoliation adjacent to the NWT and BC border.

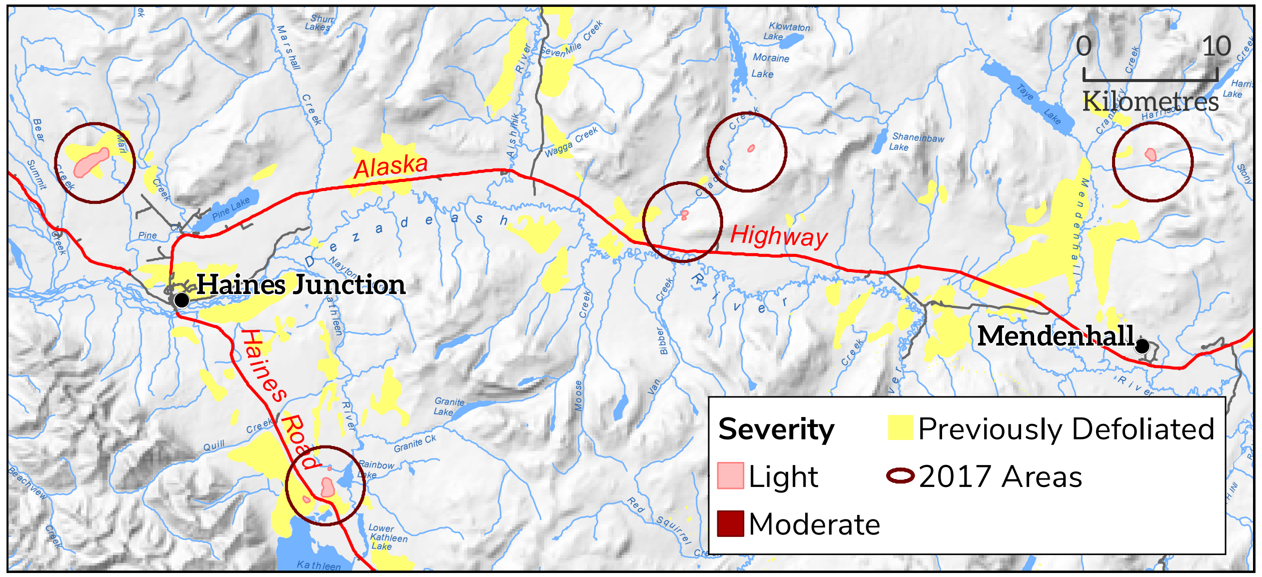


MAP 8 Moderate large aspen tortrix defoliation east of Hyland River along the Nahanni Range Road.



MAP 9 Light defoliation by large aspen tortrix west of Watson Lake, along Coal Creek.

In FHZ 1 populations continued to decline along the Alaska Highway corridor between Mendenhall and Haines Junction and south to Dezadeash Lake. Only 452 ha of light defoliation over four polygons were recorded, down from 3,029 ha in 2016, and 15,690 ha in 2015. This marks the second consecutive year of decline and undoubtedly the collapse of the outbreak that started in 2012. The majority of defoliation occurred in stands which had been previously defoliated, however two new locations were recorded near Cracker Creek (Map 10). Given the longevity of the outbreak there was an increase in the stands with decline symptoms in 2017 (see aspen decline section), however there are still some healthy aspen stands remaining (Photo 9). This confirms the spatial overlay analysis findings from 2016 which indicated that decline symptoms were found in associated with defoliation (see aspen decline section).



Map 10 Current and historic large aspen tortrix defoliation between Mendenhall and Dezadeash Lake.

Photo 8 Light to moderate large aspen tortrix defoliation with aspen decline, north of Haines Junction.

Photo 9 Healthy trembling aspen stands along the Takhini River near Ibex Valley.

Eastern Spruce Budworm *(Choristoneura fumiferana)*

The eastern spruce budworm is a significant conifer defoliator which is found throughout the boreal forest of North America. In Yukon, high budworm populations can result in defoliation ranging from light damage to growing tips to complete tree defoliation. Severe damage is rare, but has been seen in FHZ 4 in the extreme southeast (La Biche area), and near Watson Lake in the upper Liard River drainage. Moderate to severe defoliation can result in top kill and mortality in mature forests, mortality of regenerating trees, and increased susceptibility to secondary bark beetles (e.g., northern spruce engraver beetle (*Ips perturbatus*). Budworm outbreaks are often cyclical, occurring every four to ten years and persisting for one to four years. While the exact causal factors for this cycling are unknown, the forests of southeastern Yukon were moderately impacted by defoliators throughout the late 1980s and early 1990s.

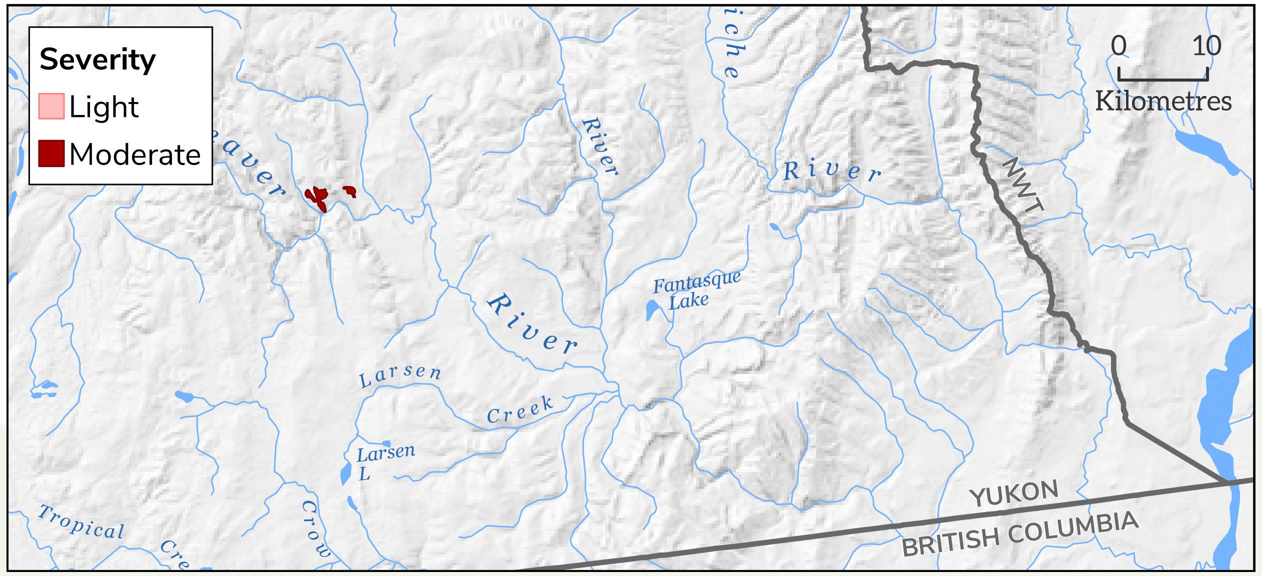
Changing climate has altered, and will continue to alter, the frequency and severity of defoliation events. Changes have already been noted with the first occurrence of eastern spruce budworm in the Mackenzie Delta in NWT occurring in 2015, and ongoing northward expansion in boreal forests of Quebec. In Yukon in 2009, 1,100 ha of defoliation were noted near Stewart landing; this marked the first time it had been noted in that area.

