2016 Yukon Forest HEALTH REPORT

Yukon
Energy, Mines and Resources
Forest Management Branch

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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 FMB 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 (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 seventh year of aerial surveys, marks the second time that a forest health zone has been resurveyed (two years of data). 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 eight km gridlines to 12 km gridlines. The only exception will be in years when significant pest activity has been noted.

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 (B.C. 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 B.C. 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 – in 2014 FMB modified this to a six km wide corridor given that baseline data has been captured for each forest health zone.
- 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.

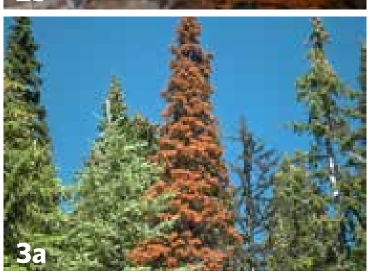
The following is a rationale (based on Ott, 2008) for the identification of major forest health concerns that pose the greatest risks to Yukon forests:

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 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, 2014).

2a Single tree attack.
2b Young adults and larva.



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

3a Single tree attack Watson Lake.
3b Adult western balsam bark beetle.

4. Budworms (*Choristoneura* spp.)—The budworm guild, comprising of eastern spruce budworm, fir-spruce budworm, two-year cycle budworm and western black-headed budworm, 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, 2014).

4a Defoliation to tips of mature spruce trees 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.

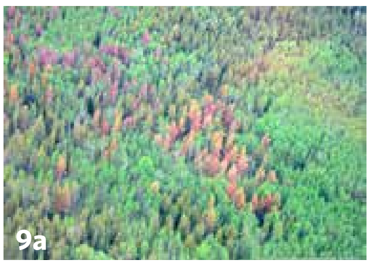
6a Stand Level defoliation Haines Junction, YT.
6b Adult moth large aspen tortrix.

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 in Dawson City, YT.
7b Leaf damage.

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).

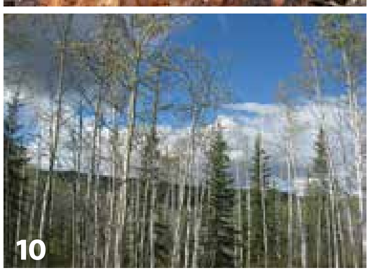
8a Stand level damage of young pine Minto, YT.
8b Damage to needles of young pine.



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 B.C. 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 in Rocky Mountain Trench, BC.
9b Surviving larva at base of tree in 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 Dieback of Aspen, 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 2016
FOREST HEALTH INITIATIVES

The following four initiatives were completed by Forest Management Branch in 2016:

Component 1: Annual Forest Health Aerial and Ground Surveys

During 2016, two separate aerial surveys were undertaken in order to map Yukon forest disturbances as described in the Yukon Forest Health Monitoring Strategy (Map 1):

i. Four-day aerial survey to map FHZ 2 (Central Yukon)
ii. 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

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

The Five Year Mountain Pine Beetle Monitoring Strategy, implemented in 2013, describes and outlines monitoring activities for the next five years in the Yukon. This plan 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

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).

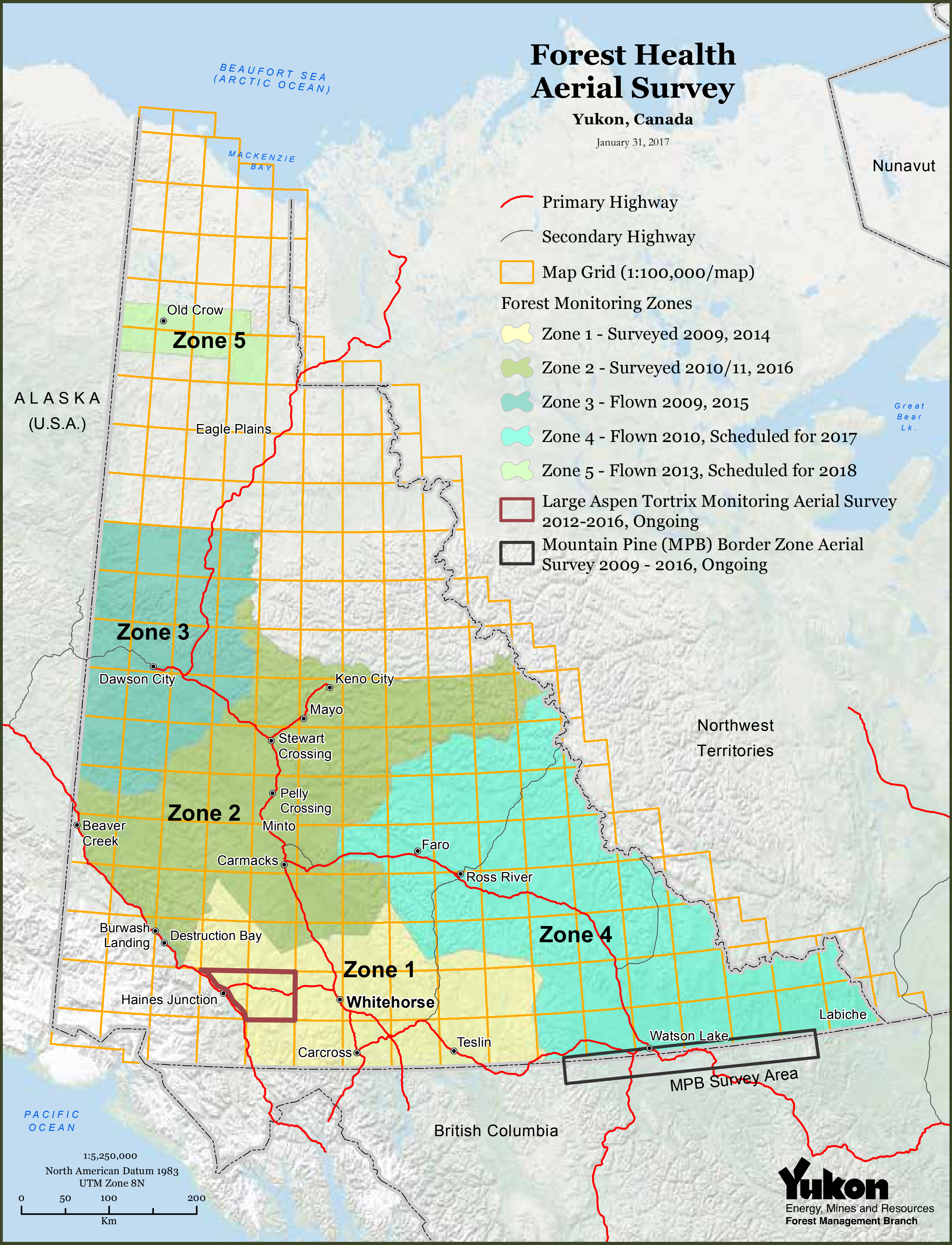
In 2016 two special projects were initiated:

1. Identification of factors contributing to aspen decline.
2. Detailed aerial surveys to map recent blowdown event near Watson Lake to better understand the potential spruce beetle risk.

Component 4: Extension – Community Engagement

Forest Management Branch prepare and deliver presentations regarding forest health, either for special projects -
e.g. mountain pine beetle, or general information. These are conducted upon request or as required to communicate FMB programs.

Forest Management Branch also responds to general forest health and pest incident reports from the public and from government agencies throughout Yukon. Ground checks include those initiated by the public - e.g. extension work, 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 such as Yellow-headed spruce sawfly.



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 extended Cessna 206

ANNUAL FOREST HEALTH AERIAL AND GROUND SURVEYS

In 2016 forest health surveys were directed at biotic and abiotic disturbances in FHZ 2 and portions of FHZ 1. A four-day aerial survey of the forested area within FHZ 2, 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).

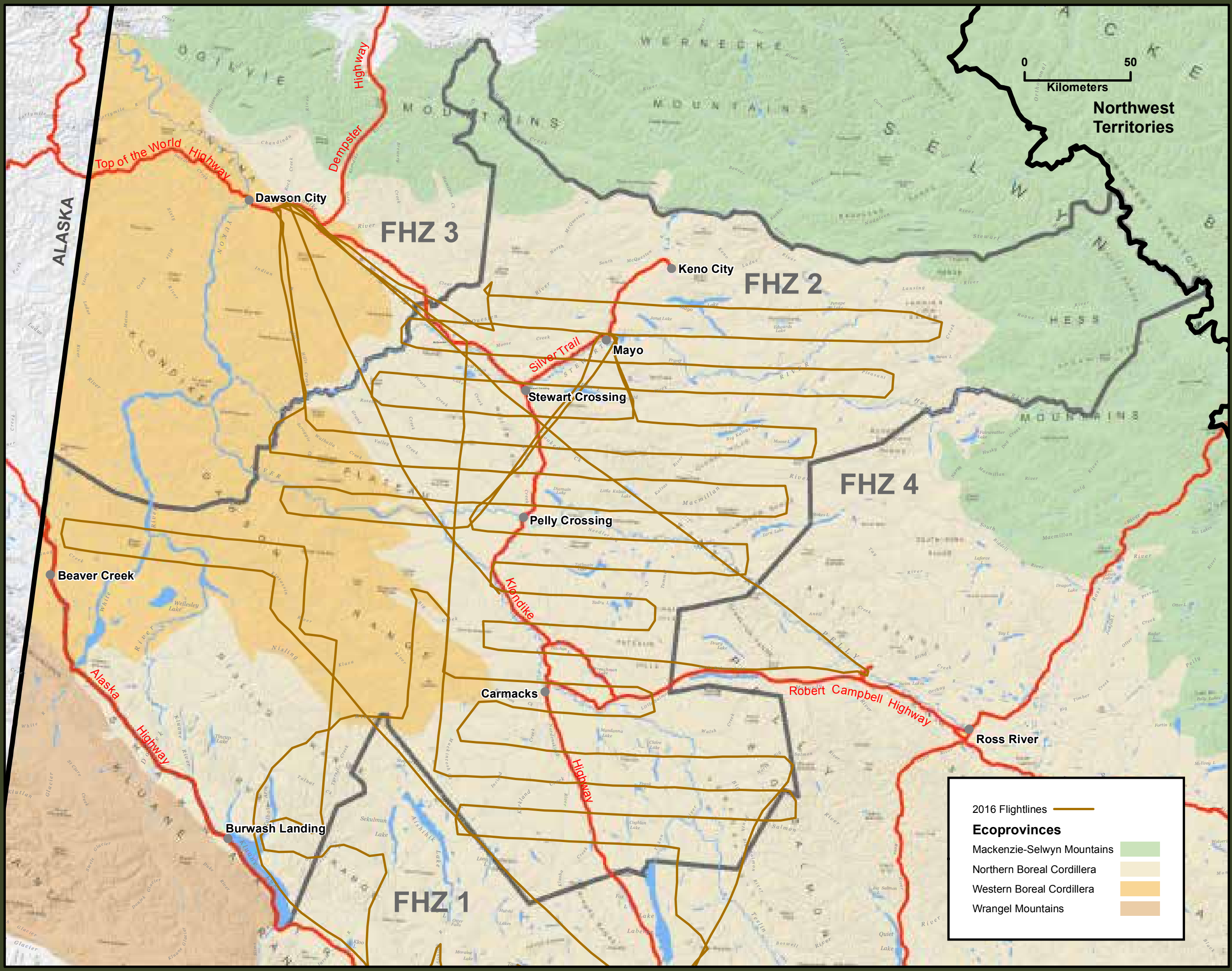
Forest health zone 2. The primary area surveyed in 2016, is a large area bounded on the south (approximately) by latitude 61° 00′ North, extending northward to latitude 64° 10′ North. To the north it runs along the Hess River, south towards the Glenlyon Range and then to Mount Black. To the west it is bordered by Kluane National Park and to the NE from Kluane to Ogilvie Mountains. It falls mostly into the northern boreal cordillera ecozones but also includes western boreal cordillera, MacKenzie-Selwyn Mountains, and a very small portion in the Wrangell Mountains in Kluane National Park (Map 2, Photo 2-4).

