FOREST HEALTH REPORT 2013

Yukon
Energy, Mines and Resources
Forest Management Branch

Backdrop Photo: Aerial survey for large aspen tortrix north of Pelly Crossing.

Photo top left: Roadside flagging on lodgepole pine near Watson Lake.

Photo center: Roadside flood damage on lodgepole pine west of Rancheria area.

Photo right: Roadside webbing of large aspen tortrix seen on aspen near Haines Junction.

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A Risk-Based Approach to Forest Health Monitoring for Yukon

In 2009, the Government of Yukon's Forest Management Branch (FMB) implemented a risk-based approach to forest health monitoring. This is in line with the National Forest Pest Strategy (NFPS) approved by the Canadian Council of Forest Ministers (CCFM) in 2006. The NFPS is a proactive, integrated response to forest pests that uses a risk-based framework for coping with native and non-native forest pests in Canada. The intent of the NFPS is to reduce forest health impacts by improving coordination across jurisdictions, enhancing capacity for identifying and assessing forest pest risks, and increasing options and effectiveness of responses to threats (CCFM, 2007).

Forest pest risk analysis uses scientific information to develop and implement programs to reduce risk associated with forest pests, while also accounting for the uncertainty of future events and outcomes (CCFM, 2007).

In response to the NFPS, FMB developed an annual risk-based forest health monitoring program. 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 agents across forested landscapes that are of the most value to Yukon residents; and
3. To contribute to the NFPS goals, one of which is developing early detection and reporting capacity of forest health pests.

Before 2009, FMB relied heavily on the Canadian Forest Service (CFS), Pacific Region to carry out its forest health program. The CFS supported the Yukon Forest Health Program through the Forest Insect Disease Survey Program (FIDS). When this national program ended in 1995, CFS continued its support through a contribution agreement with Government of Yukon.

After 2009, FMB has contracted the aerial and ground surveys portion of Yukon's forest health program, as well as some mapping and reporting components, to a forest health specialist from Victoria.

Identification of Major Forest Health Agents of Yukon

In 2009, staff from FMB and CFS and a forest consultant listed ten agents 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 of the nine forest pests listed are insects. These insect pests have the capacity to cause significant damage to forest resources. Because their damage to trees is visible, they can be effectively monitored.

The only pathogen that will be monitored by FMB is pine needle cast *(Lophodermella concolor)*, a pest that can impact large forest areas. Pine needle cast can be effectively monitored because the damage to the needle is quite visible. Needle discolouration progresses from green to red and then to straw-coloured and appear in bunches at the branch tips.

Although root rot (i.e. Tomentosus root disease) and heart rot (i.e. aspen trunk rot) fungi cause more significant damage compared to foliage pathogens, they are more difficult to detect and require specialized ground surveys and expertise. As a result, root and heart rot will not be routinely monitored except in areas affected by timber harvest projects, reforestation efforts and regeneration surveys. Tree dieback due to drought stress was also identified as an additional forest health agent of concern.

Yukon will routinely monitor the following 10 biotic and abiotic forest health agents[1]. The following is rationale (based on Ott, 2008) for the identification of major forest health agents that pose the greatest risks to Yukon forests:

[1] Although annual forest health monitoring will focus on forest pests and abiotic factors that pose the greatest risk to Yukon forests, other forest pest activity will be recorded when it is encountered.

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).

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 3000 ha (Garbutt, 2009).

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

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, spruce budworm damage has been mapped in the extreme southeast portion of Yukon (Garbutt, 2009).

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.

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.

7. **Aspen serpentine leafminer** *(Phyllocnistis populiella)*
   This insect pest occurs throughout the Yukon range of aspen *(Populus tremuloides)* 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.

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, 2009).

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 *(Pinus contorta)* and ponderosa pine *(Pinus 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 forest (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 it has moved to within approximately 30 kilometres of the southern Yukon border.

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).

Yukon Forest Health Monitoring Strategy

The Yukon Forest Health Monitoring Strategy focuses on forest stands throughout Yukon which are most susceptible to the ten forest health agents of greatest concern. Since its implementation in 2009, the strategy has met the two priorities described below each year.

Priorities of the Forest Health Strategy

1. Rotational monitoring of forest health zones.

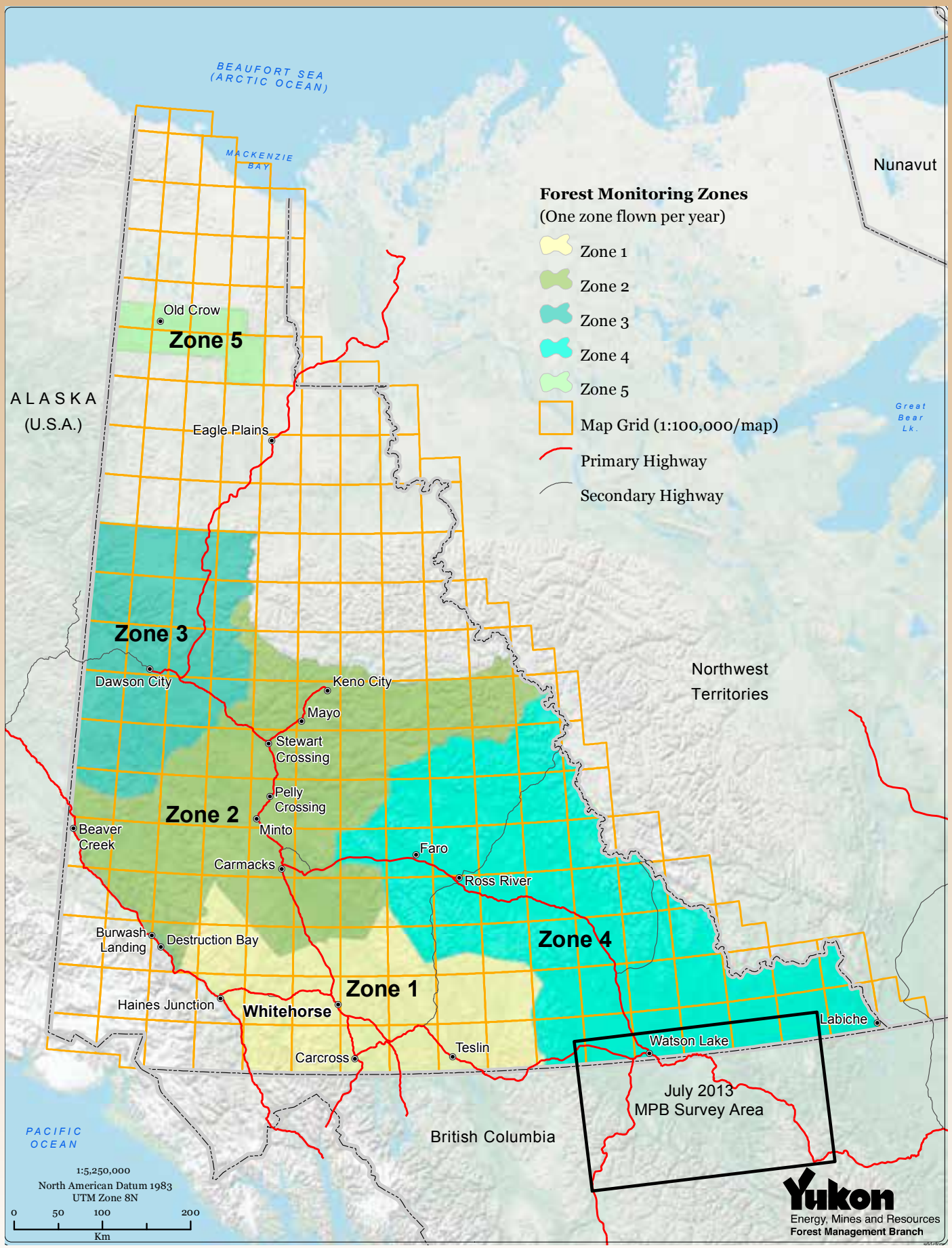
Yukon is divided into five forest health zones (Map 1). In these areas, monitoring focuses on forest stands that are the most susceptible to the ten forest health agents of greatest concern. Each year since 2009, researchers have completed aerial surveys of one out of the five zones. All communities and highway corridors are monitored within that zone. The majority of accessible commercial forest lands and areas where forest management activities occur are within highway corridors and are near the communities.

In 2013, the fifth and last of the five zones was monitored. Forest health monitoring will continue after 2013. Now, the objectives of the Yukon Forest Health Monitoring Strategy will be re-evaluated in order to assess what future action best meets the needs of Yukon.

2. Ongoing monitoring of areas of concern.

During the monitoring of the forest health zones, researchers may select disturbances for further monitoring in the same year. If necessary, these disturbances are identified as ongoing monitoring areas to be included along with the forest health zones scheduled for monitoring during the current year. These ongoing monitoring areas help set forest health program priorities.

Map 1. Yukon Forest Health Monitoring Zones



Summary of 2013 Forest Heath Initiatives

The four following initiatives were completed by FMB in 2013:

Component 1: Aerial surveys and ground field checks were completed in forest health zone 5, as per the Yukon Forest Health Monitoring Strategy. Aerial surveys were also conducted in areas where significant disturbance(s) were identified in 2012.

Component 2: Yukon FMB took a proactive approach to monitoring the northward expansion of the mountain pine beetle.

The Five Year Mountain Pine Beetle Plan, 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: FMB responded to general forest health and pest incident reports from the public and from government agencies encountered throughout Yukon.

Component 4: FMB participated in a project with the CFS to research spruce budworm populations in Canada.