The effects on climate on eastern spruce budworm will be determined by concurrent changes in host phenology, and timing of critical climate events. Defoliator populations could be negatively impacted if the timing of critical stages in the host (spring budburst) means that they are no longer in sync with key life stages of the defoliator (spring larval emergence). Late spring frosts greatly reduce the available foliage and can cause the collapse of budworm outbreaks. On the other hand, defoliator species may benefit from warmer temperatures because of higher rates of overwinter survival, fewer late spring frost events, and longer summer season for growth and reproduction. Elevated carbon dioxide levels would likely reduce the nitrogen content in host needles/leaves, which may have either a positive or negative impact on defoliators depending on their nutritional requirements.

Photo 10 Moderate eastern spruce budworm defoliation near Pool Creek, west of Beaver River.

A short life cycle, mobility, reproductive potential and physiological sensitivity to temperature (insects are cold blooded) will mean that the distribution and diversity of defoliators in general at higher latitudes could change in a relatively short period of time as they take advantage of new climatically suitable habitats. Under a warming scenario, defoliator outbreaks could become more frequent and more severe, which could increase tree mortality, particularly if trees are drought stressed.

In FHZ 4 369 ha of moderate defoliation by eastern spruce budworm were noted in SE Yukon, near Pool Creek just west of Beaver River; an area where defoliation has historically occurred (Photo 10, Photo 11, Map 11). This coincides with findings in 2016 by the Government of NWT who recorded defoliation near Fort Liard and along the Liard River, and forecast an increase in defoliation and severity.



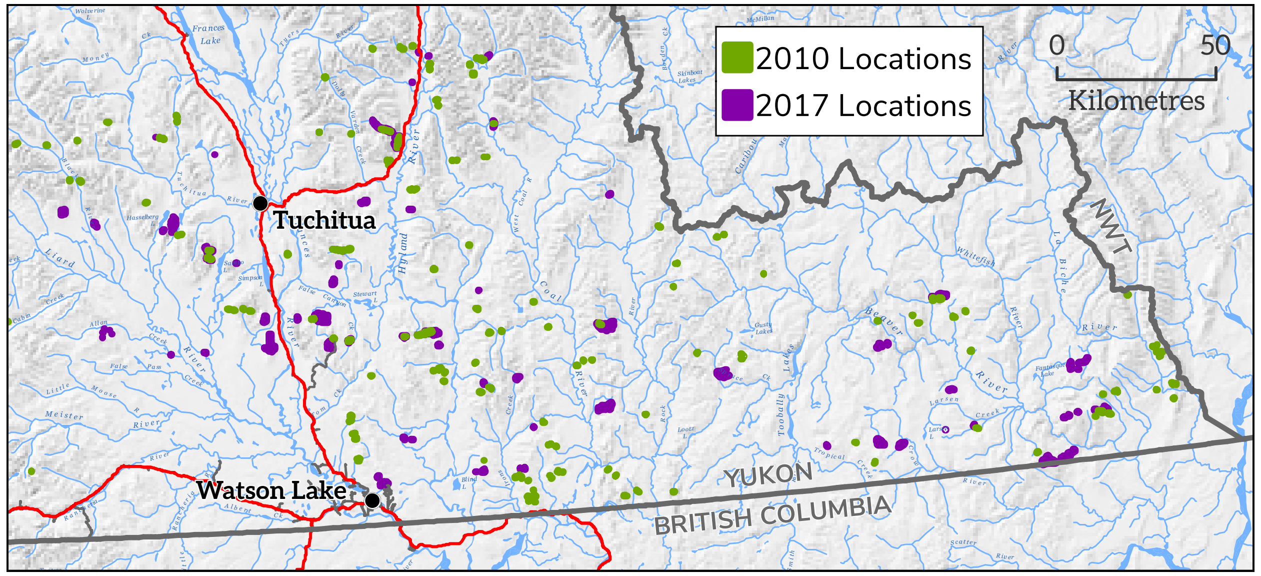
MAP 11 Moderate eastern spruce budworm defoliation west of Beaver River, NW of Watson Lake.

Photo 11 Moderate eastern spruce budworm defoliation near Pool Creek, west of Beaver River.

Western Balsam Bark Beetle *(Dryocoetes confusus)*

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

Over the last 20 years, the western balsam bark beetle has advanced north from BC 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 (<10%), current-year mortality were mapped in the La Biche 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.



MAP 12 Comparison of historical and current location of western balsam bark beetle in SE Yukon.

Photo 12 Scattered and progressive mortality of western balsam bark beetle in mature subalpine fir stand.

In FHZ 4, a significant increase in area infested occurred; from 607 ha, representing over 1000 locations in 2010, to 10,265 ha representing 98 locations in 2017. Possible explanations for this large increase in area are both the ubiquitous nature of this bark beetle once established (Photo 12), as well as the fact that infested trees retain their red foliage for up to four or five years. For the most part spots were mapped in 2010, trace polygons were mapped in 2017; new infestations were only recorded in one area, south of Allan Creek NW of Watson Lake (Map 12).

Willow Blotch Miner *(Micrurapteryz salicifoliella)*

This common leaf miner was first recorded in Yukon in 2007 adjacent to the Stewart River at Stewart Crossing. In 2017 this defoliator was mapped in both southern and northern sections of **FHZ 4**, totalling 442 ha.

Foliar Diseases

A variety of foliar tree and shrub foliar diseases, including foliar rusts, are known to occur in Yukon, many of which require an alternate host to complete their life cycle. Foliar diseases are generally more prevalent when moisture conditions at the time of sporulation are optimum; these tend to be in the wetter years but not restricted to those years if appropriate moisture conditions occur at the right time.

In FHZ 4, willow leaf rust, *Melampsora epitea*, is suspected to have occurred over 1,075 ha in 17 separate areas, ranging from eight to 186 ha in size (Photo 13). Preliminary, it was identified from the air as birch leaf miner, however birch is not a common species in the areas where it was mapped. Ground observations of infected willow near Whitehorse (Photo 14) and Watson Lake found willow leaf rust, a foliar rust that has been recorded throughout Yukon sporadically since the mid-1930s. The tree-level symptoms confirmed on the ground matched those from the air; hence willow leaf rust was deemed the causal agent.

Conifer-cottonwood leaf rust, *Melampsora occidentalis*, is suspected to have caused discoloration of 187 ha of cottonwood in stands adjacent to the Pelly River, NW of Faro.

Photo 13 Suspected light willow leaf rust near Tillei Lake, NE of Francis Lake.

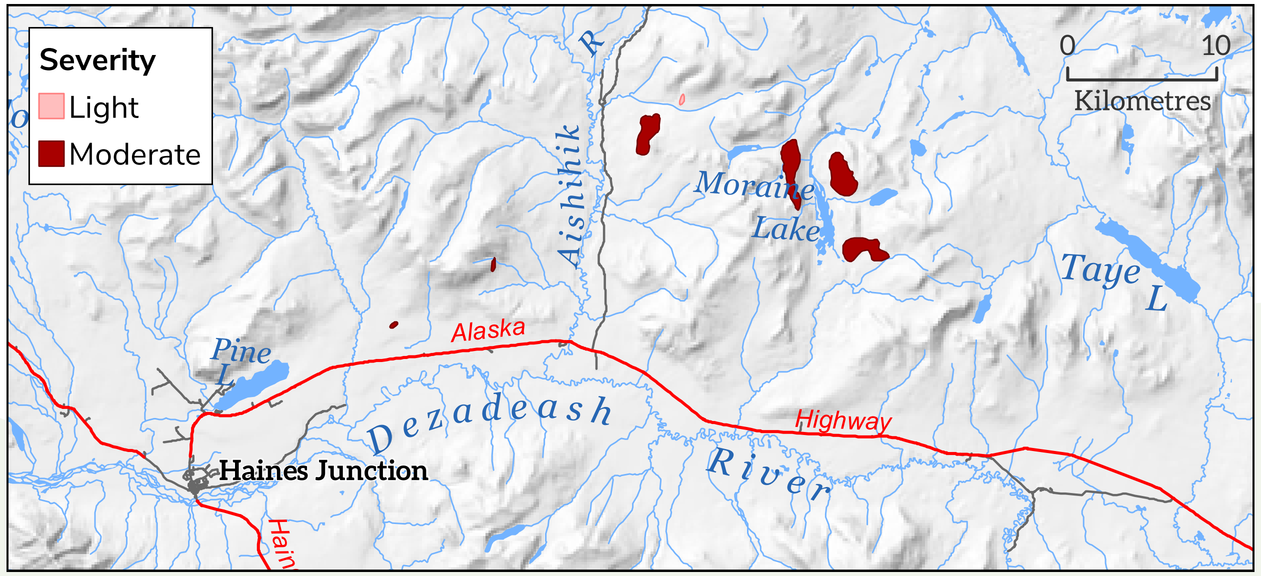
Photo 14 Willow leaf rust adjacent to the Yukon River in Whitehorse. **Inset:** infected foliage.

