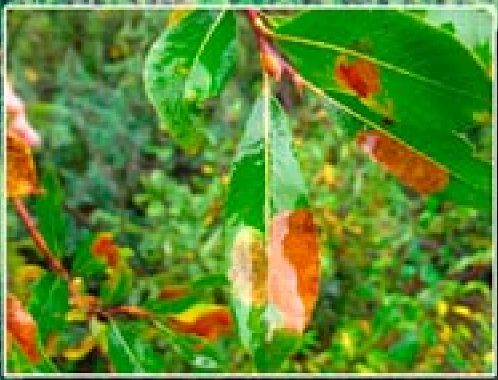
2010
Forest Health Report

Yukon
Energy, Mines and Resources
Forest Management Branch



Top right photo:
Aspen tree dieback due to drought stress. Location: Silver Trail near Mayo.

Bottom right photo:
Ground truthing of ongoing monitoring at Aussie Creek spruce bark beetle damage. Crew is Rod Garbutt, RG Pest Solutions; Aerial Surveyor, Rob Legare, Forester, Forest Management Branch and Micah Olesh, Lands and Resources Officer (Tr'ondek Hwech'in technician) Location: Near Aussie Creek.

Center photo:
Damage to willow leaf by willow blotch miner. Location: North Klondike Highway near Dawson City.

Left photo:
Top third of tree damage by northern spruce engraver. Location: North Klondike Highway near Stewart Crossing.

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A Risk Based Approach to Forest Health Monitoring for Yukon

Introduction

The Yukon Forest Management Branch (FMB) implemented a risk based approach to forest health monitoring in 2009. Prior to 2009, FMB relied heavily on the Canadian Forest Service (CFS), Pacific Region, Victoria B.C., to carry out its forest health program. CFS supported the Yukon Forest Health Program through the Forest Insect Disease Survey Program (FIDS) and following the termination of this nation-wide program in 1995, continued its support through a contribution agreement with the Yukon government. Through this agreement, CFS contributed the expertise of their forest health technician, Rod Garbutt, to carry out surveys and generate an annual forest health report, with FMB funding the field portion of the work. Most of the CFS work centered around mapping the spruce bark beetle (*Dendroctonus rufipennis*) infestation in southwest Yukon, which is the largest, most intensive spruce bark beetle outbreak ever recorded in Canada with an area of over 350,000 ha. Currently, CFS does not assist Yukon in the same capacity.

In 2006, the Canadian Council of Forest Ministers (CCFM) approved a National Forest Pest Strategy (NFPS). The NFPS offers a proactive, integrated response to forest pests by providing 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 through improved coordination across jurisdictions; to enhance the capacity for identifying and assessing forest pest risks; and to increase options for, and the effectiveness of, the response to forest pest threats (CCFM, 2007).

Pest risk analysis is the framework for the NFPS. Forest pest risk analysis is a process in which scientific information is utilized 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 has initiated the development of a risk-based annual forest health monitoring program. The objectives of this risk-based forest health monitoring program are:

1. **To provide a Yukon-wide overview of forest health issues:**
   Providing an overview of forest health across Yukon as opposed to addressing specific forest health questions in specific areas.
2. **To focus monitoring activities on high-risk forest health agents in high value forest regions.**
   The monitoring will be across forested landscapes that are of the most value to the residents of Yukon.
3. **To contribute to the National Forest Pest Strategy goal.**
   One of the major goals of NFPS is developing early detection and reporting capacity of forest health pests.

Identification of Major Forest Health Agents of Yukon

The Yukon Forest Health Advisory Team[1] came up with a list of 10 forest health agents that pose the greatest risk (i.e. extensive mortality or defoliation) to Yukon forests and can be effectively monitored as part of a risk-based forest health monitoring program. For these reasons, eight of the nine forest pests that will be deliberately targeted through annual monitoring are insects. Not only do these insects have the capacity to cause significant damage to forest resources, but their damage is visible and therefore can be effectively monitored.

The only pathogen that will be monitored is pine needle cast, *Lophodermella concolor*. This pest can impact large areas of forest and can be effectively monitored because its damage to pine foliage can be very visible. Although the damage caused by root rot (e.g. Tomentosus root disease) and heart rot (e.g. aspen trunk rot) fungi are more significant than the damage caused by 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 where timber harvest projects are being developed, when reforestation efforts are being planned, and when conducting regeneration surveys.

Tree dieback due to drought stress was identified as an additional forest health agent of concern for monitoring. The 10 biotic and abiotic forest health agents that will be routinely monitored[2] are:

1. Spruce beetle *(Dendroctonus rufipennis)*—This bark beetle is the most damaging forest pest of mature spruce (*Picea spp.*) forests in Yukon. A spruce beetle outbreak in southwest Yukon that began about 1990 is still underway, and has killed more than half of the mature spruce forest (primarily white spruce [*P. glauca*]) over this 380,000 ha area.