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 and CFS, 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 shared boundaries. 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

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
- 2 qualified aerial surveyors (one positioned on each side of plane)
- Each surveyor oversees a 4 kilometres wide corridor
- 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
    - Use on-the-ground checks to confirm the type of disturbance recorded from the aerial surveys
    - Digitize recorded mapping data and store it in the Government of Yukon Geographic Information System

Forest Health Aerial Surveys in 2013

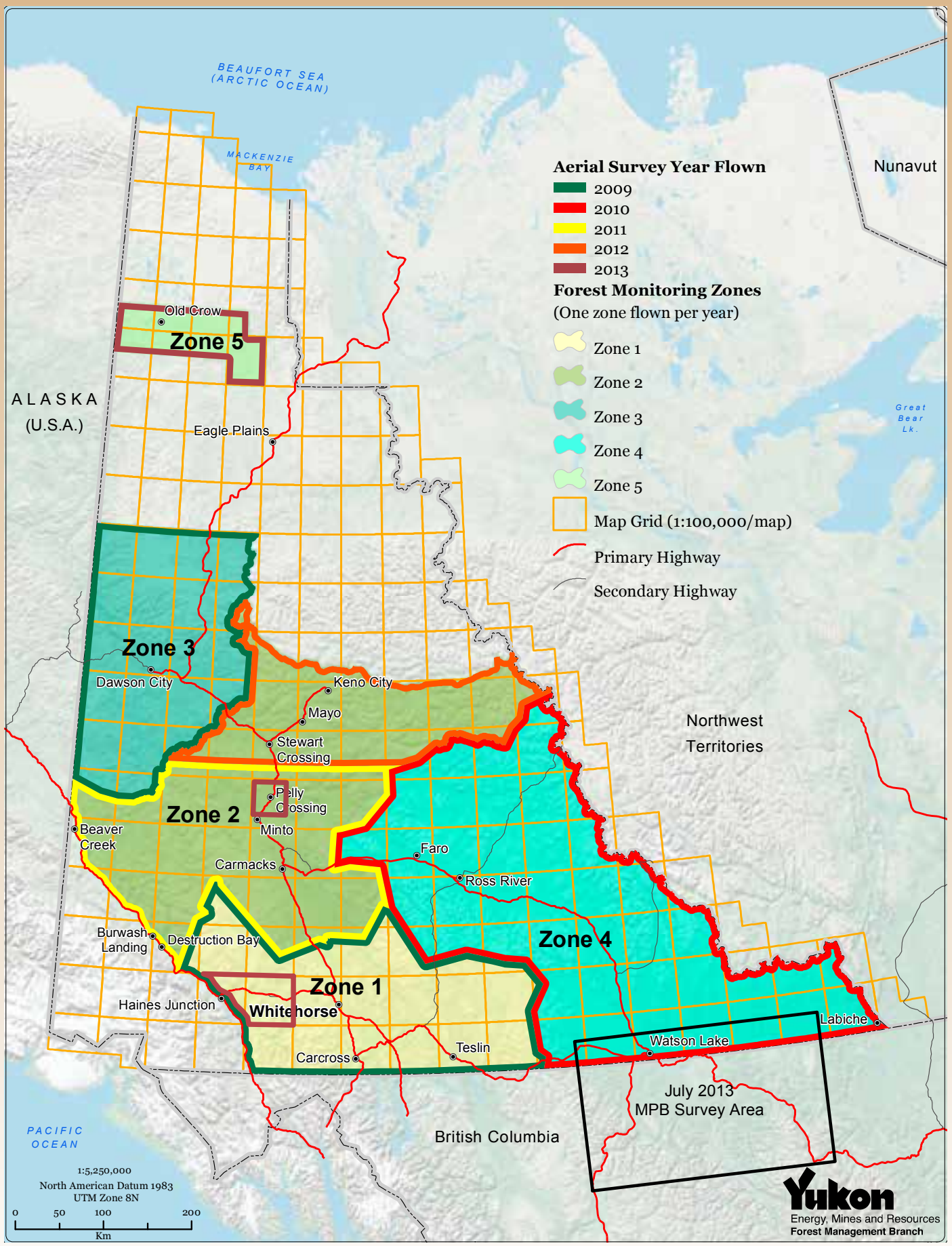
During 2013, a total of three aerial surveys were undertaken in order to map forest disturbances as described in the Yukon Forest Health Monitoring Strategy (Map 2):

i. One day aerial survey to map and monitor the ongoing large aspen tortrix defoliation in forest health zone 1 (Mendenhall River, Cracker Creek, Aishihik River, Haines Junction) and forest health zone 2 (Pelly Crossing area).

ii. Two day aerial survey was undertaken to monitor the northward movement of the MPB as per the monitoring strategy. Two areas were flown: one was along the Yukon/B.C. border near Watson Lake, and one was along the Rocky Mountain Trench area of B.C.

iii. Two day aerial survey to map forest health zone 5.

Map 2. Yukon Forest Health Aerial Surveys by year (2009-2013)



Monitoring the Northward Expansion of the Mountain Pine Beetle (*Dendroctonus ponderosae*)

Concerned about the northward expansion of the mountain pine beetle (MPB), the Government of Yukon has developed a risk analysis and subsequent monitoring strategy to track the northern movement of the insect. Below is a history of response to mountain pine beetle 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 Forest Management Branch 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 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" (Appendix 1).
- From this risk analysis, a five year mountain pine beetle plan and strategy was developed and implemented in 2013, the "Mountain Pine Beetle Monitoring Plan for Yukon Lodgepole Pine Forests 2013-2018" (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. 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 B.C.

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 has moved quickly northward in the last few years within the Rocky Mountain Trench in northern B.C.

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

Monitoring Mountain Pine Beetle in 2013

For the fourth consecutive year, the threat of MPB infestation of Yukon forests was addressed by aerial surveys in mid-July of 2013 (Map 3). In 2010 when aerial surveys were initiated, MPB populations and subsequent pine mortality within the Rocky Mountain Trench of B.C. were high (within 150 km of Yukon border). Since that time severe winter cold has killed beetle broods within the trees and slowed the northern movement of MPB populations. The only infestations of significance were seen near upper Horneline Creek, more than 120 km south of the Yukon border (Map 3). Two small patches of red pine trees (5-10 trees) were mapped within 30 km of the Yukon border. The two small patches were far to the north of the MPB that was mapped within the trench and there is some uncertainty as to whether the affected trees were caused by MPB. These areas will be flown again in 2014. Currently, MPB is not present in the Yukon.

Following the strategy outlined in the five year MPB Monitoring Plan (Appendix 2), a 30 by 300 km zone was flown straddling the Yukon/B.C. border. The zone stretches from the Rancheria River in the west to nearly as far east as the Northwest Territories border. No confirmed attacks from mountain pine beetle were found within this zone. Scattered single red lodgepole pines were mapped in this area. Single red pine trees suggests attack by either the lodgepole pine beetle *(Dendroctonus murrayanae)* or the pine engraver beetle *(Ips pini)*. These beetles are indigenous to Yukon and 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 scattered single red lodgepole pine spots will be closely monitored next year. 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.

Numerous small patches of red subalpine fir characteristic of attacks by the balsam bark beetle *(Dryocoetes confuses)* were also mapped. This insect moved north into Yukon from northern B.C. in the late 1980s and has now spread throughout the host range. It is now considered endemic.

B.C.'s Ministry of Forests, Lands and Natural Resource Operations completed aerial surveys farther to the east and west of the FMB surveys found numerous large and small polygons of light-to-severe incidences of red pine in young and middle-aged pine stands that were mapped as MPB. Most of these were patches of light attack north and east of Muncho Lake (Map 3). The infested area totalled well over 1000 ha. It is likely that mountain pine beetle migrated westward along the Liard River corridor.

Fortunately, further westward migration within the corridor 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. These young stands will not support a MPB population. A single large polygon of severe intensity was also mapped far to the west, just west of Looncry Lake, approximately 80 km south of the BC/Yukon border. This population will be monitored in 2014. 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 mountain pine beetle. Preliminary research indicates that "naive" pine trees may have lower resistance and greater MPB production capacity. However the beetle is susceptible to extended cold periods of -40°C which cause high levels of brood mortality, especially if they occur in early or late winter. We have already witnessed in the Rocky Mountain Trench it is the harsh cold winters that will likely determine the beetle's success or failure as it moves farther north.

While there has been a decrease in the northward movement of MPB in 2013, if favorable weather occurs for a few years in a row, populations could increase (Bleiker, 2012 pers com). Mountain pine beetle 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 twenty years.

Map 3. Mountain pine beetle in the Yukon/B.C. border zone and Rocky Mountain Trench

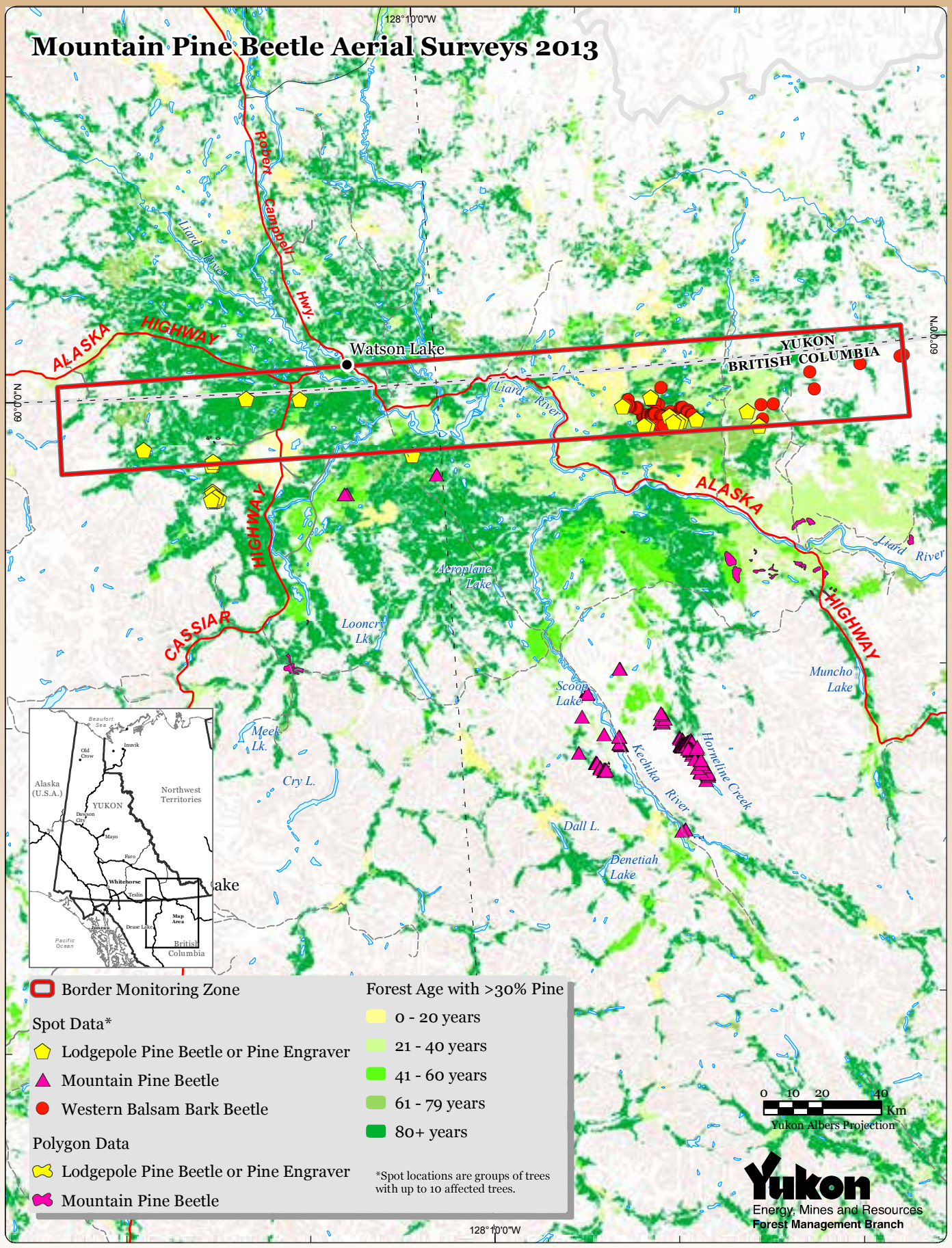


Photo 1. The red trees circled in the photo represent MPB damage at Horneline Creek, 2013