Photo 15 Winter wind desiccation on white spruce near Klowtaton Lake, NW Champagne.

ABIOTIC DISTURBANCES

Winter Wind Desiccation

In 2017 landscape level winter wind damage occurred over 1,320 ha of higher elevation spruce stands near Moraine Lake and Aishihik Creek in FHZ 1 (Photos 15-16, Map 13). Typical of this type of damage it occurred on one side of the tree. The physiological mechanisms linked to these environmental effects are not yet understood (Hadley and Smith 1983). Suggested causes have included unusually thin needle cuticles (the waxy coating on the surface of the needles) due to the short growing seasons on high elevation sites and 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.



MAP 13 Winter wind desiccation on white spruce NW of Champagne.

Photo 16 Winter wind desiccation on white spruce near Quamie Lake, NW of Champagne.

Photo 17 High water level damage near Aishihik Creek, east of Haines Junction.

Flooding

In FHZ 4 flooding was recorded in 18 different locations totaling 238 ha. The largest was SW of Watson Lake near the BC border at 41 ha. **In FHZ 1** damage due to high water levels was noted on the north side of Pine Lake, and near Aishihik Creek (Photo 17); affecting 399 ha.

Windthrow

In FHZ 4 wind caused damage to white and black spruce stands over 661 ha, the majority of which was east of Pelly Lakes in white spruce. This does not include the windthrow, which occurred in April 2016 near Coal Lake and Iron Creek, east of Watson Lake, which totaled over 477 ha (Photo 18).

Animal Damage

Young lodgepole pine stands were damaged by both porcupines and bears, with the vast majority occurring south of Francis Lake in **FHZ 4**. Spots (1 to 5 trees) of porcupine damage were mapped over 18 ha, with one trace (<1%) polygon mapped north of Beaver River. Bear damage was also mapped in two separate areas, totaling 46 ha, with the largest occurring north of Coal Creek. Bear damage often causes tree mortality, while porcupine damage generally leads to top or branch kill depending upon the location of the damage.

Photo 18 White spruce windthrow mapped in 2016 and assessed in 2017, near Coal Lake, in FHZ 4.

PEST COMPLEXES

Aspen Decline

In the most simplistic terms decline or dieback refers to mortality or damage to forests due to unknown causes, including a possible combination of biotic and abiotic factors. Symptoms include thin crowns, top dieback, stem mortality, and stem breakage. In Western Canada decline has been observed on a number of tree species including yellow cedar, birch, aspen, and cottonwood. According to Canadian Forest Service Forest Insect and Disease historical records for Yukon (which date back to 1952), aspen dieback was first detected in 1987 near Swift River. Since then dieback has been recorded intermittently on a variety of tree species, including cottonwood and trembling aspen. In 2016, 158,367 ha exhibited symptoms of aspen decline in FHZ 2, and 2,130 ha along the Alaska Highway corridor between Mendenhall and Dezadeash Lake in FHZ 1. The vast majority was in combination with defoliators. In 2015, 5,621 ha were affected in FHZ 3, some of which had visible snow and ice damage. Decline was also observed aerially in 2009 (2,488 ha), 2010 (11 ha), and 2011 (529 ha). Ground assessments of aspen mortality in 2008 between Whitehorse and Stewart Crossing found that site and stand conditions also played a role. Open grown and/or sites with poor water retention had a high incidence of pests, such as poplar borers (Saperda calcarata), which contributed to decline of the stands. Similar relationships were found in 2016 in ground assessments of symptomatic stands between Dawson City and Whitehorse.

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

As the climate warms the likelihood of ongoing decline is possible, given the potential for increased frequency of drought events and warmer springs. These changes could result in early spring flush followed by late spring frosts. Changing climate will also lead to changes in biotic factor regimes including changes to pest distribution, severity and frequency, which could also contribute to aspen decline. Ground surveys such as Climate Impacts on Productivity and Health of Aspen (CHIPA) have been developed by Canadian Forest Service to help explain factors involved in causing damage and extent levels in aspen stands.

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

In FHZ 4 only 62 ha of aspen decline were mapped in 2017, up from 11 ha in 2010. This low incidence may be in part due to the lack of large aspen tortrix defoliation.

In FHZ 1 the area with symptoms of aspen decline doubled to 4,618 ha, up from 2,130 ha in 2016 (Photos 19-20) of which 1,792 ha was in combination with large aspen tortrix, and 588 ha was standalone. This increase in area is partially due to higher visibility of affected stands in absence of defoliation, and is indicative of the longevity and severity of the large aspen tortrix outbreak. The largest area with aspen decline occurred along Mendenhall River, also had the highest levels of cumulative large aspen tortrix feeding damage (Map 14). Ongoing surveys should be conducted to determine if the stands recover.

Photo 19 Aspen decline just south of Taye Lake, along Mendenhall River, in FHZ 1.