FHZ 2 was flown in an east-west grid pattern with 12 kilometres between grids, allowing each surveyor to map six 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 the large aspen tortrix outbreak.

Photo 2 Northern boreal cordillera ecozone near Mount Joy in northeast portion of FHZ 2.

Photo 3 Western boreal cordillera ecozone east of Starvation Mountain along western boundary of FHZ 2.

Photo 4 White River in the western section of FHZ 2 in the western boreal cordillera ecozone.



MAP 2 Aerial survey flight lines in 2016 over Forest Health Zone 2.

SUMMARY OF 2016
BIOTIC AND ABIOTIC DISTURBANCES

Given that FHZ 2 south was surveyed in 2011 and FHZ 2 north in 2012, it is possible to assess trends over time by comparing pest activity in 2011 and 2012 to 2016 (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 Summary of recorded forest health disturbances in FHZ 2 (2011, 2012), and 2016, and only areas within the recent large aspen tortrix outbreak in FHZ 1 and FHZ 3.

Note: Some stands had a combination of pests – the most dominant pest is noted first.

ONLY along Highway Corridor between Pelly Crossing and FHZ 3 border.
Note direct comparison between 2014 and 2015 not possible as FHZ 1 not flown entirely in 2015.

		ZONE 2		ZONE 1	
DISTURBANCE TYPE	**2011 & 2012**	**2015**	**2016**	**2015**	**2016**
Biotic					
Aspen serpentine leaf miner	181,900	2,889	32,884		172
Aspen serpentine leaf miner/large aspen tortrix					
Aspen serpentine leaf miner/aspen decline			144,655		
Large aspen tortrix	730	29,250	6,106	15,690	1,237
Large aspen tortrix/aspen serpentine leaf miner		3,315			
Large aspen tortrix/aspen decline		650	12,648		1,792
Birch leaf roller	468		847		
Spruce beetle	48				
Western balsam bark beetle	6		27		
Willow blotch miner	168	29	526		13
Northern spruce engraver beetle			36		
Pine needle disease	7,116		85		
Abiotic					
Aspen decline	906		513		588
Flooding	213	8	48	49	
Drought - spruce			35		
Drought - aspen	20				
Landslide	234				
Windthrow					
Pest Complexes					
Aspen decline/serpentine leaf miner			1,064		
Porcupine/lodgepole pine beetle	26	0.5	15		

BIOTIC DISTURBANCES

Aspen Serpentine Leafminer (*Phyllocnistis populiella*)

The aspen serpentine leafminer is a defoliator of trembling aspen (*Populus tremuloides*) and is common throughout the host range in Yukon. The leafminer's activities were first recorded in the early 1950s along the Alaska Highway. At endemic levels, single leaf infestation is common but whole tree infestation occurs during outbreaks. Current outbreaks in Alaska and Yukon have impacted hundreds of thousands of hectares of mature and immature aspen. 10 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*) drought and age..

Area infested by this leafminer continues to decline overall in the Yukon, with 2016 marking the fifth consecutive year with minimal activity by this insect pest.

In FHZ 2, population levels did not change significantly from 2011/2012 to 2016, however they did increase significantly from that noted last year between Pelly Crossing and FHZ 3 border.

In 2011/2012 the area affected was 181,900 ha which remained similar in 2016, at 177,539 hectares. The defoliation intensity was not as severe in 2016; equally divided between light (90,968 ha), and moderate (79,897 ha) with some areas of severe aspen serpentine leafminer and aspen decline (2,331 ha). In 2012 populations in the northern part of FHZ declined significantly and was suspected to be due to adverse environmental conditions based on research conducted in Alaska.

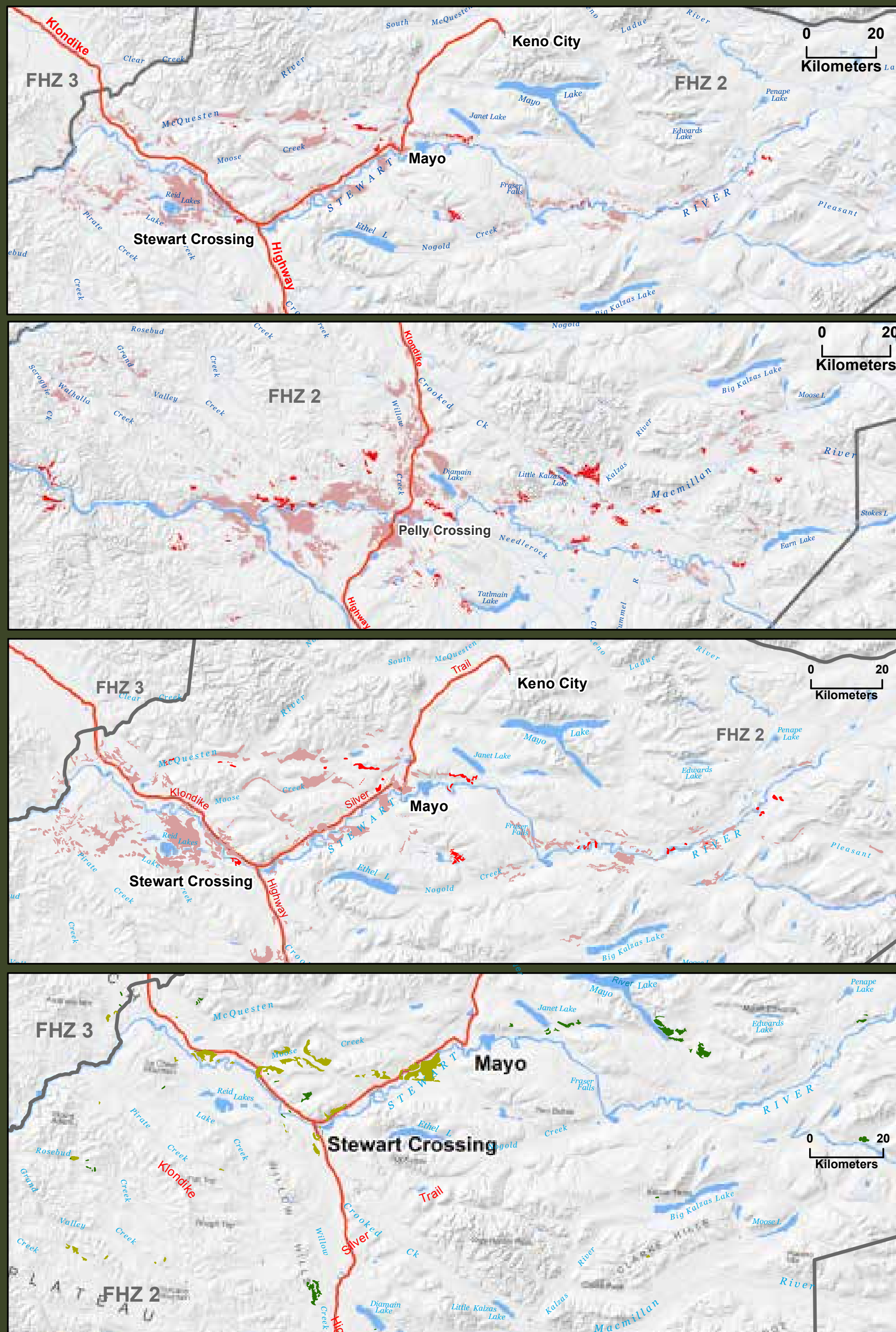
Eighty-two percent of the area infested was identified as a combination of aspen serpentine leaf miner and aspen decline, and the remainder solely as aspen serpentine leafminer (Map 3). Areas mapped in combination with aspen decline were done so due to thinning crowns, many so thin that the tree stems were often visible from the air. Seventy-five percent of these areas occurred in areas previously defoliated by aspen serpentine leafminer or large aspen tortrix, which may in part be responsible for some of the crown and stand symptoms. See aspen decline in special projects section.