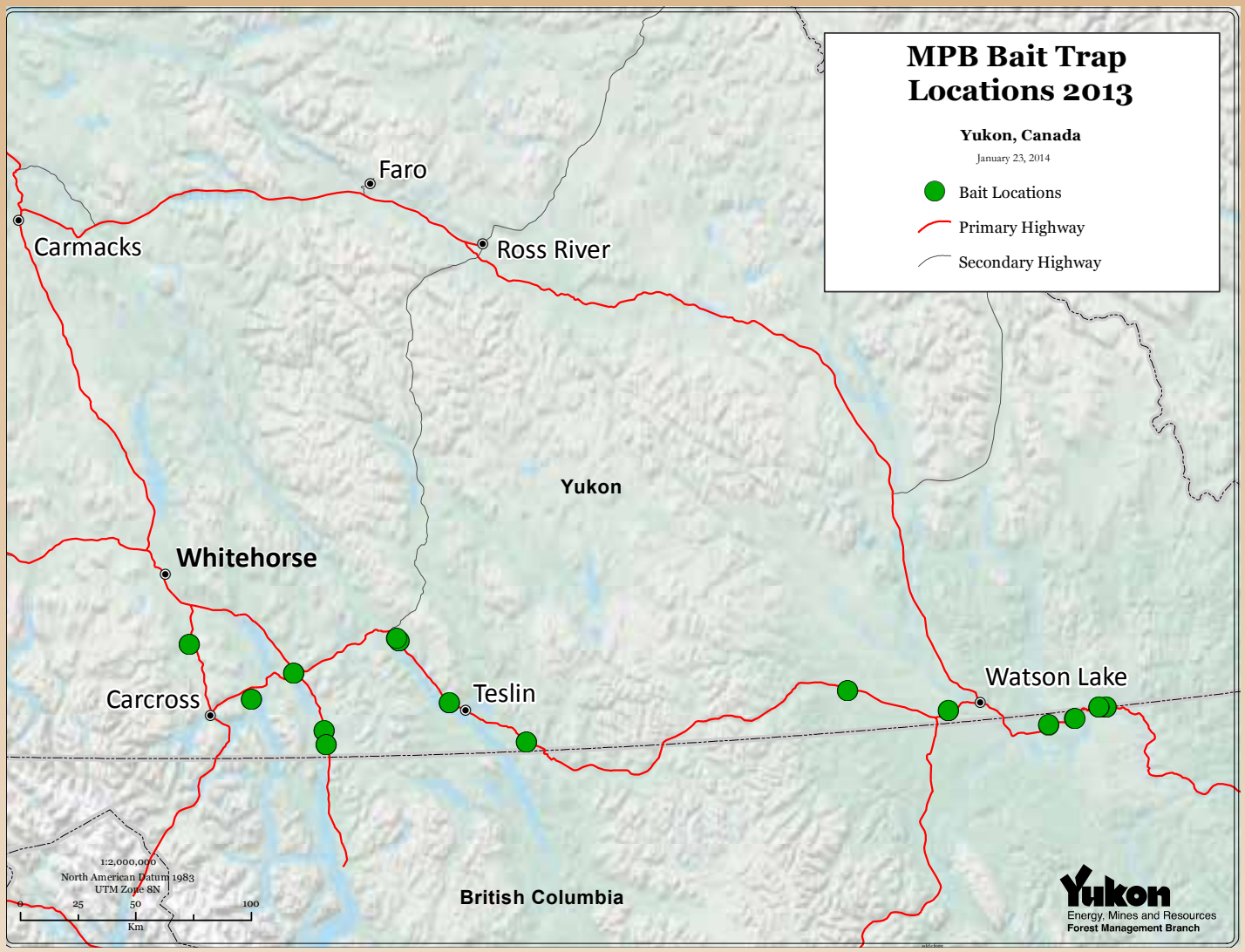
Using Bait Traps

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 4, photos 2 and 3). 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 2013.

Photo 2. MPB bait tree

Photo 3. Pheromone placed on the north side of the tree

Map 4. Mountain pine beetle monitoring bait trap locations in southern Yukon and B.C.



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. The most recent infestation was prior to 1990, and occurred near Haines Junction in stands just north of town rather than in the town itself.

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 (Photo 4). 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) is likely the main reason why the decline of recorded tortrix damage coincided with the explosion of leafminer populations. The past three years have seen a decline in leafminer damage throughout Yukon and thus a coincident opportunity for renewed success of the tortrix.

Photo 4. Tortrix pupa at edge of rolled aspen leaf

Monitoring Large Aspen Tortrix in 2013

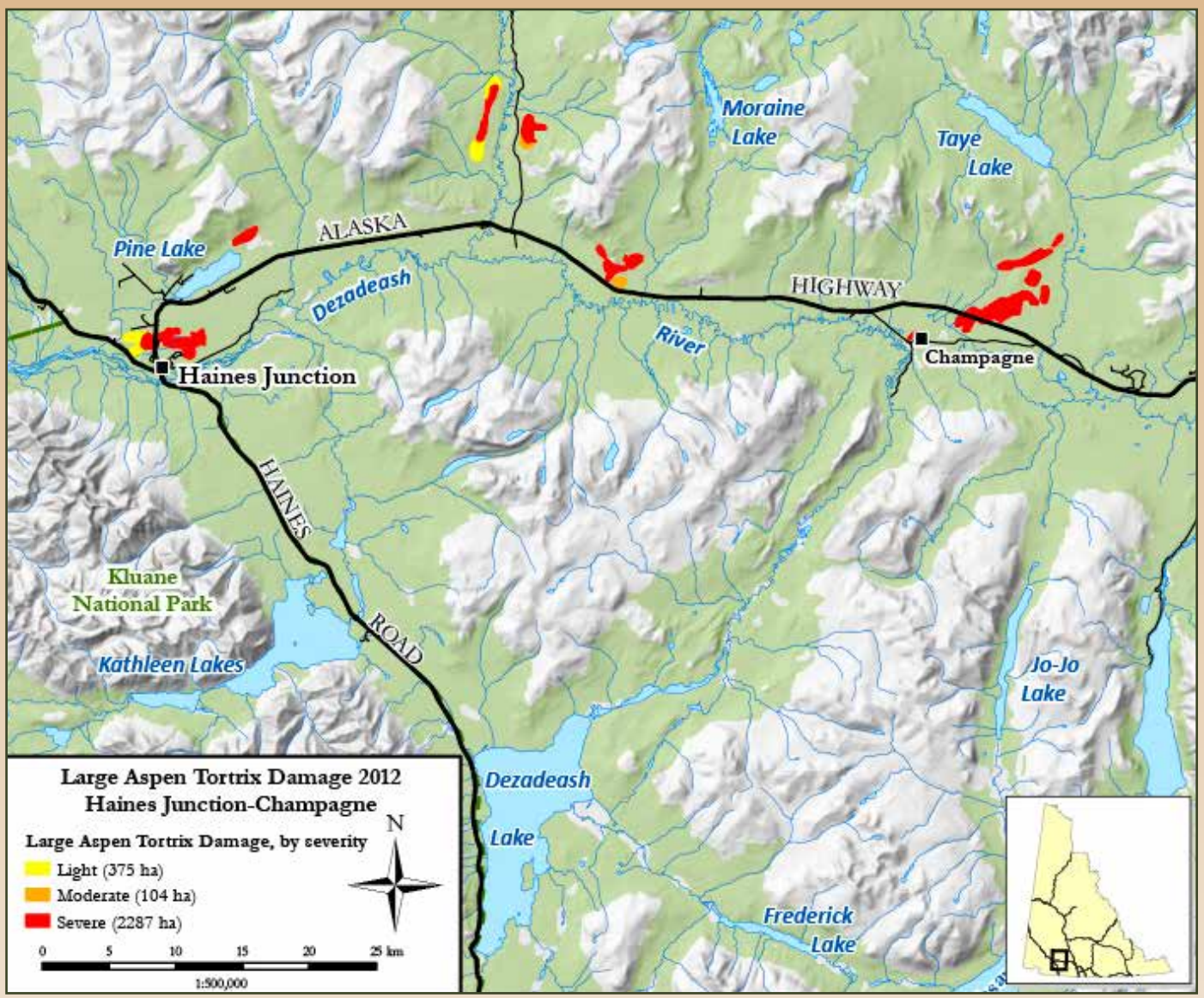
For the second consecutive year, the ongoing defoliation of trembling aspen by large aspen tortrix was mapped by aerial surveys in Yukon. A three-hour aerial survey was conducted to monitor the ongoing aspen defoliation caused by large aspen tortrix both in southwest Yukon and in the Pelly Crossing area. Five patches of defoliation were mapped over an area totaling approximately 1600 ha from Mendenhall west to Haines Junction. Large aspen tortrix was also mapped near Pelly Crossing for the second consecutive year. This year, defoliation was less severe, but covered nearly 3500 ha, significantly more than the 730 ha mapped in 2012.

Southwest Yukon

In the southwest Yukon, defoliation was mapped in four areas: Mendenhall River, Cracker Creek, Aishihik River and Haines Junction (Map 5 and 5a, photo 5). These were the same areas where defoliation was mapped last year, though the area declined from approximately 3000 ha in 2012, to 1600 ha in 2013. The intensity of defoliation also declined with only 13% mapped as severe this year compared to 80% last year. From the ground, the thin crowns of the trees made it appear that current damage was greater because the crowns remained thin as a result of the severe damage imposed last year. Adult moths had already completed egg-laying at the time of survey in late July. Ground truthing results of 10 to 15 trees sampled showed only one or two egg masses per tree, which is considered to be a very low infestation rate (Photo 6).