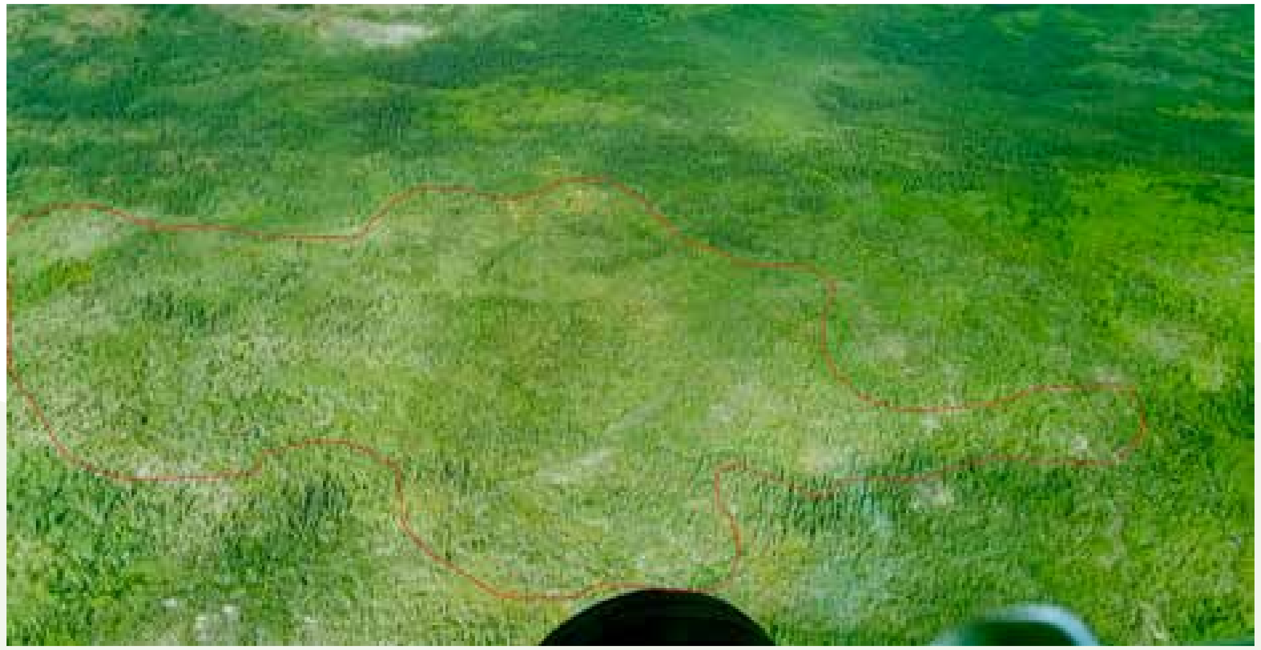
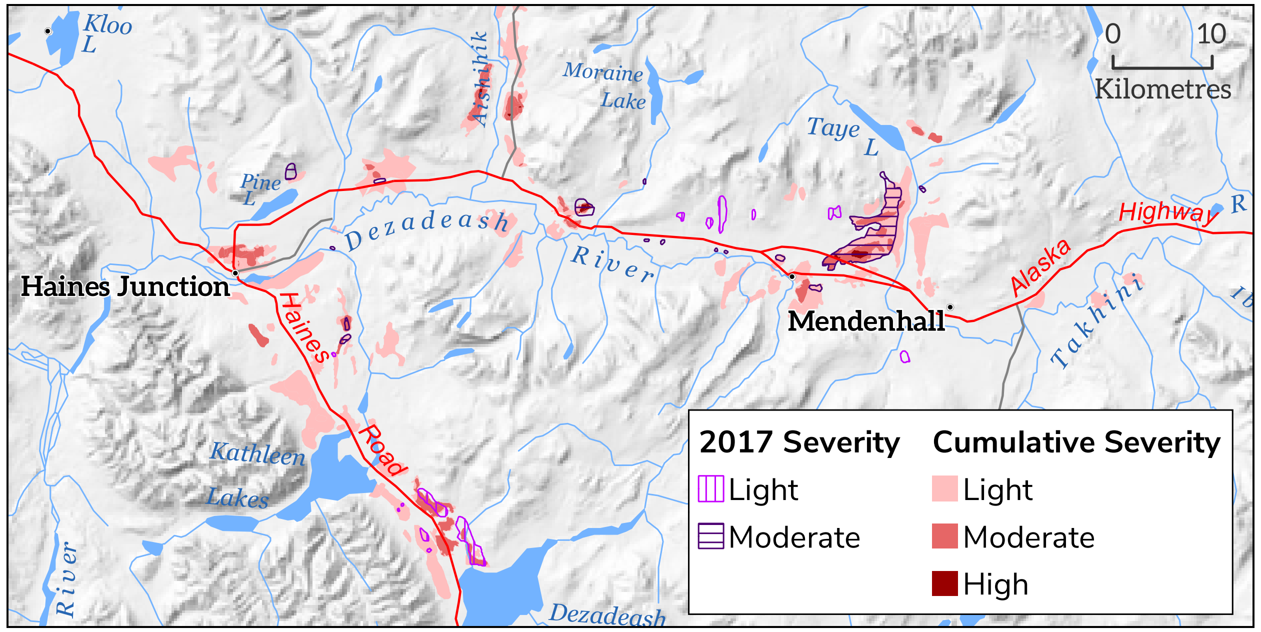


Photo 20 Aspen decline just south of Taye Lake, along Mendenhall River, in FHZ 1.



MAP 14 Location of aspen decline mapped in 2017 relative to cumulative severity of large aspen tortrix defoliation from 2000-2016, in the Alaska Highway Corridor between Mendenhall River to Haines Junction.

Wildfire Scorching and Secondary Beetles

Tree and basal scorching weakens trees such that secondary beetles are capable of overcoming a tree's resistance. In 2017, 322 ha of secondary beetles affected lodgepole pine on the perimeter of wildfires (Photo 21). The most likely causal agent is pine engraver beetle, *Ips pini*, but other secondary beetles may also be involved. Ground checks in 2010 of similar damage found both pine engraver beetle and another engraver beetle, *Ips latidens*.

Photo 21 Secondary beetle activity in previous years wildfires, near Coal Creek in FHZ 4.

PROACTIVE MANAGEMENT OF MOUNTAIN PINE BEETLE (MPB)

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

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

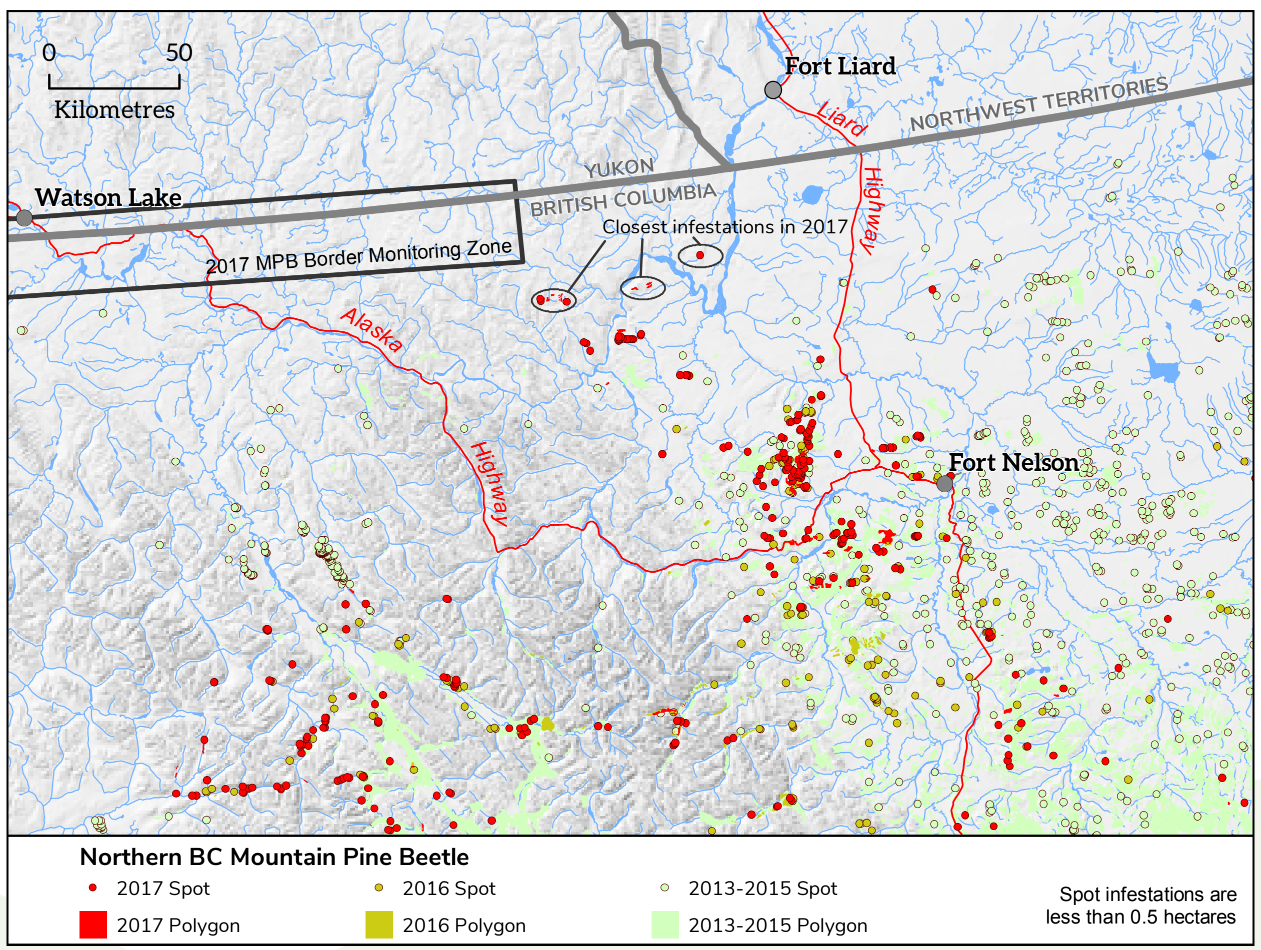
The MPB is one of ten forest health agents that pose the greatest risk to Yukon forests. It can be effectively monitored as part of a risk-based forest health monitoring program. As such, FMB has taken a proactive approach to managing the threat posed by the northward expansion of the MPB from British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