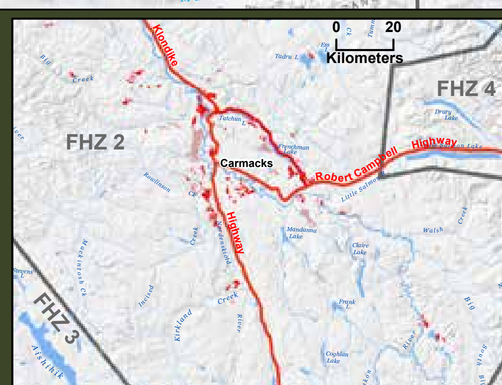
Aspen serpentine and aspen decline was recorded near Carmacks, Pelly Crossing, Stewart Crossing and Mayo; from northeast of Laberge Lake in the south, to McQuesten River in the north (Map 3, Photo 5-6). The area recorded as defoliated in 2015 between Pelly Crossing and FHZ 3 boundary increased significantly in 2016, however the presence of large aspen tortrix in 2015 make have underestimated the levels of aspen serpentine leafminer.

In FHZ 1, aspen serpentine leafminer was mapped over 172 hectares along Salmon River, just east of FHZ 2 border.

Photo 5 Moderate aspen serpentine leafminer with minor aspen decline, north of Pelly Crossing near Diamain Lake.

Photo 6 Severe aspen leaf miner with moderate to severe aspen decline, along Willow Creek north of Pelly Crossing.





MAP 3

Areas where serpentine leafminer was the dominant defoliator in FHZ 2, and in combination with aspen decline, as observed in 2016 aerial surveys.

Large Aspen Tortrix *(Choristoneura conflictana)*

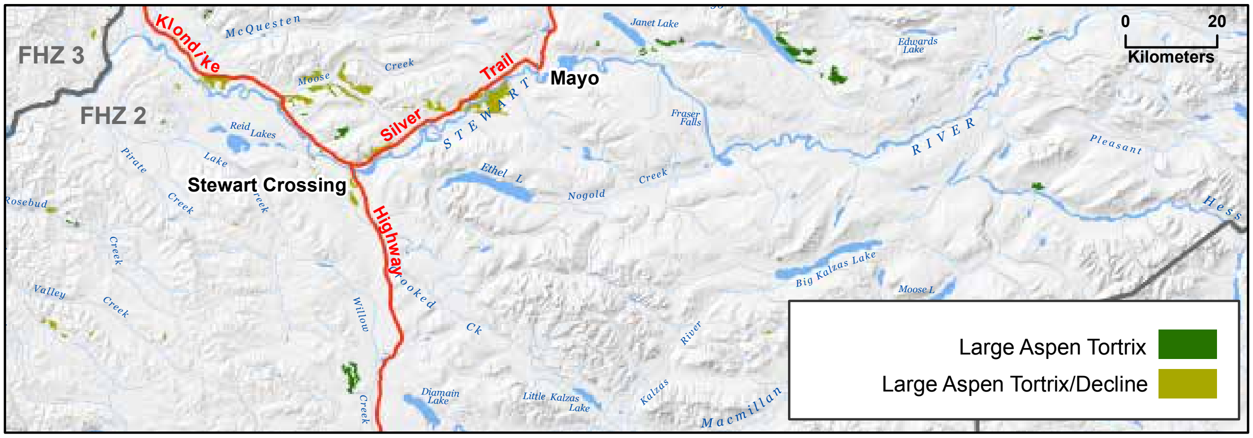
Native to North America, the large aspen tortrix is found throughout the trembling aspen's range. Before 1990 and the onset of the spruce bark beetle infestation in the southwest Yukon, it was the single most common cause of insect-based disturbance in Yukon forests. In FHZ 1 the last outbreak was prior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

This insect completes its life cycle in a single year. During that time, larvae pass through five developmental stages, known as instars, before reaching maturity. At the end of each instar, larvae shed their skins and re-emerge as the next larger stage. Small second instar larvae emerge from the tents they have spun for winter quarters in late May or early June. They then feed on the emerging buds and leaves of the aspen trees. In some instances, initial feeding damages the buds to the extent that they fail to flush. At the third instar stage of larval development, they roll the leaves and continue until they complete larval development (Photo 11). 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. This inter-specific competition (individuals of different species compete for the same resource) may be contributing to the success of large aspen tortrix in 2015 as aspen serpentine leafminer populations have declined significantly over the last 2 years. The outbreak in FHZ 1 began in 2012, and in 2015 in FHZ 2 and FHZ 3.

In FHZ 2 the area defoliated by large aspen tortrix decreased significantly to 18,754 hectares, versus 33, 215 hectares recorded between Pelly Crossing and FHZ 3 border in 2015 (Map 4, Photo 7). Sixty-seven percent of defoliation occurred in stands with aspen decline symptoms. The majority occurred in stands along the Klondike Highway corridor between Pelly Crossing and FHZ 3 border, and along Stewart River to Mayo. Isolated populations were noted east of Mayo; on the east side of Mayo Lake, the headwaters of Stewart River and Hess Creek, near Big Kalzas Lake, and near Donjek River. Isolated pockets also occurred west of the Klondike Highway near Rosebud, Grand Valley and Pirate Creeks.

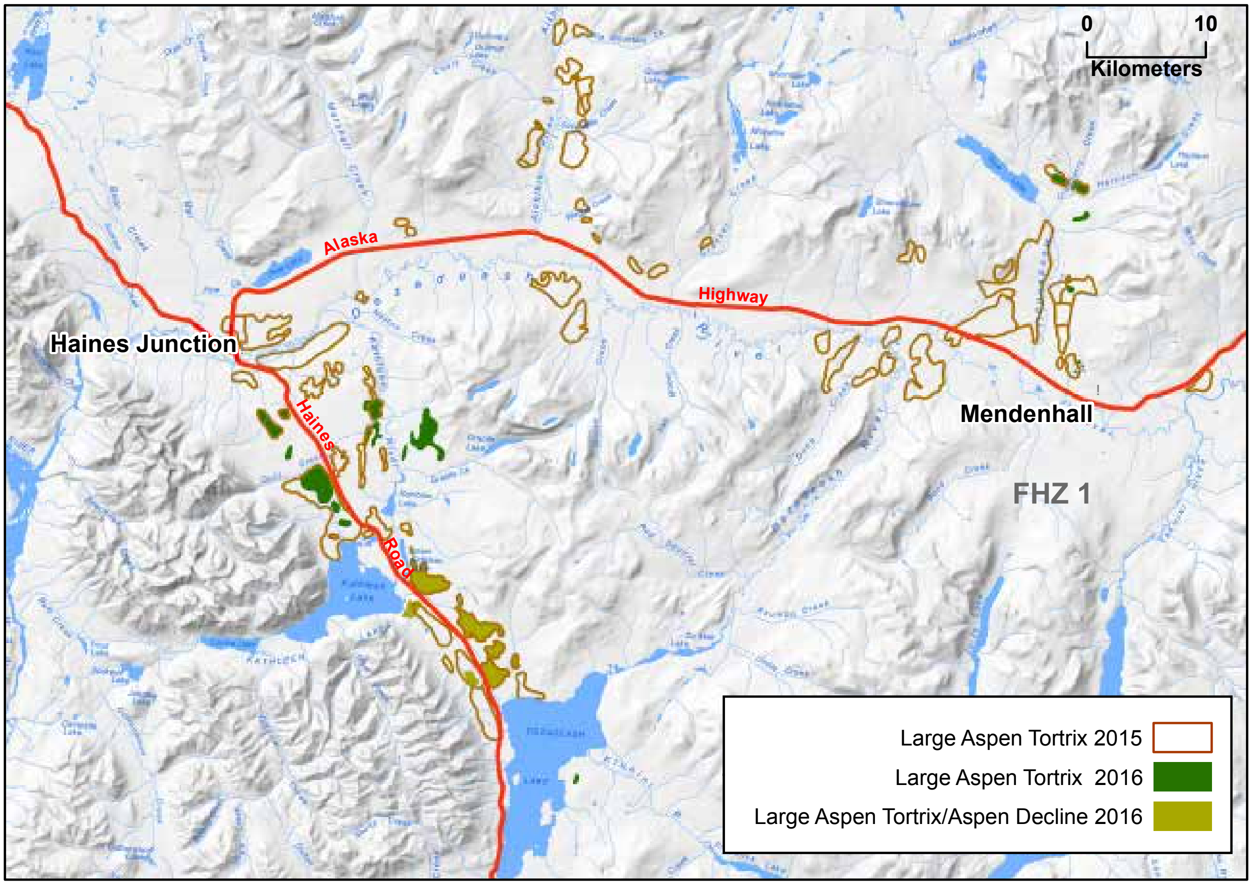
Photo 7 Moderate large aspen tortrix defoliation near Partridge Creek northwest of Stewart Crossing.



MAP 4 Area defoliated by large aspen tortrix in FHZ 2 in 2016.

In FHZ 1, similar to FHZ 2, populations declined significantly in the Alaska Highway corridor between Mendenhall and Haines Junction and south to Dezadeash Lake; this coincides with egg mass sampling completed in 2016 which forecasted decreasing populations in 2016. In 2015, populations had more than doubled to 15, 690 ha from 6, 120 ha in 2014. In 2016, only 3,029 ha were defoliated, with over half in combination with aspen decline (see aspen decline section for more information on potential impacts) (Map 5). Thirty-five percent of the large aspen tortrix solo defoliation was mapped as severe, with the remainder as moderate (Photo 8-10). The severe polygons were along Kathleen River and Harrison Creek. The majority of defoliation occurred in stands which have been previously infested, however new stands were mapped west of Granite Lake and east of Tay Lake.

In FHZ 3, aspen serpentine leaf miner in combination with aspen decline was mapped along the FHZ 2/FHZ 3 boundary, covering 657 hectares along Stewart River, near Independence Creek.



MAP 5 Area defoliated by large aspen tortrix in FHZ 2 in 2016.

Photo 8 Light-to-moderate large aspen tortrix defoliation with aspen decline, north of Dezadeash Lake.

Photo 9 . Light large aspen tortrix defoliation with light to moderate aspen decline adjacent to Kathleen Lake.