Photo 5. Aerial photo of large aspen tortrix defoliation at Haines Junction

Map 5 Large aspen tortrix defoliation in Haines Junction-Champagne area in 2012. Area of defoliation approximately 2765 hectares.



Map 5a Large aspen tortrix defoliation in Haines Junction-Champagne area in 2013. Area of defoliation approximately 1600 hectares.

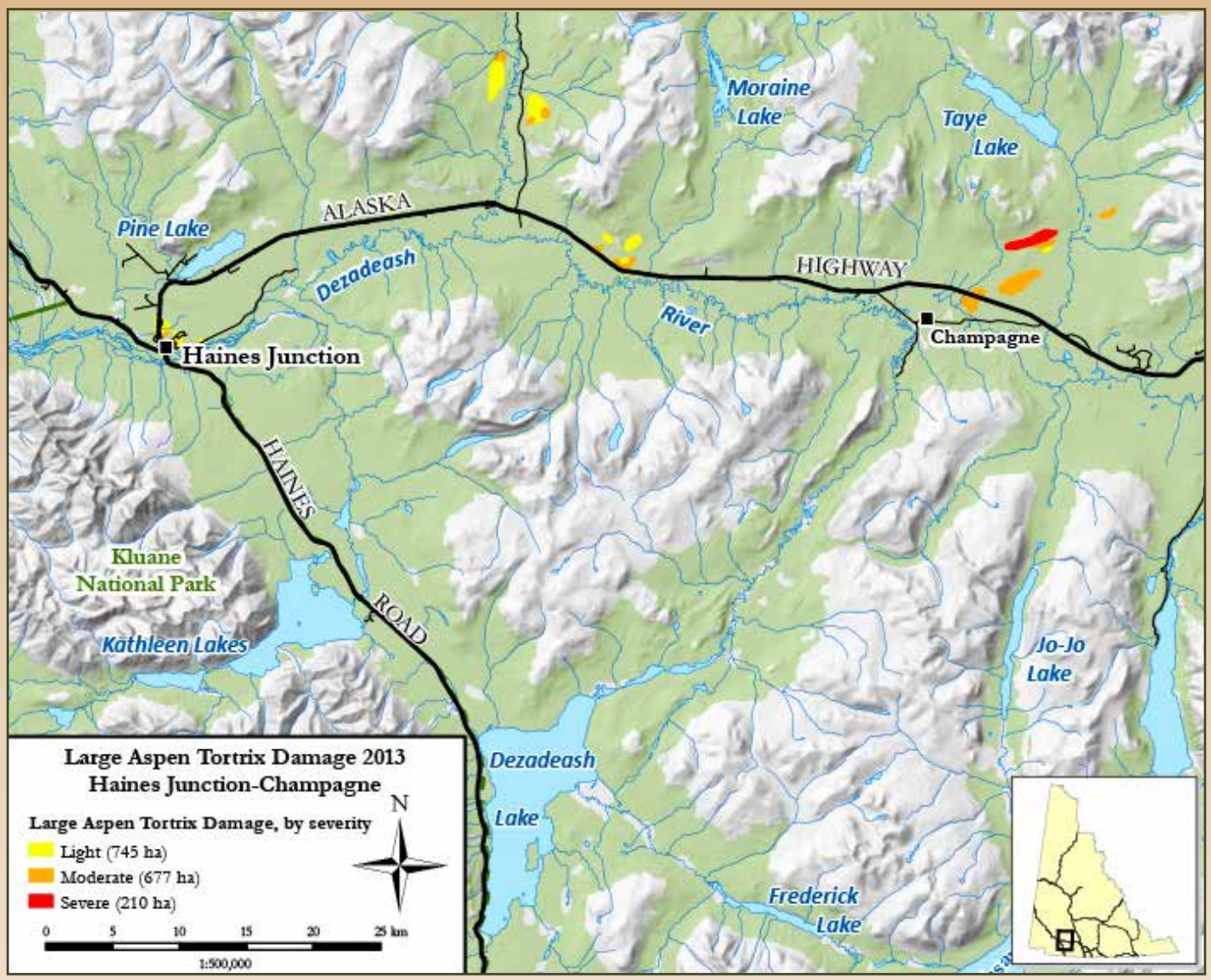


Photo 6. Large aspen tortrix egg mass on aspen leaf

Pelly Crossing Area

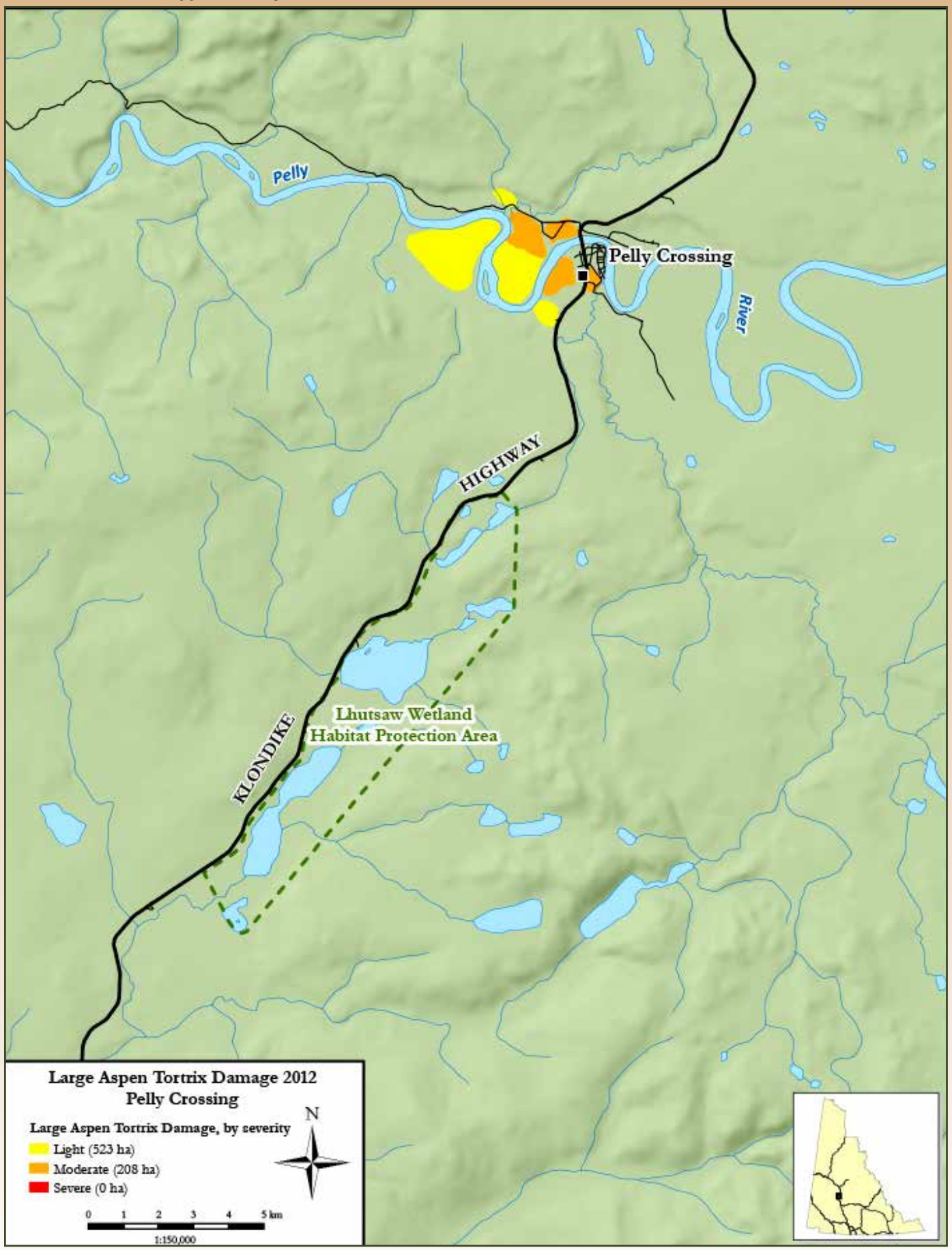
In 2013, approximately of 3500 ha of aspen defoliation was mapped in stands around the Village of Pelly Crossing (Map 6 and 6a, photo 7). This was a significant increase from the 730 ha mapped in 2012. The severity of defoliation was distributed nearly evenly among the three defoliation classes. (This pattern is also the exact opposite of what was found in the Haines Junction area). The spatial distribution of defoliation was spread over a much larger area than last year, running east and north of the village with infestations mapped almost as far to the northeast as Diamain Lake, to the northwest along Greyling Creek and to the southeast along Mica Creek.

It should be noted that unlike infestations farther to the south, there was no overlap with areas infested in 2012. The reason for this is unknown but it is possible that female moths were dispersed by wind prior to egg laying when they flew in early July of last year. Ground truthing of 12 to 15 aspen trees revealed less than five egg masses. Because of this low occurrence, damage is expected to be dramatically reduced or absent in 2014. Mortality is not expected to occur because none of the stands infested last year experienced a second year of defoliation.