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

MONITORING MOUNTAIN PINE BEETLE (MPB) IN 2017

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

Since that time severe winter cold has killed beetle broods within the trees. That, combined with declining populations in northern BC, has arrested significant northward movement of MPB populations. Hence in 2015, aerial surveys in the RMT were discontinued following two years of insignificant northward movement of MPB in the RMT. In 2017 the RMT was also not flown based on similar aerial survey results (declining populations from BC in 2016).



MAP 15 Mountain pine beetle in northern BC, including the Rocky Mountain Trench, from 2013-2107, and border zone monitoring area. Note based on preliminary BC data.

Border Zone

In 2017, MPB was not found within the BC/YT border zone. Similar to the last three years scattered single red lodgepole pines were observed in this area, suggesting attack by either the lodgepole pine beetle (*Dendroctonus murrayanae*) pine engraver beetle (*Ips pini*) and possibly porcupine. The beetles are indigenous to Yukon and generally attack old or weakened trees, posing no significant threat to forest health. A "typical" attack from MPB usually involves small groups of trees rather than one single tree. However, given the uncertainty of behavior of MPB in novel habitats (pine habitats that have not had a history of MPB infestation) these spots will be monitored as per the monitoring plan. If these spots expand to small groups of affected pine trees, ground truthing may be required to confirm whether the attacks are caused by mountain pine beetle. Currently, MPB is not present in Yukon.

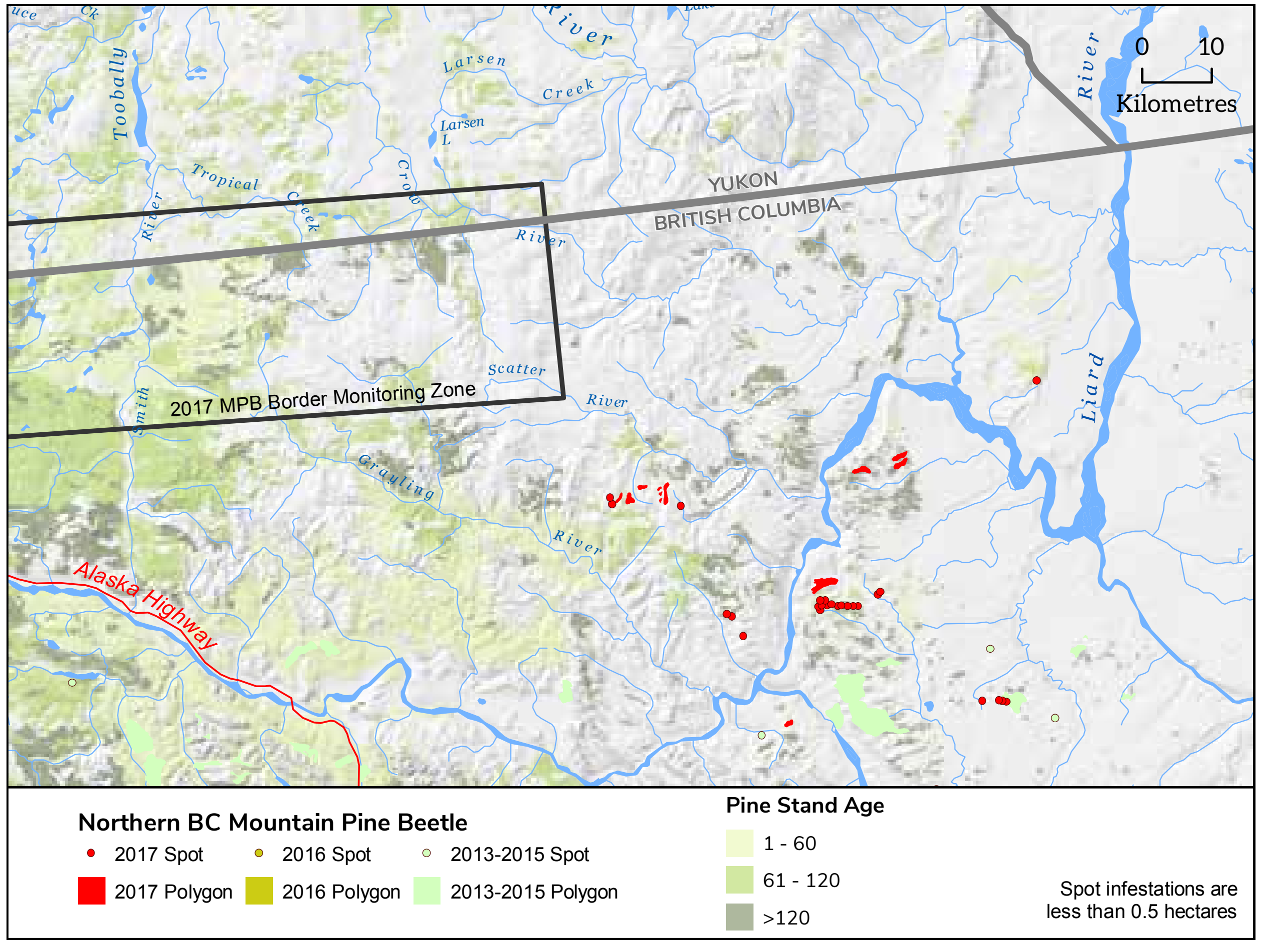
British Columbia Observations

BC's Ministry of Forests, Lands and Natural Resource Operations also conduct aerial surveys in northern BC. These surveys have found that since 2013 populations in the northern Rocky Mountain Trench have retreated with only a few spots noted from 2015-2017. However, east of RMT populations are slowly moving in a NW direction with 11 polygons (unconfirmed) totaling 1,512 ha within 50 km of the border, as well as 20 spots, noted in 2017. These are found in a very fragmented landscape with mature pine near the Scatter and Torpid rivers; both which drain into Liard River (Map 15, Map 16). The closest (unconfirmed) spot was within 30 km of the border. In 2016 the closest (unconfirmed) spot infestation was in a similar location but approximately 100 km south of the border; indicating an advance of approximately 70 km (Map 16). In 2015 a spot was also detected within 30 km of the border in a similar heterogeneous landscape in NE BC; the population has since subsided in that area.

The boundaries of Yukon's monitoring zone in southern Yukon are based on the suitability of the landscape for MPB in terms of hazard and connectivity of lodgepole pine stands. The spots and polygons noted by BC above are within 15 km of the most SE edge of the monitoring zone, as they are within a more heterogeneous landscape. Host fragmentation may not be an impediment to spread as evidenced by this continued NW expansion, and populations could continue to spread towards SE Yukon. However, it is anticipated that westward migration will likely be halted or significantly slowed by the vast young pine stands that resulted from the 1982 "Egg Fire" that burned over 100,000 ha of mature pine (Map 16). These young stands will act as sinks rather than sources given the smaller diameter and thin bark. Given the uncertainty regarding fragmented habitats FMB will continue to monitor the border zone in 2018, and conduct aerial assessments of the 'unconfirmed' MPB areas.