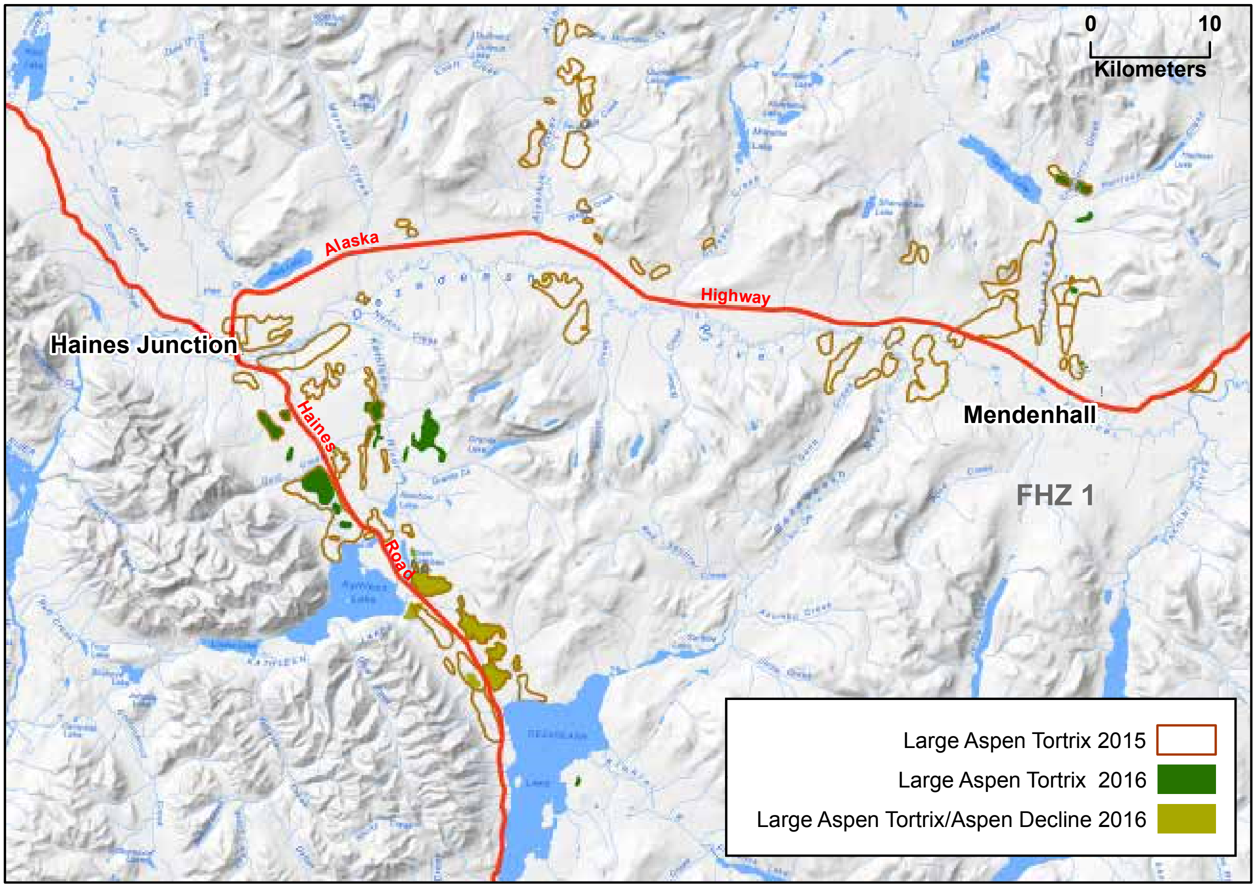
Photo 10 Light aspen tortrix defoliation with light aspen decline west of Dezadeash Lake.

FORECAST FOR 2017

Using similar protocol to that used in 2015, egg mass sampling was conducted at six sites between Kathleen Lake and Dezadeash Lake (Map 6). Based on sampling results, severe defoliation is expected in a small section of the Kathleen-Dezadeash Lake Corridor, with nil to minor defoliation on either side (Table 2).

Table 2
Large aspen tortrix defoliation forecast for six sites in 2017.

PLOT	DEFOLIATION FORECAST
1	Severe
2	Nil
3	Nil
4	Severe
5	Severe
6	Severe



MAP 6 Location of large aspen tortrix egg mass sampling sites, 2016.

Aspen Decline

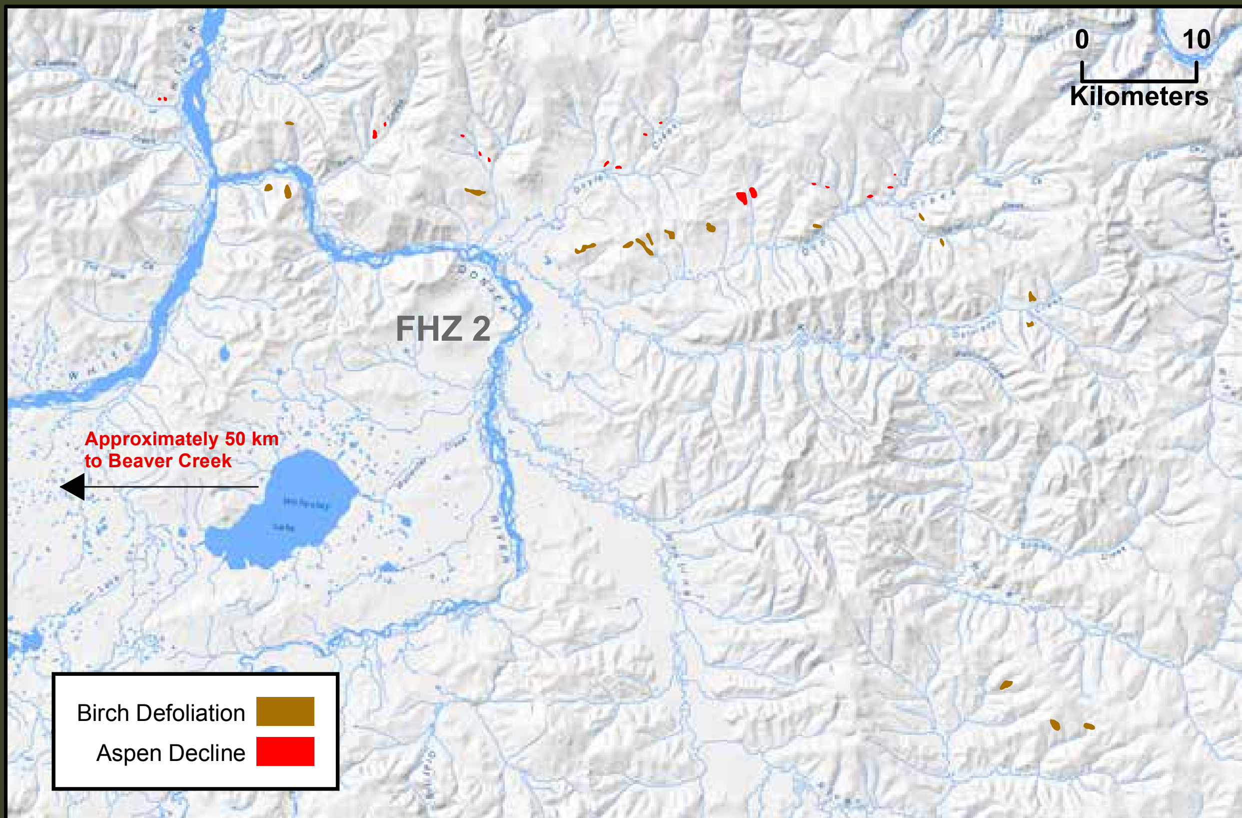
In FHZ 2, a total of 158,880 hectares of aspen decline was mapped with the majority occurring in stands where aspen serpentine leaf miner or large aspen tortrix were a component. Two separate areas in FHZ 2 were affected; west and east of White River near the junction with Donjek River (Map 8), north and east of Stewart Crossing along the McQuesten and Stewart rivers (Map 8). In 2009 similar symptoms were mapped over nearly 2000 hectares of balsam poplar near Beaver Creek as balsam poplar decline. Stands in both years exhibited very thin crowns with some visible stem mortality. These have been reported on in their respective sections above. See aspen decline section for more information.

In FHZ 1 aspen decline was mapped over 588 hectares in stands previously defoliated by large aspen tortrix between Mendenhall and Aishihik River. See aspen decline section for more information.