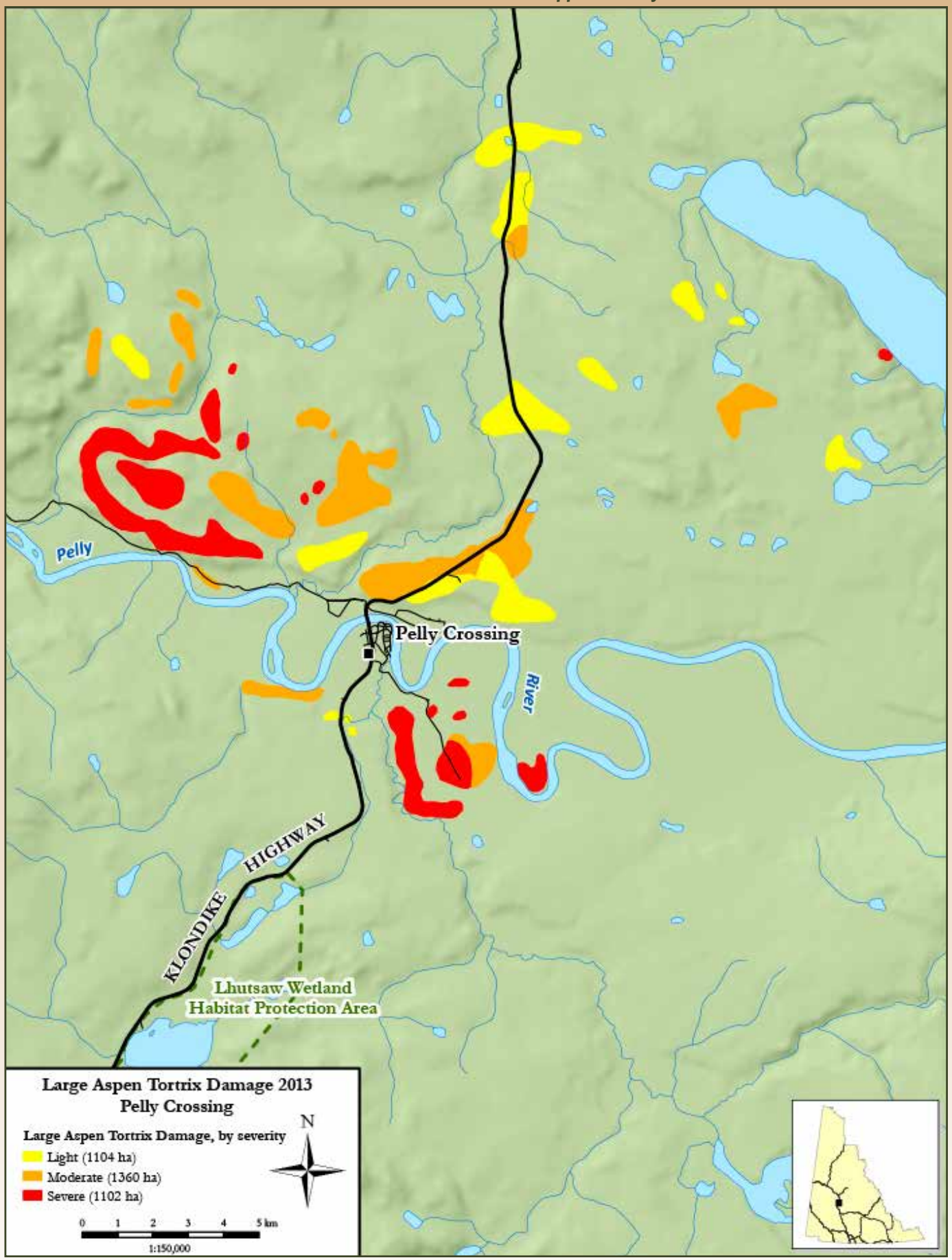
It is extremely rare for populations of this insect to survive at infestation levels for three consecutive years in the Yukon. Climatic factors such as severe winter temperatures can kill young larvae in their winter hibernacula; spring frosts can also kill them as they re-emerge from their winter refuge and migrate to feed on emerging leaves. Numerous larval and egg parasites have been found associated with tortrix infestations in Alaska (USDA Pest Leaflet #139). However, host depletion with resultant starvation of late instar larvae is thought to be the main cause of population collapse. In Haines Junction, many larvae had dropped from the depleted crowns to search for food on the forest floor. This was evidenced by the abundant webbing and signs of feeding on alternate and less favoured hosts such as young spruce and fireweed. For this reason and because so few egg masses were found, it is unlikely that a third year of damage will occur. Following the two years of infestation, it is likely that some trees will have expended all of their available resources and therefore some mortality can be expected, particularly in smaller understory trees.

Photo 7. Aerial photo shows large discoloured area of aspen tortrix defoliation north of Pelly Crossing

Map 6 Large aspen tortrix defoliation in the Pelly Crossing area in 2012. Area of defoliation is approximately 730 hectares.



Map 6a Large aspen tortrix defoliation in the Pelly Crossing area in 2013. Area of defoliation is approximately 3566 hectares



Forest Health Zone 5

A two day aerial survey of the forested area within forest health zone 5 was flown using a Cessna 206 fixed-wing aircraft (Map 7). This most northern forest health zone includes a section of the Porcupine River drainage basin. This area provides material resources for the Village of Old Crow, including timber and firewood. The majority of this zone is located north of the Arctic Circle. Ecologically, it includes the northern limit of the taiga biome and the beginning of the Arctic Tundra. The forested areas are comprised of discontinuous but vigorous stands of white spruce and scattered larch along the river courses. There are also large continuous stands of stunted black spruce overlying permafrost mixed in with discontinuous pockets of aspen stands along the upland sites (Photos 8 and 9). The majority of the area was flown in an east-west grid pattern with 8 kilometres between grids, though some contour flying was done in mountainous areas. No insect or disease related forest disturbances were found in this area. Neither aspen serpentine leaf miner nor large aspen tortrix were found in the zone (as opposed to the south) is perhaps due to the cold climate of northern Yukon.

Map 7. Forest Health Zone 5 - The most northerly forest health zone in Yukon

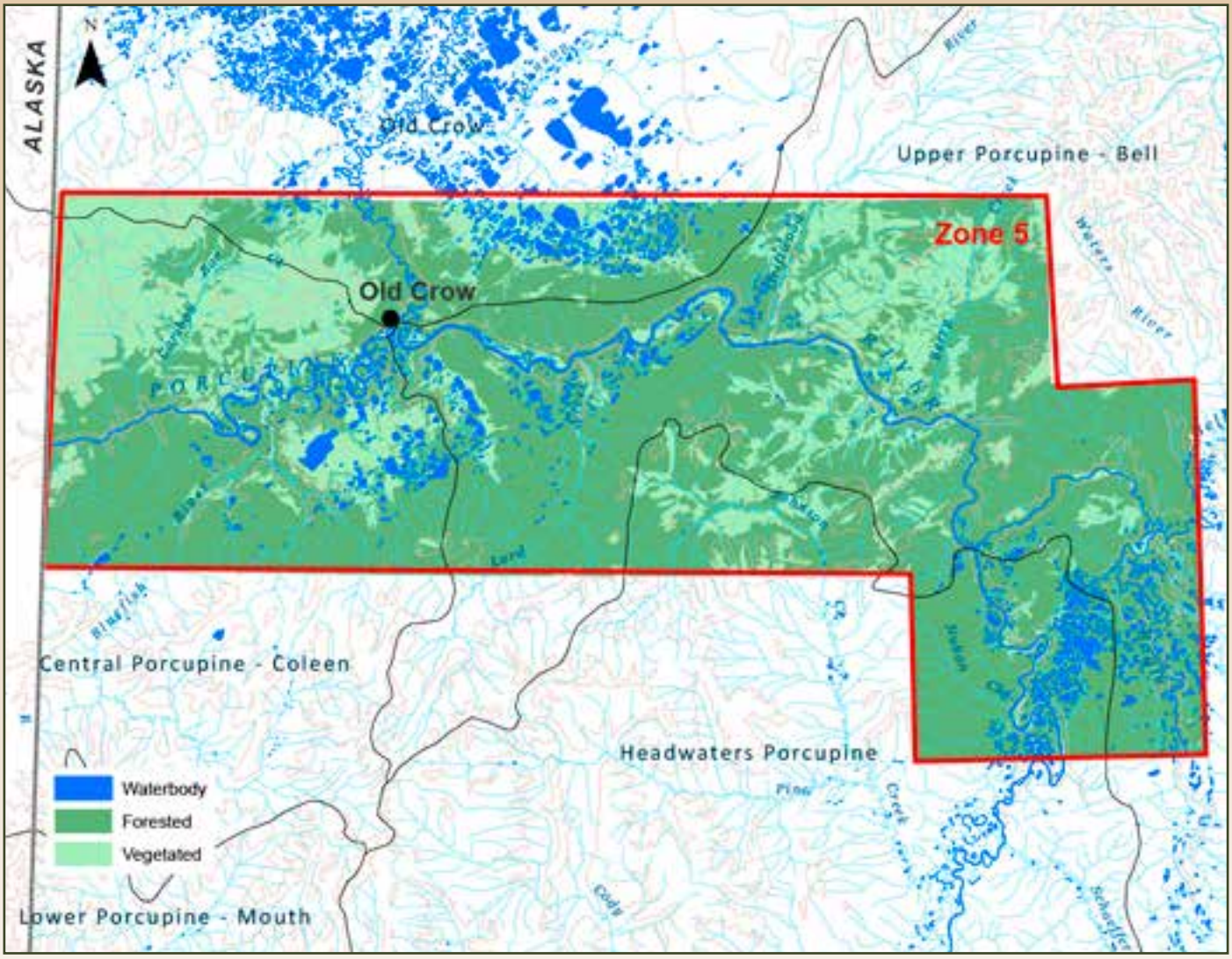


Photo 8. Aerial survey at Lord Creek, Forest Health Zone 5, shows no forest health concerns

Photo 9. Aerial survey Old Crow area, with large continuous stands of black spruce and pockets of aspen

Biotic and Abiotic Disturbance Monitoring 2013

Aspen Serpentine Leafminer *(Phyllocnistis populiella)*

A reduction in the extent and severity of aspen serpentine leafminer damage to the leaves of trembling aspen (and balsam poplar, to a lesser extent) was first reported in 2012. The trend has continued into 2013, with further reductions seen throughout Yukon. Many areas that were severely infested in recent years are now experiencing light to moderate infestation rates. Around Whitehorse, infestation rates have decreased sharply. There are now individual trees without any sign of infestation. No sign of aspen defoliation was noted in the Old Crow region during the aerial survey (Photo 10).

Photo 10. Aspen in Old Crow, showing no sign of Aspen serpentine leaf miner

Ambermarked Birch Leafminer *(Profenusa thomsoni)*

Populations of the ambermarked birch leafminer in native and ornamental birch trees in 2013 within Dawson City were similar to 2012. Some trees show light infestation, while others remained unaffected (Photo 11). A five metre tree in the middle of Dawson City was found to be severely infested with over 80% of leaves mined. In Whitehorse, trace levels of leaf mining were seen in some ornamental birch at Shipyards Park. The insect was found in both Dawson City and Whitehorse in 2013 and the population appears to have stabilized. To contrast, Anchorage, Alaska populations experienced epidemic levels in 2013. It is likely that the climate in both Whitehorse and Dawson City is harsh enough to limit the population, though not severe enough to eliminate them completely.

The ambermarked birch leafminer was introduced into the eastern United States and was first identified in 1923. Since then, populations have spread throughout North America. Most of the recorded outbreaks have occurred on ornamental plantings in urban settings, with only light attacks on native birch. Fortunately effective biological control has been achieved by a variety of parasitic wasps that are either native to North America or were introduced with the leafminer. The most important of these is the parasitic wasp, *Lathrolestes luteolator*, which is a native species that has apparently adapted to parasitize a new host (Digweed et al., 2003). Infestation levels in Edmonton dropped from epidemic to low levels between 1992 and 1995 due to a subsequent increase in populations of the parasite. Population levels have remained low there since 1995.