2. Northern spruce engraver (*Ips perturbatus*)—The northern spruce engraver acts as both a secondary bark beetle that attacks trees infested with spruce beetle, as well as a primary bark beetle that attacks and kills stressed spruce trees (primarily white spruce). The population of this engraver beetle has increased in Yukon as a result of the increased availability of host material associated with the spruce 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 across 3,174 ha (Garbutt, 2009).

3. Western balsam bark beetle (*Dryocoetes confusus*)—This beetle attacks subalpine fir (*Abies lasiocarpa*). It has moved north from B.C. over the last 20 years, and has become an active disturbance agent in the mature subalpine fir stands in southern Yukon.

4. Budworms (*Choristoneura spp.*)—The budworm guild, comprising eastern spruce budworm, fir-spruce budworm, two-year cycle budworm, and western black-headed budworm cause similar defoliation damage to spruce, subalpine fir, and to a lesser degree, larch (*Larix laricina*) forests in Yukon. In 2008, eastern spruce budworm damage was mapped across 1,003 ha, primarily near Stewart Crossing. Historically, eastern 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 Yukon, mature larch stands in southeast Yukon were heavily defoliated and experienced some mortality in the mid- and late 1990s.

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 sometimes extensive tree mortality. Outbreaks of large aspen tortrix have occurred in several places throughout southern Yukon, including Teslin Lake, Braeburn and Haines Junction.

7. Aspen serpentine leafminer (*Phyllocnistis populiella*) —This defoliator occurs throughout the range of aspen in Yukon. Currently, a massive outbreak of aspen serpentine leafminer extends from Alaska, through Yukon, and into British Columbia. This insect is defoliating balsam poplar (*Populus balsamifera*) as well as aspen trees.

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. The most northern observation of needle cast was observed in young pine stands in the Minto Flats-McCabe Creek area in the interior of Yukon (Ott, 2008). The most severe damage in these pine stands covered 477 ha (Garbutt, 2009).

[1]Members of the Yukon Forest Health Advisory Team were Aynslie Ogden, Forest Science Officer, Yukon Forest Management Branch; Rob Legare, Forest Health, Yukon Forest Management Branch; Rod Garbutt, Forest Health Technician, Canadian Forest Service; and Robert Ott, Forest Ecologist and Forester, RAO Ecological Consulting Services.

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

9. Mountain pine beetle (*Dendroctonus ponderosae*)—This bark beetle is endemic to North America, but currently is not present in Yukon. Most western pines in North America are suitable hosts, but lodgepole pine 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). The mountain pine beetle is currently the single biggest forest health concern in western Canada. The current mountain pine beetle outbreak in British Columbia is responsible for killing over 13 million hectares of pine forest (Carroll, 2007). Cold-induced mortality is considered the most important factor controlling mountain pine beetle dynamics (Régnière and Bentz 2007). A warming climate is expected to allow the beetle 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 the mountain pine beetle was deemed a high priority because of its severe impact on pine forests during outbreaks and because of its proximity to the southern border of Yukon.

10. Tree dieback due to drought stress—In Yukon, trembling aspen occupies the driest sites. As a result, 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 stands were located on level ground with gravelly, well-drained 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 monitoring strategy focuses on forest stands throughout Yukon which are most susceptible to the 10 forest health agents of greatest concern. The strategy consists of two major priorities that will be monitored over the next five years. Once the baseline data has been collected at the completion of the five years, the monitoring strategy will be re-evaluated based on any new concerns as well as existing priorities that are encountered in implementing the forest health program.