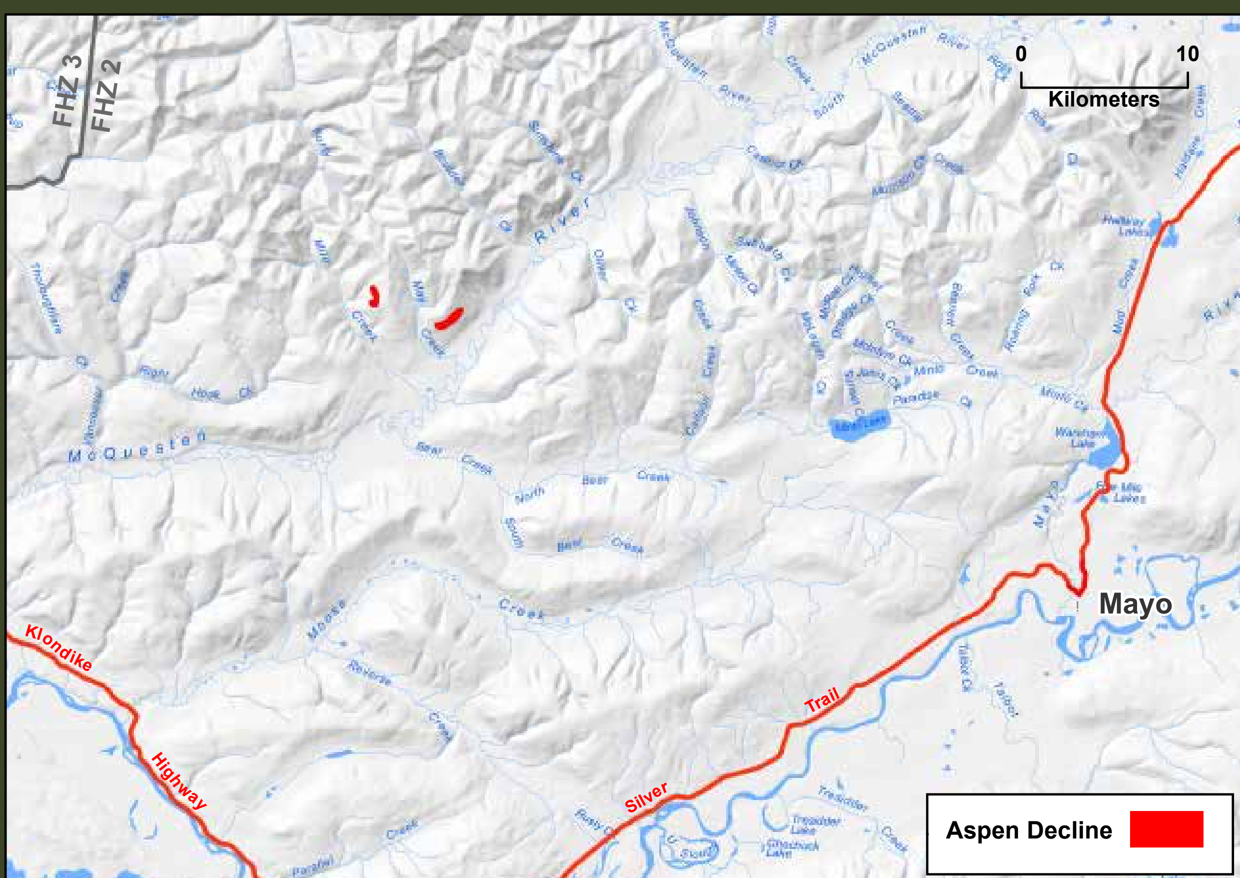
Birch Defoliation

In FHZ 2 light discoloration/defoliation of birch leaves was observed over 847 hectares northeast of Beaver Creek, mostly between Donjek River and Mount Cockfield (Map 7, Photo 11), with a few isolated spots south and east of Carmacks. In 2009 thinning birch crowns attributed to leafrollers were mapped southeast of Beaver Creek, and again in 2012 birch defoliation suspected to be caused by the leafroller family, was mapped west of Pelly Crossing. Leafrollers were confirmed as causal agents of thinning crowns of birch in 2009 near Whitehorse and Midnight Dome at Dawson City, however survey timing did not coincide with optimal sampling time hence the specific species was not confirmed. It was suspected that either the birch-aspen leafroller, *Epinotia solandriana*, or obliquebanded leafroller, Choristoneura rosaceana were responsible. By rolling the leaves the insect larvae are afforded some protection from predators and the elements while feeding on the leaf surface within the roll. Some minor photosynthetic capacity is compromised but overall, damage is negligible.

Photo 11 Thinning crowns on birch near Donjek Creek, NE of Beaver Creek, FHZ 2.



MAP 7 Thinning crowns on birch, aspen decline and aspen decline/serpentine leaf miner defoliation near Donjek Creek, northeast of Beaver Creek, FHZ 2.



MAP 8 Aspen decline northeast of McQuesten.

Western Balsam Bark Beetle

Scattered spot (two to five trees) infestations, totaling 5 hectares, of western balsam bark beetle were found near Coldspring Creek, Ferry Hill, MacMillan River, McGregor Creek, and Earn Lake in **FHZ 2**. Two larger polygons, totaling 22 hectares, were also noted near Nelson Creek, east of Mayo. This marks a slight increase from six hectares mapped in 2011/2012.

Alpine fir mortality resulting from attack by balsam bark beetle was first recorded in Yukon in 1995 in the LaBiche River drainage. However it is likely that it may have been present for longer given the level of grey attack in the area. Northward movement of balsam beetle from BC into Yukon is suspected to be in part due to a moderating climate. If such is the case, then continued gradual northward movement is anticipated.

Northern Spruce Engraver Beetle

The northern spruce engraver beetle is the second most important bark beetle affecting spruce in Yukon forests. Populations peaked in 2008 when over 3,000 hectares were infested, many in association with areas which had been attacked by spruce beetle. Shortly thereafter, populations collapsed with only scattered roadside mortality recorded in 2010.

In FHZ 2, a 36 hectare spruce stand along a flood plain of the Stewart River showed symptoms typical of northern spruce engraver damage. Historically this beetle has been found in association with spruce-beetle infested stands, stressed stands, or stands with abiotic damage, particularly drought. At its peak in 2008 the northern spruce engraved infested 3,174 hectares.

Willow Blotch Miner

Moderate to severe defoliation of willow along creek and river corridors occurred over 11 polygons, totaling 526 hectares in **FHZ 2**. This marks an increase from 168 hectares mapped in 2011. The largest, 304 hectares, was mapped south of Carmacks, between Nordenskiold Creek and Klondike Highway, and 100 hectares east of Mayo on Stewart River. In 2015, 29 hectares were mapped along the Highway corridor between Pelly Crossing and border of FHZ 3.

In FHZ 1, 13 hectares were mapped in a willow stand along Aishihik River between Haines Junction and Mendenhall.

Pine Needle Cast

Climate change has resulted in an increase in average temperatures throughout Yukon, as well as increased rainfall in many areas. This disease relies on rainfall in the spring to coincide with maturing of the spore-laden fruiting bodies from previous year's infections. At high intensity the disease can kill all of the current needles over large areas and significantly reduce growth potential. Successive years of severe infection result in a phenomenon known as "lions tailing" where the current needles are all that remain on the trees.

This foliar disease of lodgepole pine caused moderate discoloration of one stand (85 ha) east of Five Mile Rapids along Stewart River in **FHZ 2**. This is down significantly from 2011 when over 7,100 hectares were infected following a wetter than normal spring which intensifies spread of the diseases via raindrops.

Photo 12 Flooding damage on floodplain spruce near Watson Lake.

ABIOTIC DISTURBANCES

Flooding

In FHZ 2, flooding damage to spruce stands was mapped over 48 hectares in four areas; McQuesten River, Grand Valley, McGregor and Murray creeks.

Drought

Drought symptoms were mapped in a 35 hectare spruce stand along Raft Creek near Granite Bay on Kluane Lake.

PEST COMPLEXES

Aspen decline

Thinning crowns and stem mortality were found in conjunction with large aspen tortrix defoliation in **FHZ 1** and with large aspen tortrix/serpentine leaf miner in FHZ 2. See respective sections for further details.

Porcupine/lodgepole pine beetle

This combination of mammal and insect activity was suspected in four spots totaling one hectare, and a 13 hectare lodgepole pine stand near South Nelson River in **FHZ 2**. Lodgepole pine beetle can easily colonize trees which are predisposed, such as those girdled by porcupines. Trees may not necessarily die depending upon the degree of girdling and lodgepole pine beetle attack rates. Pine engraver beetle, Ips pini, can also be found in association with this pest complex. Historically this type of damage has been most common on drier sites. Porcupines feed on the nutrient-rich inner bark of all species of conifers and deciduous trees, but they prefer pine.

PROACTIVE MANAGEMENT OF MOUNTAIN PINE BEETLE

Concerned about the northward expansion of the Mountain Pine Beetle, 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 by Government of Yukon:

- 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 the FMB and the British Columbia's Ministry of Forests, Lands and Natural Resource Operations have been conducting aerial surveys together. MPB bait trapping has also been conducted each year.
- 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.
- The MPB committee completed a Yukon specific pest risk analysis in 2012, "Mountain Pine Beetle Pest Risk Analysis for Yukon Lodgepole Pine Forests" Summary of Mountain Pine Beetle Pest Risk Analysis for Yukon Lodgepole Pine Forests'' (Refer to Forest Health Report 2013 [Garbutt 2013]), Appendix 1).
- 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 hectares of pine forest in B.C. 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 B.C, 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 2016

This marks the seventh consecutive year that the threat of MPB invasion of Yukon forests was addressed by aerial surveys in mid-August (Map 2). In 2010 when aerial surveys were initiated, MPB populations and subsequent pine mortality within the RMT of B.C. were very high (within 150 kilometers of Yukon border). Given the beetle pressure and risk associated with active MPB populations in the RMT, aerial surveys were expanded in 2014 to assess the ongoing risk in two areas; a 30 by 300 kilometer border zone straddling the Yukon/B.C. border, as well as the Rocky Mountain Trench (RMT) in British Columbia. The border zone stretches from the Rancheria River in the west to nearly as far east as the Northwest Territories border, and encompasses areas with lodgepole pine as the dominant species.

Since 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 (see Monitoring Plan Appendix 2, Figure 5). In 2016 the RMT was also not flown based on similar aerial survey results - e.g. declining populations from BC in 2015.

Border Zone

In 2016, mountain pine beetle was not found within the border zone. Similar to the last two 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 (Photo 13). The beetles are indigenous to Yukon and generally attack old or weakened trees, as such they pose no significant threat to forest health. A "typical" attack from MPB usually involves small groups of trees rather than one single tree. However, given the uncertainty of behavior of MPB in novel habitats (i.e. pine habitats that have not had a history of MPB infestation) these spots will be monitored as per the monitoring plan (see ground surveys below). If these spots expand to small groups of affected pine trees, ground truthing may be required to confirm whether the attacks are caused by mountain pine beetle. Currently, MPB is not present in the Yukon.

Ground Surveys

Ground surveys were not conducted in the area ground-truthed south west of Watson Lake. This decision was based on 2015 and 2016 aerial survey observations which indicated static or decreasing levels of red trees. Ground checks in 2015 had revealed that lodgepole pine beetle (IBL) was responsible for tree mortality. One tree however was suspect MPB as the pitch tubes were higher up the stem; greater than two metres, which is typically characteristic of IBL. Most trees had incurred partial attacks or strip attacks over a number of years, and had eventually succumbed to IBL or a combination of IBL and pine engraver beetle, Ips pini. All trees were the largest in the vicinity also suggesting MPB, however no MPB was found.

Photo 13 Ongoing scattered single tree lodgepole pine mortality in an over-mature (200+ years old) spruce and pine stand in northern British Columbia (59° 52.74') southwest of Watson Lake.