L. luteolator adults and pupae were collected in northern Alberta and released in Anchorage, Alaska between 2004 and 2007 (MacQuarrie, 2008). Introduction was successful and *P. thomsoni* populations have declined slowly since the introductions. Populations of both species are being closely monitored.

Photo 11. Mined birch leaf showing ambermarked birch leafminer larvae

Larch Sawfly *(Pristiphora erichsonii)*

Photo 12. Larch sawfly larvae on Siberian Larch

A chronic small population of larch sawflies caused trace levels of defoliation in a single ornamental Siberian larch at the FMB office in Whitehorse (Photo 12). This population has remained viable in the same tree for more than 10 years.

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

In the mid 1990s, a severe outbreak on the slopes of Mt. Martin in the LaBiche River area killed most of the mature larch (Garbutt, 1995). A forest health survey in 2005 found 14 dead mature eastern larch in a stand adjacent to the Miner River, a tributary of the Porcupine River south of Old Crow (Garbutt, 2005). Sawfly larvae were found feeding on immature larch at the stand edge. Judging by their condition, all of the mature trees appeared to have been killed at the same time which was approximately before that date. Outbreaks of defoliators have historically occurred simultaneously in widely scattered locations. It was possible, therefore, that the Miner River larch were killed in the same outbreak that caused the mortality in the southeast.

Yellow-headed Spruce Sawfly *(Pikonema alaskensis)*

Photo 13. Yellowheaded spruce sawfly larvae on ornamental white spruce

For the fifth consecutive year, ornamental white spruce at Shipyards Park in Whitehorse were defoliated by larvae of this sawfly. Damage in 2013 was similar to that seen in 2012, with only a few trees lightly defoliated (Photo 13). For the first time this year, feeding damage on ornamental white spruce was seen just south of the main terminal building at Whitehorse Airport. Signs of older damage suggest that a small population had been active here before this year.

This insect selects open-grown trees. For this reason, most damage recorded in North America occurs on young planted urban trees rather than in dense forest (Kusch and Cerezke, 1991). Eggs are laid singly in early June in slits at the base of needles. Usually all eggs of a single adult are laid on a single shoot. When eggs hatch, young larvae commence feeding on newly flushed needles. Like most sawflies, the yellow-headed spruce sawfly is a colonial feeder. When the new growth has been consumed, larvae will continue feeding on the older needles until they are ready to pupate in mid July. Pre-pupal larvae drop to the ground and dig into the duff layer under the tree where they spin their cocoons. They remain there until the adult emerges the following season to coincide with the swelling of buds in the spring.

Control

Because the trees are small, the simplest current method of population control is to locate clusters of feeding larvae while they are still small. Larvae can be dislodged by shaking branches and catching the falling larvae in a bucket of soapy water (Hansen and Walker). Control can also be achieved by the application of insecticidal soap when larvae have just begun to feed (Alberta Department of Agriculture and Rural Development, 2006). A third method involves placing a sheet covered with spruce needles under the tree while larvae are still feeding. Mature larvae drop to the ground (in this case, on to the sheet) just prior to pupation. The sheet can then be removed and the pupae can be destroyed.

Pine Engraver Beetle *(Ips pini)*

A single dead roadside lodgepole pine was noted in 2013, and was killed by pine engravers in 2012 near Rancheria (Photo 14). Though the insects had left the tree, the identity of the attacker was determined by the characteristic larval galleries which radiated from single loci where mating and egg laying took place.

Spruce Bark Beetle *(Dendroctonus rufipennis)*

This year (2013) was the first year since 1994 that aerial surveys were not conducted in order to map white spruce mortality due to spruce bark beetle in the southwest Yukon. These were suspended this year because recent surveys have suggested that the infestation is coming to an end. The spruce bark beetle infestation in the southwest Yukon has been the largest, most severe and long lasting infestation in Canada. It has extended across 400,000 ha of white spruce forest for the last 23 years (Photo 15).

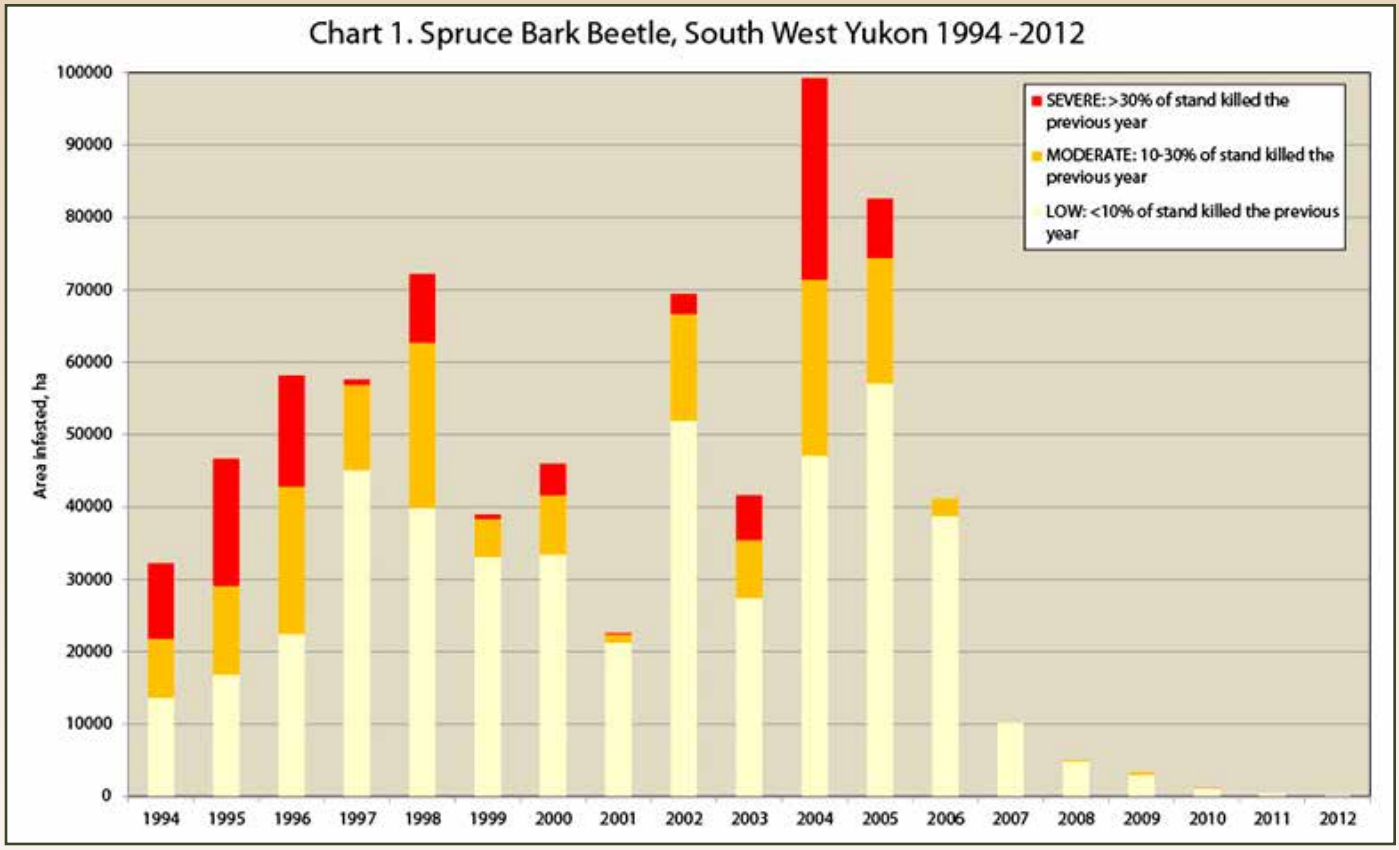
The prolonged drought that started in the mid 1980s caused severe stress within the forests of the southern Yukon. It allowed the beetle to successfully attack and breed within white spruce trees in the Shakwak Trench and Kluane National Park. The drought-stressed trees had little defense against the beetles and the infestation built swiftly until it was discovered in the Alsek River Valley in 1994. Until then, there was no history of aerial overview surveys in Yukon.

The spruce bark beetle epidemic peaked in 2004 when almost 100,000 ha of stands containing red trees were mapped (mortality occurred in the previous year). Light infestation rates (<10% of trees killed in stands) occurred in 2011, and were mapped at 263 ha during the 2012 aerial survey. Last year's survey results, coupled with the previous eight years of consecutive decline, suggest that the infestation is coming to an end for now. Because of this, an aerial survey was not conducted this year. FMB will monitor any future instances of spruce bark beetle in Yukon, not ruling out the fact that another infestation could occur given suitable climatic patterns. Factors such as an overabundance of mature white spruce host material combined with several consecutive droughts and mild winters has the potential to trigger a return of a spruce beetle outbreak.

Photo 14. Single roadside lodgepole pine killed by pine engraver beetles

Photo 15. In 2004 spruce bark beetle infestation at its peak, Haines Junction area

Chart 1. Spruce beetle infestation history in southwest Yukon: No aerial survey of spruce beetle in 2013.



Animal Damage

Porcupine *(Erithizon dorsatum)*

Five scattered mature white spruce were killed by porcupines near the Continental Divide. The trees were girdled as the porcupines fed upon the sapwood of the trees from the ground level to a height of one meter on the boles. Deep scratches left by the large incisors were clearly visible on the trees.

Red Squirrel *(Tamiasciurus hudsonicus)*

In the early spring when red squirrels have exhausted their winter store of cones, they often forage for immature cones in stands of young lodgepole pine. They harvest the cones by stripping them from the outer branches, and in doing so girdles the branches, causing them to die and turn red the following summer (Photo 16).

There were many stands of young roadside pines affected by squirrels between Rancheria and the Continental Divide (Photo 17). This recurring phenomenon has been more visible in some years than in others; it is dependent on the abundance of cones that the squirrels are able to collect in the fall for their overwinter store.

Photo 16. Scar on branch resulting from cone stripping by red squirrels

Photo 17. Dead branch tips resulting from cone stripping by red squirrels

Environmental Damage

"Flagging" in spruce and pine

A common environment effect is branch "flagging", seen commonly throughout Yukon affecting white spruce and lodgepole pine in the latter part of the summer (Photo 18). This is a natural annual phenomenon whereby the trees lose their oldest needles. In 2013, the effect of flagging was more evident due to the dry summer season and the tree's natural response to drought. Trees lose moisture by the process of transpiration through the needles. This process is the means by which trees draw water from the soil by capillary action to feed its living tissues. When moisture becomes limited, the tree sheds the older needles first in favour of new ones which gather and process the most light energy from the sun.