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

If favorable weather occurs for a few years in a row, populations could increase (Bleiker, 2012, pers com). MPB is an opportunistic species and a large pool of susceptible hosts is present. A possible future scenario could result in small remnant populations surviving and crossing the BC/Yukon border into southeast Yukon and killing scattered individual trees or small groups of trees. According to the MPB risk analysis conducted for Yukon, this could occur within the next five to 20 years.



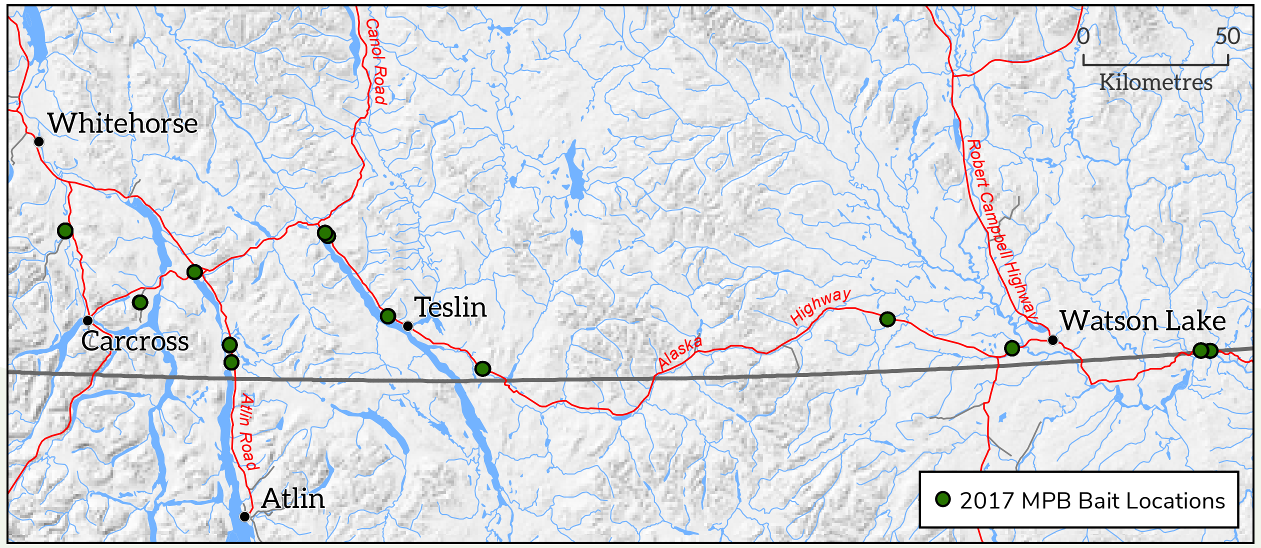
MAP 16 2016 and 2017 MPB detections in northern BC in relation to host distribution and age and Yukon FMB's MPB monitoring zone.

Photo 22 Pheromone placed on the north side of the tree.

Using Bait Traps

Since 2009, FMB has been setting up and monitoring 15 pheromone bait tree stations in southern Yukon to detect the presence of MPB (Map 17, Photos 22-23). 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 2017.

Photo 23 MPB bait tree.



MAP 17 Mountain pine beetle monitoring bait trap locations in southern Yukon and BC, conducted by Yukon FMB.

SPECIAL PROJECTS

Two special projects were undertaken in 2017 to better understand pest disturbances and inform risk management. The first was a continuation of a project initiated in 2016.

1. Ground checks of areas that sustained wind damage and significant blowdown near Watson Lake to determine if spruce bark beetle was present. Detailed aerial surveys of this blowdown had been completed in 2016.
2. A spruce bark beetle risk assessment of wood piles along a road right of way near Haines Junction.

Spruce Blowdown Risk

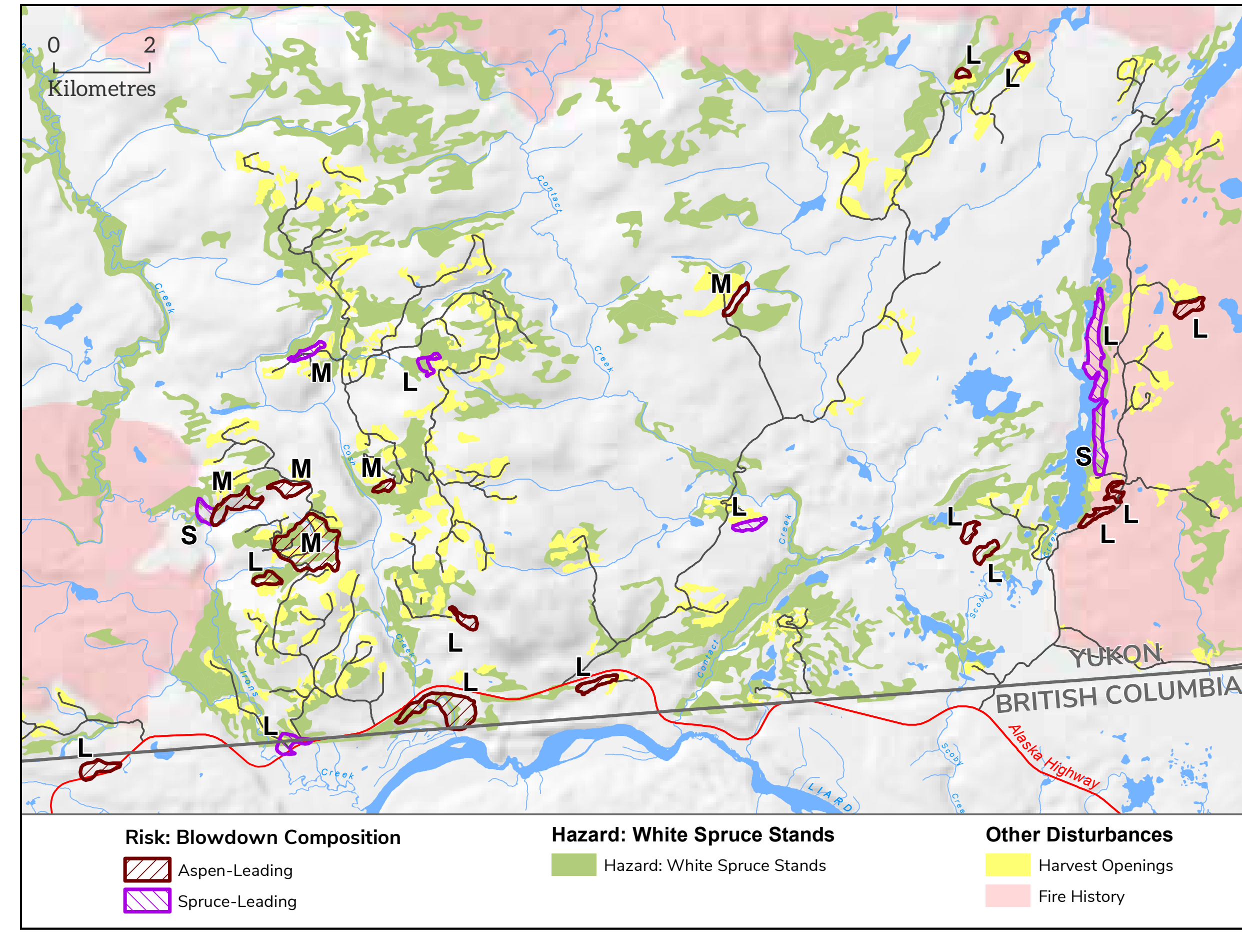
Background

In April 2016, a windstorm resulted in blowdown, some of which was white spruce, approximately 60 km east of Watson Lake, from Contact Creek, YT to Smith River, BC (Map 18). In recognition of the potential for spruce bark beetle, FMB conducted aerial surveys to delineate the area affected in order to assess the spruce bark beetle hazard and risk.