British Columbia Observations

B.C.'s Ministry of Forests, Lands and Natural Resource Operations also conduct aerial surveys in northern BC. These surveys have found that since 2013 populations in the northern Rocky Mountain Trench have retreated significantly with only a few spots noted in both 2015 and 2016. The closest (unconfirmed) spot infestation was approximately 100 km south of the border, southeast of the Liard River drainage, and 150 km south of Watson Lake in the Rocky Mountain Trench Liard (Map 9). The latter is a retreat of approximately 70 km south from 2015. The largest concentration of MPB is similar to 2015; about 200 km south of the Yukon/BC border (Map 9).

Based on preliminary BC aerial survey results it appears that populations are contracting somewhat in northeast BC near the NWT/AB border, and growing slightly west of Fort Nelson (Map 9). Westward migration from these infested areas 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 hectares of mature pine. These young stands will not support an MPB population; they will act as sinks rather than sources given the smaller diameter and thin bark.

During the course of its recent 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.

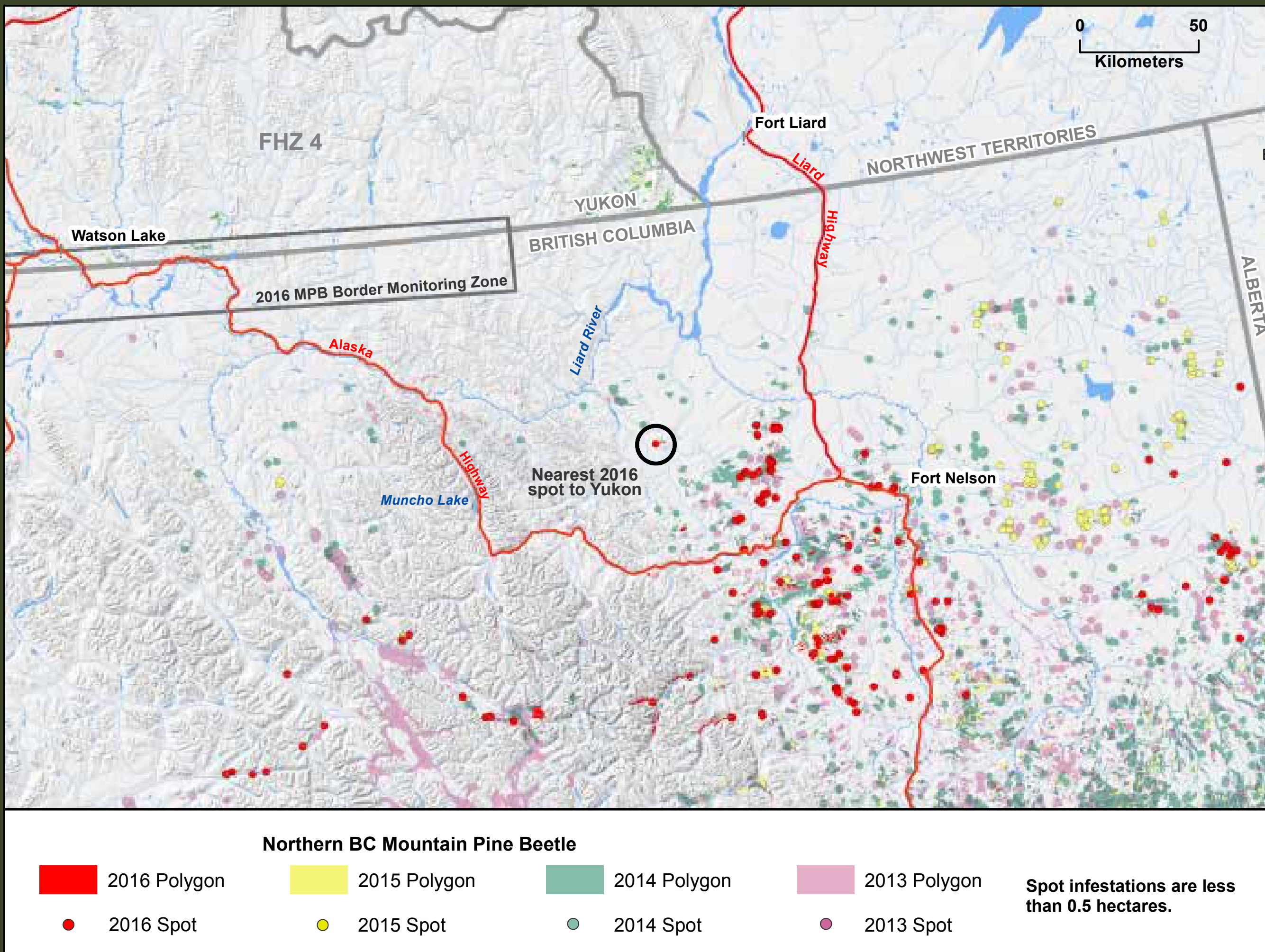
While there has been a decrease in the northward movement of MPB for four consecutive years, if favorable weather occurs for a few years in a row, populations could increase (Bleiker, 2012, pers com). MPB is an opportunistic species and a large pool of susceptible hosts is present. A possible future scenario could result in small remnant populations surviving and crossing the B.C./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. However this scenario appears less likely as it seems that the imminent threat from the current outbreak in British Columbia has subsided.

Using Bait Traps

Since 2009, FMB has been setting up and monitoring 15 pheromone bait tree stations in southern Yukon and northern B.C. to detect the presence of MPB (Map 10, Photo 14-15). 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 2016.

Photo 14 MPB bait tree

Photo 15 Pheromone placed on the north side of the tree.



MAP 9 Mountain pine beetle in northern BC, including the Rocky Mountain Trench, from 2013-2106, and border zone monitoring area. Note based on preliminary BC data.

MAP 10 Mountain pine beetle monitoring bait trap locations in southern Yukon and B.C.

SPECIAL PROJECTS

Two special projects were undertaken in 2016 to better understand pest disturbances and inform risk management; examination of factors associated with aspen decline and mapping and risk assessment of blowdown near Watson Lake.

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 (Photos 16-19). In Western Canada decline has been observed on a number of tree species including yellow cedar, birch, aspen, and cottonwood. According to Canadian Forest Service Forest Insect and Disease historical records for the Yukon (which date back to 1952), aspen dieback was first detected in 1987 near Swift River. Since then dieback has been recorded intermittently on a variety of tree species, including cottonwood and trembling aspen. In 2016, 160, 010 hectares exhibited symptoms of aspen decline in FHZ 2 and the highway corridor between Mendenhall and Dezadeash Lake in FHZ 1. The vast majority was in combination with defoliators. In 2015, 5,621 hectares were affected in FHZ 3, some of which had visible snow and ice damage. Decline was also observed aerially in 2009 (2,488 hectares), 2010 (11 hectares), and 2011 (529 hectares).

Photo 16 Aspen decline symptoms observed from the air – thinning crowns and stem mortality, 2016.

Photo 17 Aspen decline southeast of Dawson City, an area where moderate aspen decline was mapped in 2015 and symptoms remains visible in 2016.

Photo 18 Light to moderate aspen decline east of Mayo, between Stewart River and Janet Lake, 2016.

Photo 19 Moderate aspen decline on the hillsides adjacent to Scroggie Creek, southwest of Stewart Crossing, 2016.

Photo 19 Moderate aspen decline on the hillsides adjacent to Scroggie Creek, southwest of Stewart Crossing, 2016.

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 the 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.

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

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

SPATIAL ANALYSIS

In 2015 Forest Management Branch completed a spatial analysis of large aspen tortrix defoliation was completed. This year the analysis was expanded to include the 2015 bruce spanworm (Operophtera bruceata) and serpentine leafminer data. The objective was to determine if defoliation is contributing to aspen decline, as recorded in 2016.

Spatial data for forest pest disturbances is available from 1994 onwards, however given the size of Yukon annual survey coverage can vary from year to year. From 2009 onwards FMB commenced rotational monitoring of forest health zones, such that each zone was surveyed every five years. The analysis, referred to as an overlay, combines multiple years of survey data to identify areas which have incurred defoliation, both in terms of where on the landscape and how frequently such as total years (Table 3). In areas which have been monitored annually, such as that for large aspen tortrix through the Mendenhall-Dezadeash corridor, the number of maximum years defoliated can also be determined (See 2015 FMB Forest Health Report). The result of the analysis can then be compared to areas where decline has been recorded and infer potential relationships where they overlap.

The limitation of this analysis is the lack of survey data over the same geographic area from year to year (Table 3), with the exception of the large aspen tortrix aspen outbreak mentioned above.

Table 3 Years each forest health zone was surveyed and pests mapped e.g. active defoliators.

		ACTIVE DEFOLIATORS		
Forest Health Zone	**Years Flown since 2009**	**Bruce Spanworm**	**Large Aspen Tortrix**	**Serpentine Leafminer**
FHZ 1	2009, 2012[1], 2014, 2015[1]	2002, 2003, 2014	2000, 2012, 2013, 2014, 2015	2009, 2011[1], 2014
FHZ 2	2009[1], 2011 (south), 2012 (north)		2004, 2012, 2013, 2015[1]	2009[1], 2011, 2012, 2015[1]
FHZ 3	2009, 2015		2004, 2015	2009, 2015
FHZ 4	2009[1], 2010			2009[1], 2010
FHZ 5	2013			

[1] Highway corridor for large apsen tortrix with exception of 2009 when all highway corridors were flown in all zones except FHZ 5.

The majority of areas within each FHZ have been defoliated for only one year. FHZ 3 has the highest area of stands where defoliation has occurred for two years (Table 4).

FOREST HEALTH ZONE	TOTAL YEARS DEFOLIATED	AREA (HA)	PERCENT OF AREA INFESTED/FHZ
FHZ 1	1	121,042	88.9
	2	10,913	8.0
	3	3,028	2.2
	4	1,007	0.7
	5	180	0.1
FHZ 2	1	354,407	89.7
	2	36,190	9.2
	3	3,073	0.8
	4	1,290	0.3
	5	106	0.0
FHZ 3	1	143,366	76.7
	2	41,941	22.4
	3	1,604	1.3
FHZ 4	1	111,674	93.5
	2	7,758	6.5

Table 4 Summary of total number of years of defoliation in a given stand collectively caused by bruce spanworm, large aspen tortrix or aspen serpentine leafminer, and percent infested within each FHZ for the time period 2000-2015.