Photo 18. Typical late summer "flagging" in lodgepole pine

Red Belt

In 2013, winter wind desiccation was the likely cause of the reddening of the crowns of lodgepole pine over a one hectare area that is two kilometres east of Rancheria (Photo 19). Typical of red belt injury, the red trees follow a distinct elevation band across the slope. The same phenomenon has been observed in the same stands numerous times in the past. The unseasonable occurrence of warm, dry winds during the day followed by cold air drainage at night leads to wind desiccation injury. Frozen soils do not allow lost moisture to be replaced quickly enough and the affected needles discolour and are eventually shed (B.C. Ministry of Forests and Range). The affected needles, particularly those on the exposed face, die and turn red. The effects of the damage vary, according to how much of the tree crown is affected and whether the damage is repeated. In severe cases with repeated occurrence, some tree mortality can result.

Photo 19. Red Belt affecting lodgepole pine near Rancheria

Persistent multi-species dieback

For the third consecutive year, a progressive roadside dieback affecting coniferous and deciduous tree species was observed in the Cowley Creek sub-division south of Whitehorse. In the two years since it was first reported, the dieback has progressed (Photos 20 and 21).

This incidence of dieback was first reported in the 1970s along the Alaska Highway north of Burwash Landing. Since then many other instances of progressive dieback have been observed including numerous locations along the Mayo Road, along the Robert Campbell Highway, along the South Klondike and along the road to Atlin.

Multiple species of conifer, including spruce and lodgepole pine, were disturbed in different areas; deciduous species such as aspen, balsam poplar and willow species are also affected. The multi-species aspect of the damage eliminates any biotic pest, leaving only the environment as the root cause. But whether the damage is climate-induced or involves soil chemistry or some other environmental influence has remained a mystery.

Photo 20. Dieback of white spruce at Cowley Creek subdivision

Photo 21. Dieback of aspen at Cowley Creek subdivision

Spruce Budworm Bait Traps Deployment – Canadian Forest Service Study

Defoliators are a significant forest health factor and natural disturbance agent of forests in North America. The eastern spruce budworm *(Choristoneura fumiferana)*, fir-spruce budworm *(Choristoneura orae)* and two-year cycle budworm *(Choristoneura biennis)* have historically been present in the Yukon. Defoliator outbreaks are often cyclical, occurring every four to ten years and persisting between one and four years. High budworm populations can result in defoliation ranging from light damage to growing tips to complete tree defoliation. However, severe damage is rare and the forests of southeastern Yukon were moderately impacted by defoliators throughout the late 1980s and early 1990s. Since 2000, trace amounts of defoliation have been recorded consistently in southeast Yukon, as well as central Yukon in 2009 and 2010 (Government of Yukon EMR; R Garbutt, 2010). The northern range of the budworm's current distribution is generally limited by the range of its main hosts, balsam fir and white spruce trees.

In 2013, FMB participated in a research project being carried out by the CFS to monitor populations of eastern spruce budworm (*C. fumiferana*) and fir-spruce budworm (*C. Orae*) in Yukon, as part of a Canada wide study. The objective of the project is to identify genetic markers that can be used to identify if spruce budworm populations are local to Yukon or are migrant wind dispersed populations.

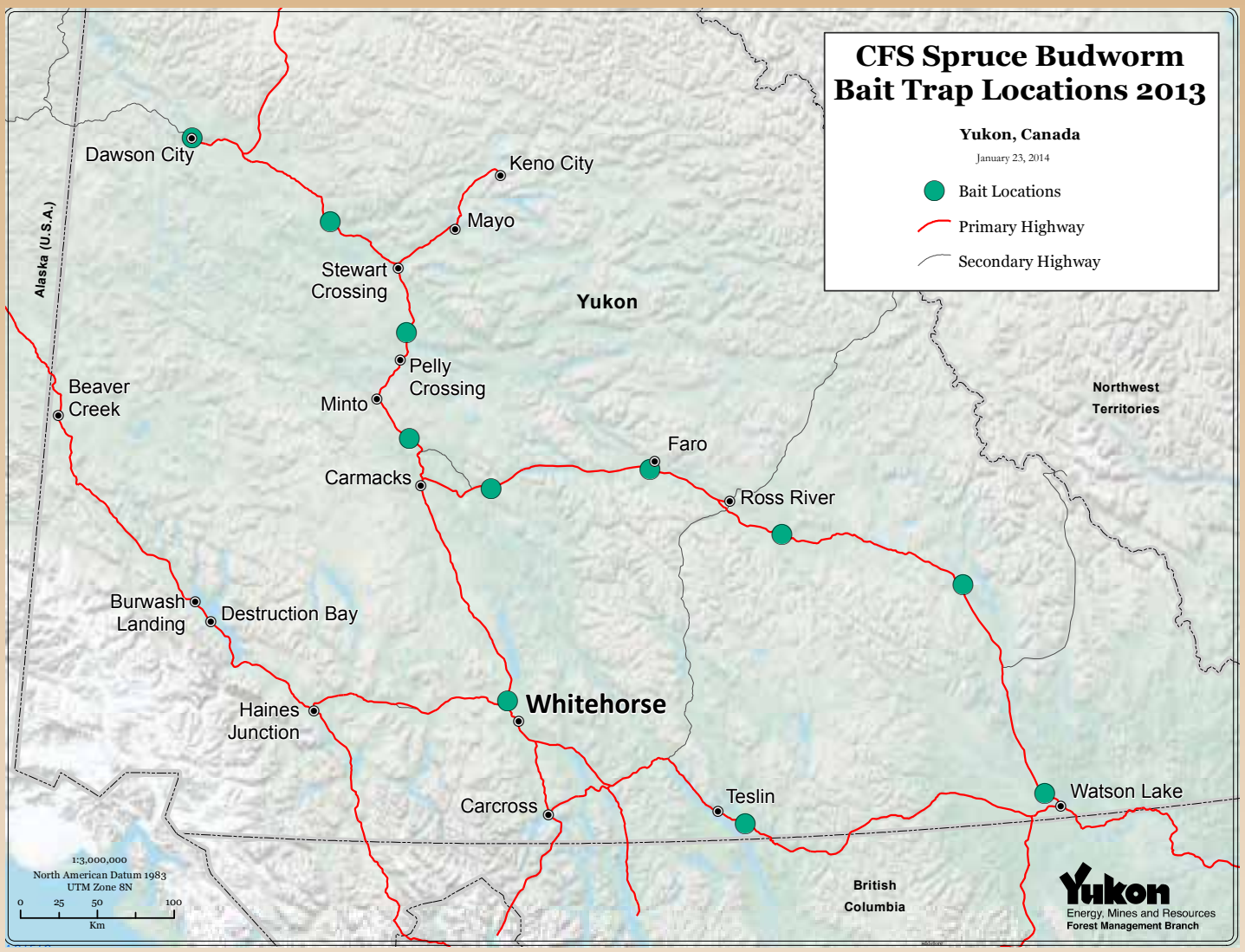
Two bait traps were set up at each of nine locations throughout central Yukon (Map 8). Each trap had a pheromone bait attractant placed in it specific to the species of budworm moth of interest. The two traps were deployed 50m apart in selected white spruce stands in late June to correspond with the time of adult moth emergence and flight during the summer (Photos 22 and 23). The traps were then collected in late August or early September. The moths were counted, preserved in a dry paper bag, and were then shipped to the Laurentian Forestry Center in Quebec.

The DNA recovered from the moths will undergo a process called genotyping-by-sequencing, which will allow researchers to discover the genetic markers. The ultimate goal of the project is to be able to sample moths at a site, then use the genetic markers and the environmental conditions (wind direction, temperature for example) to determine the direction and the distance of the dispersal event. Over time, this information could be used to further develop reliable models to assist with in aiding spruce budworm management decisions (L. Lumley, pers com 2013).

Initial results show that moth species of each type are present in central and northern Yukon, and CFS has successfully extracted DNA from some of the moths that were trapped. The raw data from the project, which will be available early in 2014, will be presented in next year's forest health report.

Photo 22. (left) Spruce budworm trap deployment
Photo 23. (above) Moth collection *C. Orae*

Map 8. Location of spruce budworm bait traps in Yukon



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Appendix 1

Summary of the *Mountain Pine Beetle Pest Risk Analysis for Yukon Lodgepole Pine Forests*

In 2012, a Pest Risk Analysis (PRA) - *Mountain Pine Beetle Pest Risk Analysis for Yukon Lodgepole Pine Forests*, was completed. Field assessments were led by the Forest Management Branch, and direction for the risk analysis was provided by the Yukon Government Mountain Pine Beetle Interdepartmental Committee. The purpose of the risk assessment was to assess the likelihood and the consequences of mountain pine beetle introduction to Yukon forests. A plain language summary is provided here in Appendix 1.

For copies of the *Mountain Pine Beetle Pest Risk Analysis for Yukon Lodgepole Pine Forests*, please contact the Forest Management Branch via email: forestry@gov.yk.ca or by telephone: 867-456-3999.

Mountain Pine Beetle Pest Risk Analysis for Yukon Lodgepole Pine Forests

Executive Summary

Mountain pine beetle (*Dendroctonus ponderosae* Hopkins) (MPB) is a native bark beetle that attacks pines in western North American forests. It is now the single most destructive insect for mature pine trees in western Canada. In the past, outbreaks have been held in check by cold topographic barrier. However, an unprecedented outbreak in British Columbia (B.C.) began in the late 1990s and firmly established in Alberta. The MPB is moving northward in B.C., and its presence has been confirmed approximately 75 km south of the Yukon border in the Rocky Mountain Trench (RMT), and there are suspected spot infestations about three km south of the Yukon border in the Liard Basin. These spot infestations have been mapped by experienced aerial surveyors by the B.C. Ministry of Forests, Lands and Natural Resource Operations and Yukon government's Forest Management Branch. These spots will require ground truthing in order to confirm presence or absence of MPB. Factors such as climate change and a vast supply of host material pine have been responsible for the expansion of MPB into new habitat - these are commonly referred to as novel habitats containing naïve pine.

This PRA was completed to assess the potential threat by the MPB to novel lodgepole pine forests and the values of the people of Yukon.

The PRA is science-based and transparent approach that characterizes the risks of MPB by examining evidence and identifies uncertainties or information gaps. Uncertainties are a result of missing, inconsistent or insufficient information.

The objectives of the PRA are to answer the following questions, using scientific evidence and input from land managers (including First Nations and municipalities) and Yukon government.