Aerial surveys delineated a total of 477 ha which were affected, the majority of which had low levels of windthrow, and occurred in non-leading white spruce forests. Other tree species which were windthrown included aspen, lodgepole pine, and subalpine fir, none of which have any major forest pest risks associated with windthrow.

As spruce bark beetle preferentially attacks weakened trees, including windthrow, the possibility of spruce bark beetle attacking these windthrow spruce exists. Adults emerging from this windthrow could subsequently attack standing live white spruce trees, hence populations could build and expand, depending upon the local hazard and risk. In terms of landscape level hazard the surrounding area (within Yukon) has a fragmented and discontinuous white spruce landscape, with most stands found along riparian zones or adjacent to lakes (Map 18). Large wildfires have also occurred in three of four cardinal directions (west, north, and east) thereby further reducing the hazard.

Photo 24 Severe spruce windthrow in steep terrain near Coal Lake Road.



MAP 18 Blowdown east of Watson Lake by blowdown severity (L=Low 1=10%, M=Moderate 11-30%, S = Severe >30%) and percentage of white spruce within affected polygons, overlaid against the distribution of white spruce stands in the area.

Ground Assessments

In 2017 ground assessments were conducted to determine if spruce bark beetle was present. This follow-up assessment is viewed as a best practice given the risk associated with spruce windthrow and the recent increase in spruce bark beetle populations in northeastern BC.

Access was limited due to terrain (Photo 24) and lack of helicopter landing sites, hence the assessments were restricted to two areas. No spruce bark beetle was found in standing or windthrown trees. Only low incidence of northern spruce engraver beetle, *Ips perturbatus*, and wood borer galleries (Photo 25) were found in downed material.

- Site 1 – Area with visible signs of dead and dying standing spruce along creek and adjacent to bank with windthrow (Photo 26). There were no signs of spruce bark beetle on dead or dying trees. Mortality was due to fluctuating water levels.
- Site 2 – Area with significant white spruce windthrow adjacent to Alaska Highway (Photo 27). Low populations of northern spruce engraver beetle, and wood borers were found.

Photo 25 Wood borer galleries found in windthrow adjacent to Alaska Highway near Coal River.

Photo 26 Symptomatic white spruce adjacent to creek; damage due to flooding not spruce bark beetle.

Photo 27 Windthrow ground assessment along Alaska Highway near Coal River.

RISK ASSESSMENT OF DECKED WOOD

Pest risk analysis is an internationally recognized process that assesses the pest risk by identifying the likelihood and consequences of pest establishment (Figure 1), and formulates an appropriate risk response. The process is informed by science and evidence, and highlights uncertainties associated with the pest risk analysis. In Canada, the Canadian Council of Forest Ministers has endorsed pest risk analysis (PRA) (CCFM, 2007) as a tool in forest pest management and developed a PRA framework as part of the National Forest Pest Strategy. Participating partners, including FMB, use this framework to help guide pest risk assessment and response. In 2012 this framework was used by FMB to develop the mountain pine beetle (MPB) pest risk analysis in response to the Northward expansion of MPB in BC.

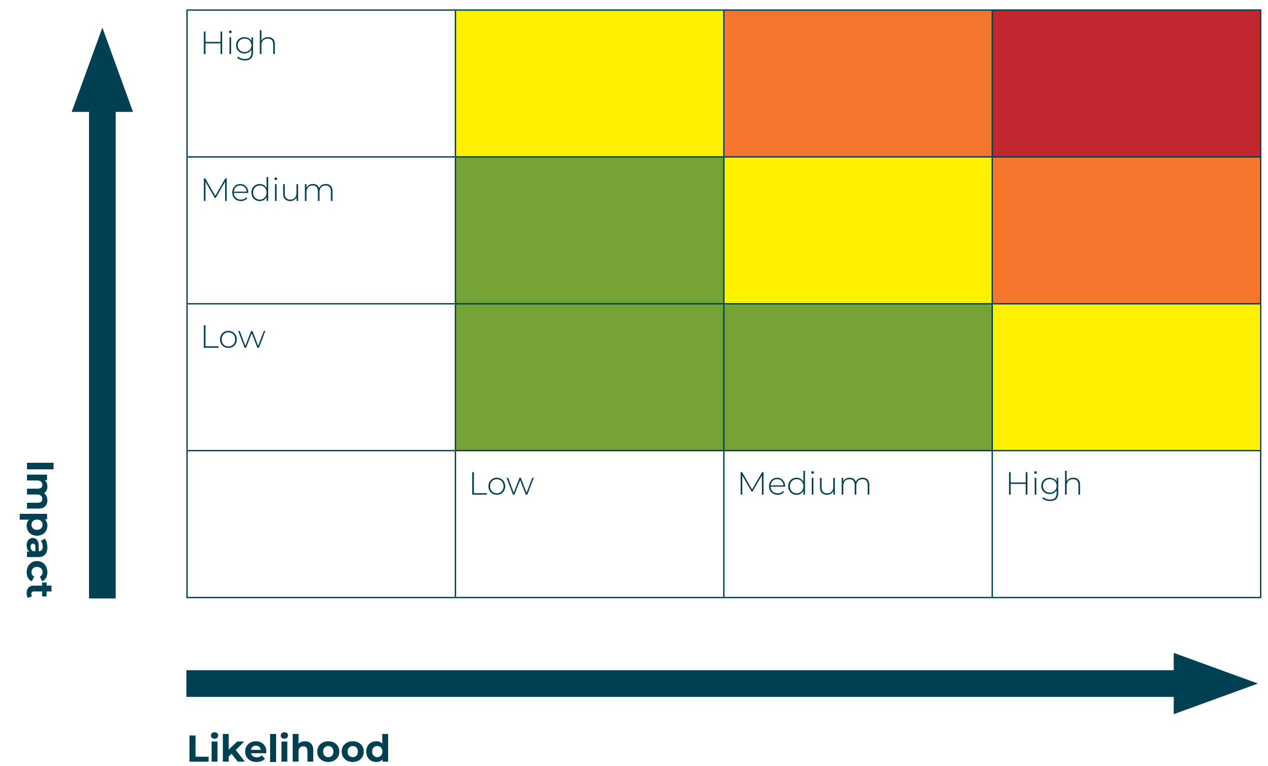


Figure 1 Pest risk matrix – likelihood and consequences of occurrence (Source: International Plant Protection Convention training slide decks).

TRIGGER

Approximately 30 green white spruce wood decks were observed to have bark beetle activity in early June 2017 along a newly constructed Forest Resource Road in the Macintosh East area near Haines Junction. The trees had been felled in the winter of 2015/2016 and decked in the spring of 2016. It is estimated that there are on average 25 to 30 cubic metres (m3) per log deck for a total of approximately 800 m3 green timber.

There has been significant increase in spruce bark beetle populations, both in South Central Alaska and NE British Columbia. Populations in both of these areas have expanded significantly in the last 3 years with outbreak conditions in the Susitna Valley and on the western Kenai Peninsula of Alaska, and in the Peace-Omineca area of NE BC.