In order to determine the potential impacts the cumulative severity of defoliation was determined. This was accomplished by assigning a value to each defoliation category light (1), moderate (2) and severe (3) respectively. These were summed for all defoliators for all years and assigned a severity value of low (1-3), moderate (4-9) or high (9-12) severity. The majority fell into the low impact category, with FHZ 3 having the highest level of moderate impacts (Table 5).

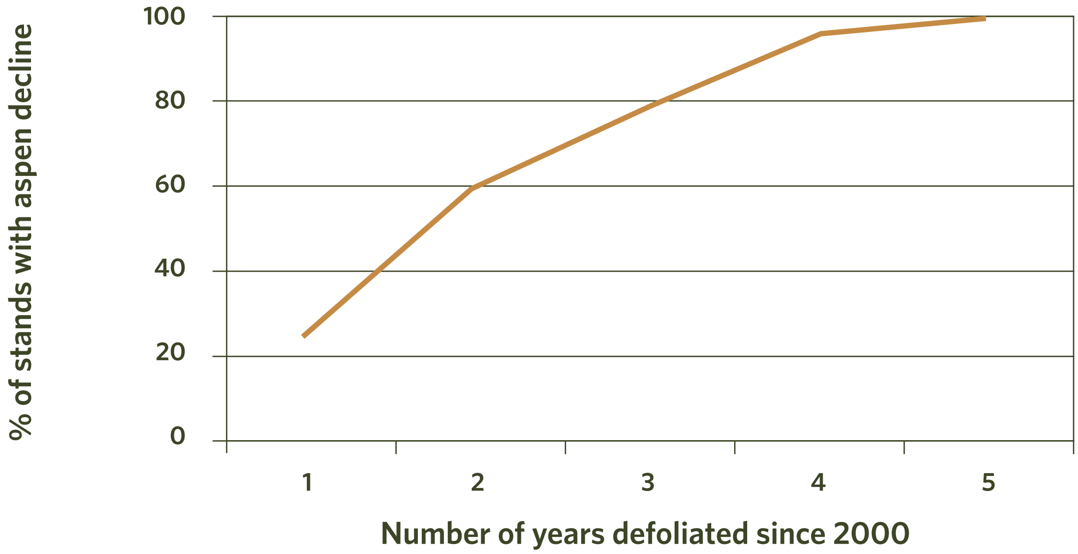
FOREST HEALTH ZONE	LOW (1-3)	MODERATE (4-9)	HIGH (10-12)
1	90	9	1
2	91	9	0
3	77	23	0
4	93	7	0

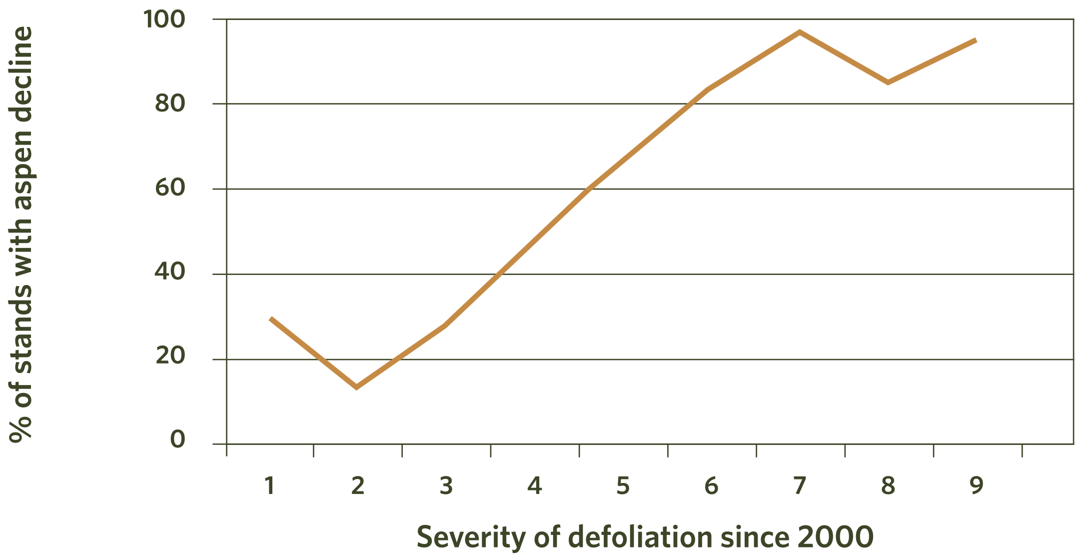
Table 5 Cumulative severity of defoliation since 2000 by FHZ, expressed as a percentage of affected area.

To determine if aspen decline was related to defoliation the area defoliated from 2000 to 2015 was intersected with the area where aspen decline was mapped in 2016. This part of the analysis was completed for FHZ 2 as it was the only FHZ fully covered and mapped for aspen decline symptoms in 2016.

Seventy-one percent of the area mapped as defoliated did not have any symptoms of decline, of which only 4 percent had been defoliated for two or more years. Of the 29 percent which had been defoliated and showed symptoms of decline there was a strong relationship between areas with aspen decline symptoms and defoliation; both when looking at total years and severity of defoliation (Figure 1). Stands which are defoliated for two or more years, or have a cumulative severity of 2 (1 moderate year, or 2 light years) have a higher incidence of aspen decline.

Figure 1 Relationship between total years defoliated (top) and cumulative severity (bottom) of defoliation since 2000 expressed as a percentage of similar stands e.g. same total years or cumulative severity category, which are exhibiting symptoms of decline in 2016.



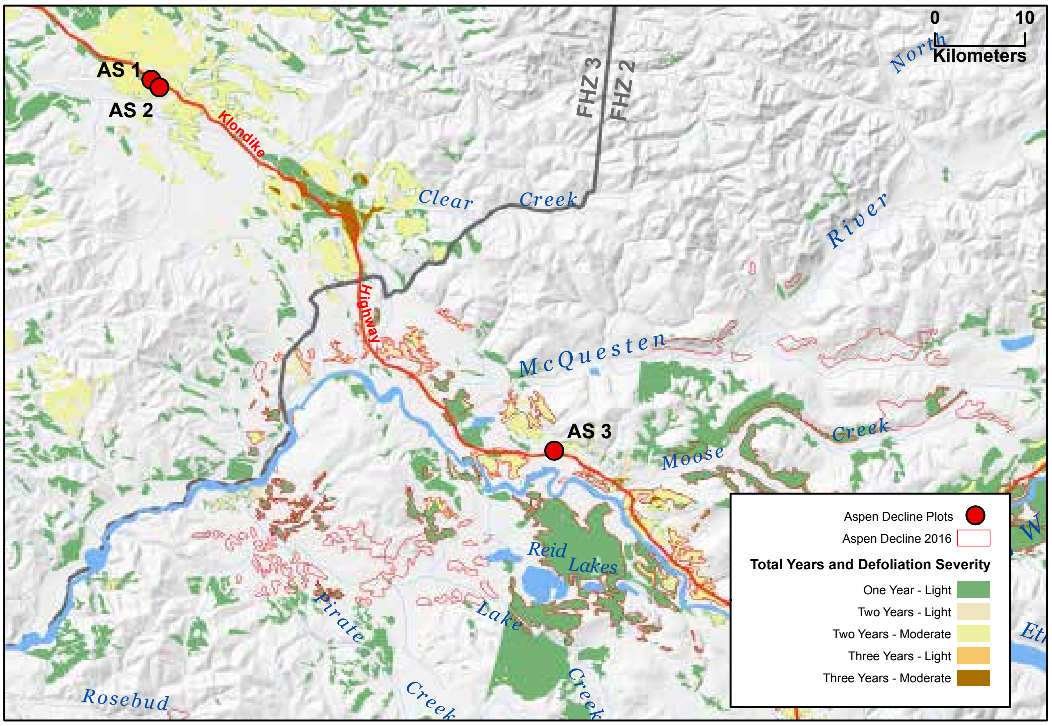


Further analysis could be completed to determine if one or a combination of defoliators contributes to aspen decline, and whether or not site and/or stand attributes are involved. Weather should also be considered in a future analysis to determine if drought or other abiotic events have contributed to aspen decline.

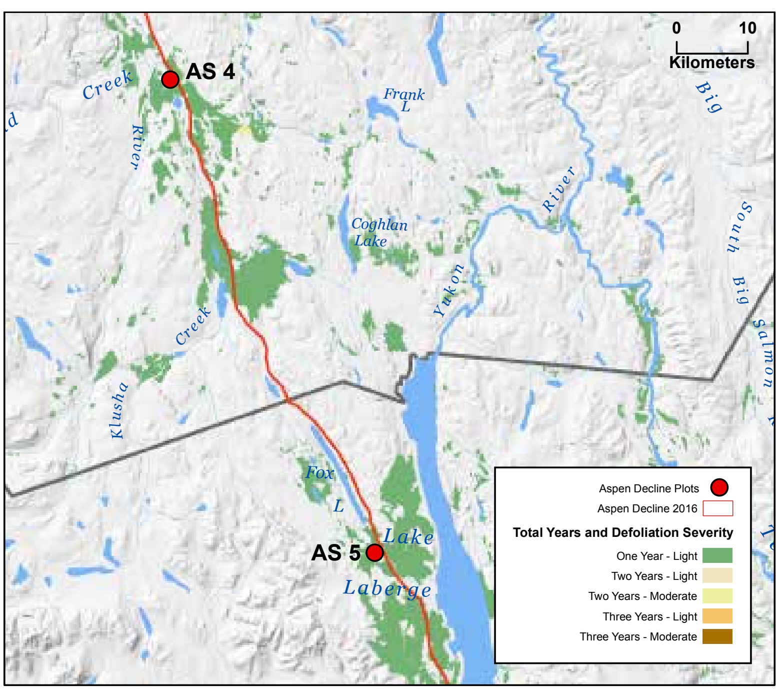
GROUND PLOTS

Five roadside examinations of aspen stands were conducted along the Klondike Highway between Dawson City and Whitehorse to identify factors which may be contributing to decline (Map 11-12, Photo 20-25). Symptomatic stands such as thin crowns and/or stem mortality, were selected for examination.