1. What is the likelihood of the MPB invading Yukon and what are the potential social, economic, and environmental effects, both short-term (before2020) and long-term (2070)?
2. What steps should the Yukon government consider to limit both short and long-term consequences?
3. What information is needed to help better understand the risk to Yukon forests?

Yukon differs from other jurisdictions currently managing MPB in that non-timber values are significant. In Yukon, forest fibre (merchantable wood for forest timber products) is not the main value of concern. The potential impacts of MPB on social and cultural values, including those of First Nations, and other economic and environmental values, are integral components of a Yukon-specific MPB pest risk analysis. To gain a sense of non-traditional values (e.g., non-fibre), a MPB workshop was held in Whitehorse in June 2012 to familiarize land managers and government stakeholders with MPB and to gather information regarding their values. Value forms, which assessed tolerance to risk or impacts to values caused by incipient (building phase) or outbreak populations, were completed by land managers and users and government stakeholders after the workshop. In total, five responses were received, with possibly more to come. These value responses are an integral component of the pest risk analysis for Yukon.

What is the level of risk?

Risk is defined as a combination of the likelihood of introduction and consequences of the introduction of MPB. Risk identifies response options and promotes risk communication. The overall risk is rated as low in the short term (before 2020) and moderate to high in the long term (2070). The following evidence was considered when evaluating and determining the level of risk. Levels of uncertainty for the information are noted in brackets:

- MPB has been moving steadily northward. There are suspected infestations within three km of the Yukon border, and confirmed infestations 75 km from the Yukon border (*very low uncertainty*).
- There is ample supply of mature pine (host material) in Yukon forests, which will support a MPB outbreak under favourable climatic conditions (*very low uncertainty*).
- MPB populations are reproducing and surviving at low levels in the Rocky Mountain Trench of northern B.C. (*very low uncertainty*).
- The likelihood of MPB long distance wind dispersal events influencing continued population growth in the Rocky Mountain Trench is low due to declining populations in northern B.C. (*very low uncertainty*).
- Climate models predominately show that conditions in Yukon will become more favourable for MPB survival by 2070. However, the climate suitability will remain low and very low throughout most of Yukon, with some higher suitability in SE Yukon (*very low uncertainty*).
- Very low climate suitability may be limiting the northward spread of MPB in the Rocky Mountain Trench, even with plenty of available mature pine trees. In 2011, MPB expanded in a NE direction toward a fragmented pine landscape with better climatic suitability, rather than up the Rocky Mountain Trench (*moderate to high uncertainty*).
- MPB have twice as many offspring in naïve pine trees (pine habitats that have not had a history of experiencing MPB in past, e.g., Yukon pine forests) as experienced pine (pine habitats that have a history experiencing MPB, e.g., pine in Southern B.C.). The naïve pine trees may have lower resistance to the MPB, which may lead to more outbreaks in suitable weather conditions (*moderate uncertainty*).

Concerns from land managers included the following:

- Sociocultural values of the highest concern are the possibility of wildfires, the impact on forests in general, community well-being, healthy watersheds, recreational trapping and northern woodland caribou.
- Environmental values of highest concern are the possible impacts on northern mountain caribou, water and trapping.
- Economic values that would be moderately impacted are: tourism, forestry and water.

What should the response be?

Currently the MPB is not in Yukon. A long-term prevention strategy is therefore recommended, with a potential to shift to a suppression strategy once MPB expands into Yukon. Detection and monitoring by annual air surveys and ground checks are essential for preventing and controlling outbreaks. It is very important to examine the way populations of MPB behave in previously untouched forests. Uncertainties should be addressed to determine the need and timing of any suppression activities and ultimately reduce the risk and associated consequences.

What have we learned?

It is highly likely that MPB will expand into Yukon by 2020. Populations will likely remain low until several successive years of suitable weather conditions allow for the beetle to become established.

1. A cycle involving a low number of permanently present beetles (erupting and briefly experiencing population outbreaks followed by a collapse of populations down to a low number of permanently present beetles) will happen through to 2070, unless new models show a different pattern.
2. Impacts will be low in the short term and moderate to high in the long term. Social and cultural values will be most affected in the short term, and environmental and economic values will be most affected in the long term.
3. Annual aerial surveys along the border where the beetle might enter and where the highest susceptible forests occur (e.g. mature pine), are very important for monitoring the risk. These surveys are the highest priority, followed by ground checks.

What steps can we take?

The following are key considerations that will help to determine how Yukon might minimize the MPB risk to lodgepole pine forests and to identify appropriate and effective management responses.

1. Research the biology and the causes, distribution and control of the MPB in novel forests.
2. Identify the peak tree-fading time period in northern forests so that aerial surveys can better pinpoint where beetle outbreaks occur and how they are moving.
3. Update the pest risk analysis with any new information as it becomes available.
4. Develop a five-year plan and strategy for monitoring and dealing with MPB.
5. Develop an agreement with neighbouring jurisdictions that have MPB infestations, such as B.C., to allow Yukon to manage areas not currently being managed that pose a risk to Yukon lodgepole pine forests.
6. Address uncertainties as time and/or funding permits.

Appendix 2

Summary of the Five Year Mountain Pine Beetle Plan: *Mountain Pine Beetle Monitoring Plan for Yukon Lodgepole Pine Forests 2013-2018*

In 2012, a Yukon MPB Pest Risk Analysis (PRA) was undertaken by the Yukon Interdepartmental Mountain Pine Beetle Committee to assess the likelihood and consequences of MPB introduction to Yukon Forests. For more information on the PRA please see Appendix 1 for a Summary of the MPB Pest Risk Analysis for Yukon Lodge Pole Pine Forest.

The PRA identified a low risk to MPB in the short-term (2020), and a moderate to high risk in the long-term (2070).

The PRA also identified a number of uncertainties associated with MPB movement, establishment and spread into Yukon novel lodgepole pine forests (i.e. lodgepole pine forests that have not had a history of MPB infestation)

The PRA assigned priorities for addressing these uncertainties, and also developed a list of key considerations for moving forward with regards to proactive MPB management in Yukon. Monitoring was identified as the highest priority to help fill uncertainties. The development of a five year monitoring plan was a key recommendation of the PRA. For copies of the five year *Mountain Pine Beetle Monitoring Plan for Yukon Lodgepole Pine Forests 2013-2018*, please contact the Forest Management Branch via email: forestry@gov.yk.ca or by telephone: 867-456-3999.

Mountain Pine Beetle Monitoring Plan for Yukon Lodgepole Pine Forests 2013-2018

The purpose of the five year monitoring plan is to describe and outline monitoring activities and their timing, and to serve as a resource to help guide effective and efficient management of MPB in Yukon lodgepole pine forests.

Monitoring activities will focus on operational needs:

- When and where to conduct aerial surveys
- What would trigger further ground assessments

Given the uncertainties identified in the PRA with regards to MPB behavior in novel habitats, additional research-oriented activities will also be suggested. Similarly lodgepole pine trees in the novel habitat are considered naïve to MPB, and preliminary research indicates that these trees may have lower resistance and greater MPB production capacity. Therefore it is important to have a better understanding of observed behavior in novel habitats in order to make decisions regarding further monitoring.

While the plan will focus solely on monitoring activities, treatment activities where necessary will be identified for conducting control options in regards to MPB.

The monitoring plan, which is essentially a decision tree, is dynamic in nature, such that monitoring activities in any one year are determined by results of monitoring activities the preceding year – monitoring results include those from Yukon, British Columbia, Alberta, and Northwest Territories. Hence the plan could extend beyond the 2013-2018 timeframe provided the status of MPB has not changed significantly.

Baseline Monitoring Zone

Based on the observed behavior in novel habitats as determined by two years of studies at Scoop Lake B.C. (within the Rocky Mountain Trench), it was determined that the MPB was not going to erupt and move quickly across the landscape, therefore:

- A monitoring zone south of the Yukon border in B.C. should provide ample warning to Yukon forest managers should MPB become established in that zone.
- The monitoring zone is 30 x 300 Kilometers wide, stretching north of the Yukon border five Kilometers, and south 25 Kilometers into B.C.
- The zone will run the length of the border (300 Km) in the area with the greatest amount of susceptible lodgepole pine, and the highest risk corridor – east and west of Watson Lake.
- Adjustments to this baseline monitoring zone will be made annually based on monitoring results.

Additional Monitoring Zone for 2013/2014

Yukon FMB has undertaken both aerial and ground monitoring of MPB in the Rocky Mountain Trench (RMT) in B.C. for the last two years. Given the likelihood of a semivoltine (generation time is more than one year) population in northern locales, abandoning RMT aerial surveys requires two consecutive years with no northward movement detected – erring on the side of caution given the susceptibility of this corridor and population increase just south of the RMT in 2012.

Baseline Susceptibility Data

As the proposed monitoring plan is based on lodgepole pine distribution and susceptibility, it assumes that the forest inventory used to generate susceptibility maps accurately reflect current lodgepole pine stand characteristics and distribution on the landscape. It also assumes that stand susceptibility will increase over time as a function of both stands aging and a warming climate.

Monitoring and Detection Tools

Traditional tools used to monitor MPB include both aerial and ground surveys, with the selection of appropriate tools based on MPB population status and monitoring zone, and described/depicted in the monitoring decision trees.

Ground Surveys

Ground surveys complement aerial surveys and are generally undertaken to:

1. Monitor the presence or absence of MPB through a baiting program.Yukon Government currently has a pheromone baiting program in place for the purposes of monitoring, and this acts as an early warning system by detecting potential long distance dispersal events. The number and location of baits currently deployed in Yukon will be re-evaluated should MPB activity be observed beyond the current baiting area. It should be noted that no presence of MPB has been detected to date.
2. Confirm via ground assessments if MPB is causal agent of red trees mapped during Aerial Overview Surveys (AOS).
3. Assess overwinter mortality of MPB (r-values).
4. Assess green: red tree ratios to estimate the population status for example; increasing, decreasing, or static. Also to determine if a long distance dispersal (LDD) event has occurred (ratios of greater that 10:1 imply LDD).

Aerial Surveys

Aerial surveys will be the primary tool in monitoring MPB. Aerial survey standards used by Yukon are similar to those used in British Columbia.

Aerial surveys should occur in July as tree fading occurs sooner than in historic southern locales given the increased light and earlier accumulation of degree days of northern climates. Aerial survey timing tries to capture the optimum fade period. However, given the potential semivoltine populations in northern climates it is possible that tree fading occurs throughout the summer months, or that there are two distinct fade periods. Therefore survey results in the RMT should be complemented with B.C.'s results, as their surveys take place later in the summer.

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