ASSESSMENT

Risk

Field assessments of several log decks identified attack by spruce bark beetle (*Dendroctonus rufipennis*) and northern spruce engraver beetle (Ips perturbatus (IPS)); both are native pests to Yukon forests. This identification was based on 1) the presence of IPS larvae and adults beneath the bark, on the boles of felled trees, and on one standing green tree adjacent to the log decks, and 2) spruce bark beetle galleries, larvae and pupa. Galleries of IPS closely resemble those of spruce bark beetle therefore it was difficult to determine how much spruce bark beetle attack existed. Spruce bark beetle main galleries tend to be shallower and full of frass compared to those of IPS (Photo 28). Those were deemed to be spruce bark beetle had ranged from having poor or no larval galleries to well-developed larval galleries with the former being the most common. Both live and dead spruce bark beetle larvae were observed, with live larvae thought to be mid-instar, which would coincide with the two-year life cycle observed in Yukon. One spruce bark beetle adult was found on the log decks which is likely a new attacking adult from local endemic populations rather than an emerging adult from the wood decks given the two-year life cycle. Parasitic fly larvae (Photo 28), predatory clerid beetles, and wood borers (Photo 29) were also found.

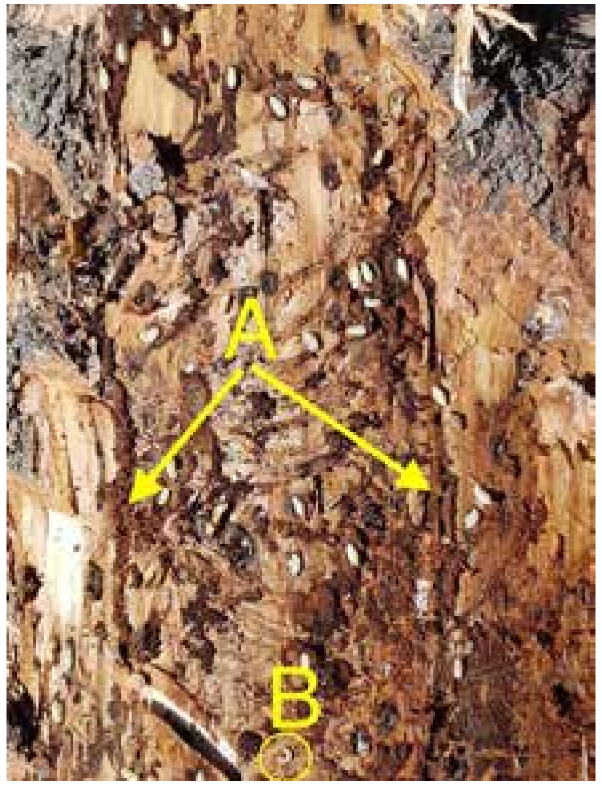


Photo 28 Spruce bark beetle adult and larval galleries with pupa; A. characteristic frass-packed main galleries, and B. parasitic fly larvae.

Photo 29 Wood borer larvae and tunnels on decked wood.

Hazard

The surrounding forest has a significant composition of mature white spruce, hence a high adjacent hazard.

Pest Characterization - Biology and Observed Behavior

SPRUCE BARK BEETLE

Spruce bark beetle (SBB) preferentially attacks suppressed or predisposed trees (windthrow, drought, other disturbance). However once populations build in these predisposed trees; SBB populations are such that they are capable of attacking and killing standing healthy mature trees. This could lead to outbreak conditions at a landscape level, as recently witnessed in Yukon and Alaska. The life cycle in Yukon takes two years, with larvae overwintering in the first year and mostly adults (at the base of the tree) in the second year. Adults emerge in the spring/early summer two years after initial attack to disperse and attack new trees.

Based on the field observations it appears that the log decks were attacked by endemic spruce bark beetle in the spring of 2016, shortly after they were decked. Based on the presence of spruce bark beetle larvae and pupa it is anticipated that these will develop through summer of 2017; overwinter as teneral adults; emerge and disperse to attack new healthy trees in the spring of 2018. The teneral adults (Photo 30) that develop from pupa must overwinter to emerge the following spring as sexually mature adult spruce bark beetles. Given sufficient spruce bark beetle populations these could potentially expand into a larger scale infestation in standing trees.

- The **likelihood of establishment/ expansion** into adjacent standing trees is **low to medium** based on observed populations in decked material, the presence of stressed standing trees from road building, and possibly IPS attack.
- The **consequence of expansions** are **high** given the value of the adjacent white spruce, and potential for larger scale eruption given suitable host connectivity and climate.
- The overall **spruce bark beetle risk** is deemed **medium** based on Figure 1 matrix.
- **Uncertainty** is moderate as the assumption is they are on a two-year life cycle and the decked wood will have sufficient moisture to sustain insects through another winter.

Photo 30 Teneral adult spruce bark beetles emerging from pupa. **Note:** tenerals must overwinter to emerge the following spring as sexually mature adults to disperse and attack new host trees.

NORTHERN SPRUCE ENGRAVER BEETLE

Northern spruce engraver beetle is considered a secondary bark beetle that attacks stressed trees e.g. abiotic damage, human disturbance, or infested with spruce bark beetle. However when host conditions are suitable e.g. availability of stressed host, populations can build and attack standing healthy trees. This was observed in the last spruce bark beetle outbreak in Yukon, as well as in 2007-2008 along the Yukon River south of Dawson City as a result of severe drought. In Yukon IPS has one or two generations per year, hence trees attacked in the spring produce adult populations in the same year. These adults overwinter in the duff and emerge to attack new host material in spring/early summer (May-June). Unlike spruce bark beetle, IPS generally attacks smaller diameter standing host material.

Based on field observation of both adults and larvae it appears that log decks were attacked in late spring/early summer of 2016 and possibly again in spring 2017 given the warm temperatures. Adults will continue to emerge in June and potentially attack stressed trees along the roadway border. Populations could build and continue to attack trees depending upon host stress levels.

- The **likelihood of expansion** into standing trees is high given the proximity of the adjacent high hazard host material and the presence of stressed trees along the roadway perimeter.
- The **consequence of expansions** are **medium** given their preference for smaller diameter stems, however they could serve to predispose trees to SBB attack.
- The overall IPS **risk** is deemed **medium** based on Figure 1 matrix.
- **Uncertainty** of attack to adjacent standing trees is **low** given the high populations observed in the log decks, and moderate to high regarding populations building in the adjacent stand.

Overall Risk

The overall risk is rated as **medium** with low to moderate uncertainty.

Risk Response

Given a forest pest management objective of minimizing the risk from forest pests to forest resource values the proposed risk response is to remove all decked wood prior to spruce bark beetle flight, which is projected to be spring of 2018.

In October 2017 Yukon Wildland Fire Management burned 30 piles of decked wood (Photo 31). The project consisted of six days of wood burning.

Photo 31 Burnt deck of white spruce in the Macintosh East area near Haines Junction.

FOREST HEALTH EXTENSION

Forest Management Branch made several presentations to various stakeholders in 2017 to familiarize them with various aspects of the program.

OTHER NOTEWORTHY DISTURBANCES IN 2017

As part of the forest health program FMB assists both the public and other government agencies in identification of forest pests. This section includes those pests which are either mostly urban in their occurrence, or those observed on the ground but 1) not visible during aerial surveys, or 2) outside forest health monitoring zone 2.

Disturbance	Host	Setting	Location	Comments
Amber birch leafminer, Profenusa thomsoni	Birch	Urban	Watson Lake	Photo 32
Powdery mildew	Trembling aspen	Urban/Forest	Whitehorse	Photo 33

Photo 32 Birch leafminer on birch near Watson Lake.

Photo 33 Powdery mildew on aspen along Yukon River in Whitehorse.

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