As expected, a combination of pests were found at most sites (Table 6).



MAP 11 Location of reconnaissance plots for aspen decline between Dawson City and Stewart River; in relation to total years of defoliation and defoliation severity.



MAP 12 Location of reconnaissance plots for aspen decline between Pelly Crossing and Whitehorse; in relation to total years of defoliation and defoliation severity.

As expected, a combination of pests were found at most sites (Table 6).

Table 6 Results of aspen decline reconnaissance of five plots between Dawson City and Whitehorse, including defoliation history from spatial analysis.

	DEFOLIATION HISTORY		LARGE ASPEN TORTRIX			OTHER PESTS						SYMPTOMS	
Plot	Total Years	Defoliation Severity	Defoliation	Pupal Casings	Egg Masses	Aspen Leaf Miner	Mites	Foliar Rust	Leaf Scorch	Heart Rot	Stem Canker	Small Leaves	Branch/Top Dieback
1	2	5	Very Light	Very few; very small[1]	No	Very Light		Very Light	Very Light	No	No	Yes	Moderate
2	2	4	Light		No	Light		-	-	Yes	Yes	Yes	Moderate
3	1	3			1 small[1]	Light		-	-	Yes	No	No	No
4	1	3			1 small[1]	Light	Very Light	-	-	No	No	No	Minor
5	1	3		Very few	Very few	Very Light		-	-	No	No	No	Severe frost damage

[1] small egg mass indicative of collapsing population.

The results of these reconnaissance plots coincide with the results of the spatial analysis, in that stands with two or more years of defoliation are impacted. These stands show signs of decline via branch or top dieback as well as the production of smaller leaves. Smaller leaves will likely contribute to continued decline in 2016 from lower levels of photosynthetic material.

Photo 21 Serpentine leaf miner (upper left), thinning crowns and branch dieback in Plot 1.

Photo 20 Plot 1 crown and stand symptoms – top and branch dieback with stem mortality.

Photo 22 Thinning crowns from small leaves and branch dieback in Plot 2. Small large aspen tortrix egg mass (upper right) indicative of a declining population in upper right.

Photo 23 Fuller healthier crowns with minor branch dieback in Plot 3. Fuller healthier crowns with minor branch dieback in Plot 3.

Photo 25 Severe frost damage and resultant top and branch dieback north of Whitehorse in Plot 5.

Photo 24 Fuller healthier crowns with minor branch dieback in Plot 4, and high levels of aspen serpentine leaf miner (lower right).

Spruce Blowdown Risk

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 13). In recognition of the potential for spruce beetle FMB conducted aerial surveys to delineate the area affected in order to assess the spruce beetle hazard and risk.

Aerial surveys mapped affected areas and assigned windthrow severities to affected polygons; low for 1-10%, moderate for 11-30%, and severe for greater than 30%. In total 477.6 hectares were affected, the majority of which had low levels of windthrow, and which occurred in non-leading white spruce forests (Table 6). Other tree species which were windthrown included aspen, lodgepole pine, and balsam fir, none of which have any major forest pest risks associated with windthrow (Photos 26-27).

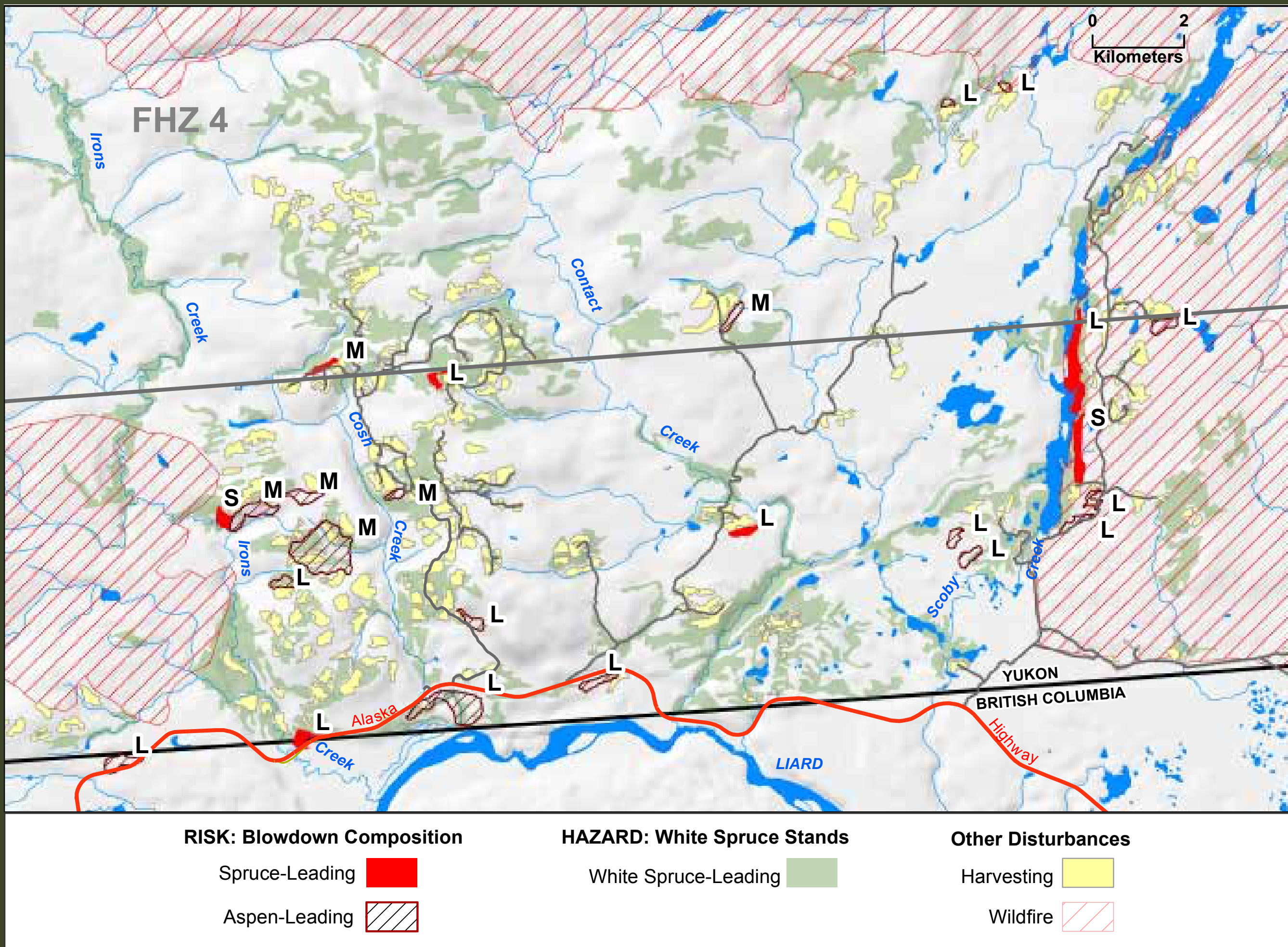
As spruce beetle preferentially attacks weakened trees, including windthrow, the possibility of spruce beetle attacking these windthrow spruce exists. Adults emerging from this windthrow could subsequently attack standing live white spruce trees, hence populations could build and expand depending upon 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 13). Large wildfires have also occurred in three of four cardinal directions: west, north, and east, thereby further reducing the hazard. Given the risk associated with spruce windthrow (albeit low in this case) and the recent increase in spruce beetle populations in northeastern BC, continued and vigilant monitoring is warranted. Ground surveys in 2017 will be completed to determine if spruce beetle is present. If so, populations will be assessed.

WHITE SPRUCE-LEADING	SEVERITY (PERCENT AFFECTED)	HECTARES	PERCENT
Yes	1-10%	85.8	18.0
	11-30%	9.6	2.0
	>30%	40.8	8.5
Total		**136.2**	**28.5**
No	1-10%	171.0	35.8
	11-30%	170.4	35.7
	>30%	0	0
Total		**341.4.**	**71.5**

Table 7 Summary of area affected and blowdown severity by white spruce hazard.

Photo 26 Severe windthrow in a spruce-leading stand along Coal Lake road. Note adjacent burn.

Photo 27 Severe windthrow in aspen/spruce adjacent to burn near Barney Lake.



MAP 13 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.

FOREST HEALTH EXTENSION

The Forest Management Branch made several presentations to various stakeholders in 2016 to familiarize them with various aspects of the program. These include: 2015 Forest Health Presentation to Dawson District Renewable Resource Council, and Mayo District Renewable Council.

OTHER NOTEWORTHY DISTURBANCES IN 2016

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.

Table 8 Summary of area affected and blowdown severity by white spruce hazard.

DISTURBANCE	HOST	SETTING	LOCATION	COMMENTS
Amber birch leafminer, *Profenusa thomsoni*	Birch	Urban	Host range	Photo 28
Powdery mildew	Trembling aspen	Urban/Forest	Whitehorse	Photo 29
Drought	Trembling aspen	Urban/Forest	Whitehorse	Photo 30
Gall aphid	Trembling aspen	Forest	Haines Junction	Photo 31
Comandra stem rust, *Cronartium comandrae*	Lodgepole pine	Forest	Watson Lake	Photo 32
White trunk rot	White spruce	Forest	Fox Lake	Photo 33
Northern spruce engraver beetle, *Ips perturbatus*	White spruce	Forest	Haines Junction	Photo 34

Photo 28 Birch leafminer on birch along Yukon River in Whitehorse.

Photo 29 Powdery mildew on aspen along Yukon River in Whitehorse.

Photo 30 Drought damage to trembling aspen near Whitehorse.

Photo 31 Gall aphid, possibly Pemphigus borealis, on twig of trembling aspen near Haines Junction.

Photo 32 Animal feeding on comandra stem rust canker.

Photo 33 White trunk rot on white spruce in Fox Lake burn.

Photo 34 Northern spruce engraver beetle, Ips perturbatus, in a log pile near Haines Junction.

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Published March 2017
Government of Yukon
Energy, Mines and Resources
ISSN 1708 - 9360

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