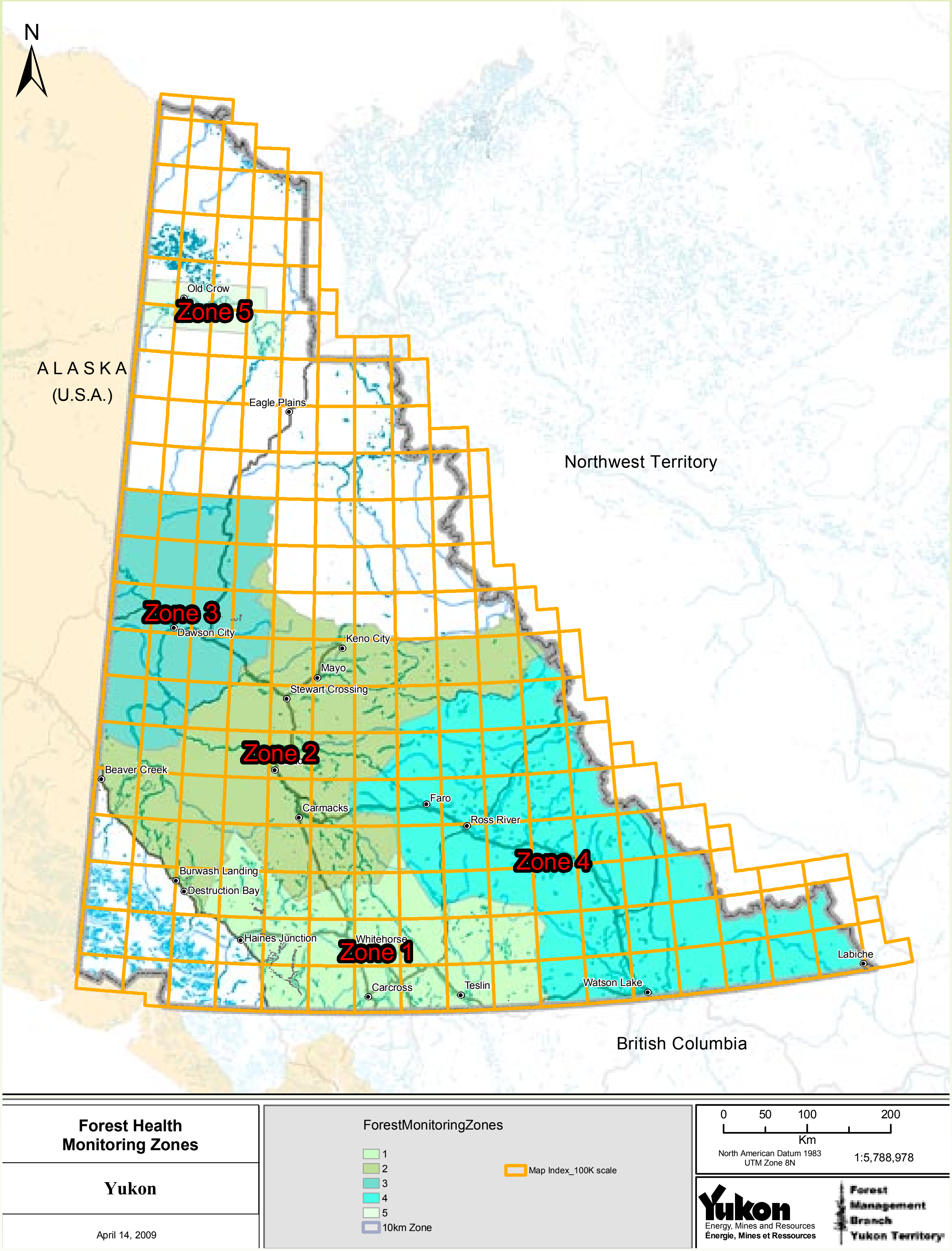
Priorities of the Forest Health Strategy

1. **Monitoring forest health zones on a rotational basis.**

Yukon is divided into five forest health zones based on the high level strategic planning areas (Map 1). In these areas, monitoring focuses on forest stands that are the most susceptible to the 10 forest health agents of greatest concern. Every year, at least one forest health zone is flown on a five year rotational basis and all communities and highway corridors within these regions are monitored. It should be noted that the majority of accessible commercial forest lands and areas where forest management activities occur are within these highway corridors and are within close proximity to the communities.

2. **Ongoing monitoring of areas of concern.**

During the monitoring of the five forest health zones, disturbances may be selected for more monitoring in the current year based from the results of previous surveys. If necessary, these disturbances are considered **ongoing monitoring areas** and will be included along with the forest health zones scheduled for monitoring during the current year. These ongoing monitoring areas will assist the forest health program in prioritizing enhanced monitoring and further response initiatives.



Map 1: Yukon map showing 1:100,000 map grid and the five Forest Health Zones

Aerial Surveys and Ground Truthing as the Primary Tools for Monitoring Strategy

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; McConnell and Avila, 2004). Aerial overview surveys are also sufficient and timely enough for regional and provincial summaries, and national requirements for the Forest Health Network (B.C. Ministry of Forests, Lands and Mines and CFS, 2000).

For all of the above reasons, aerial overview surveys will be 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 Mines will be used in Yukon, to assure continuity across their common boundaries. An important factor in validating the data collected from the aerial surveys is to carry out field checks on a portion of the areas that have been mapped to confirm the identity and severity of the pest or disease disturbance.

Standards for conducting aerial surveys

- Using a Cessna 206 or other equivalent high wing single engine airplane
- A flying height of 800 m above ground level
- 1:100,000 scale maps utilized by aerial surveyors
- 2 qualified aerial surveyors (one positioned on each side of plane)
- Each surveyor should see approximately a 4 km wide corridor
- Aerial surveys limited to days with clear, sunny skies
- Aerial surveyors map and record the severity and identify the type of disturbance such as:
  - Dead and dying trees caused by bark beetles
  - Defoliation from insects and diseases such as budworm, leaf miners, needle diseases
  - Stressed or dead trees from climatic factors such as flood, drought, or windthrow
  - Trees damaged by animals such as porcupine
- On the ground checks are utilized to confirm the type of disturbance recorded from the aerial surveys
- Recorded mapping data is digitized and stored in the Yukon government Geographic Information System

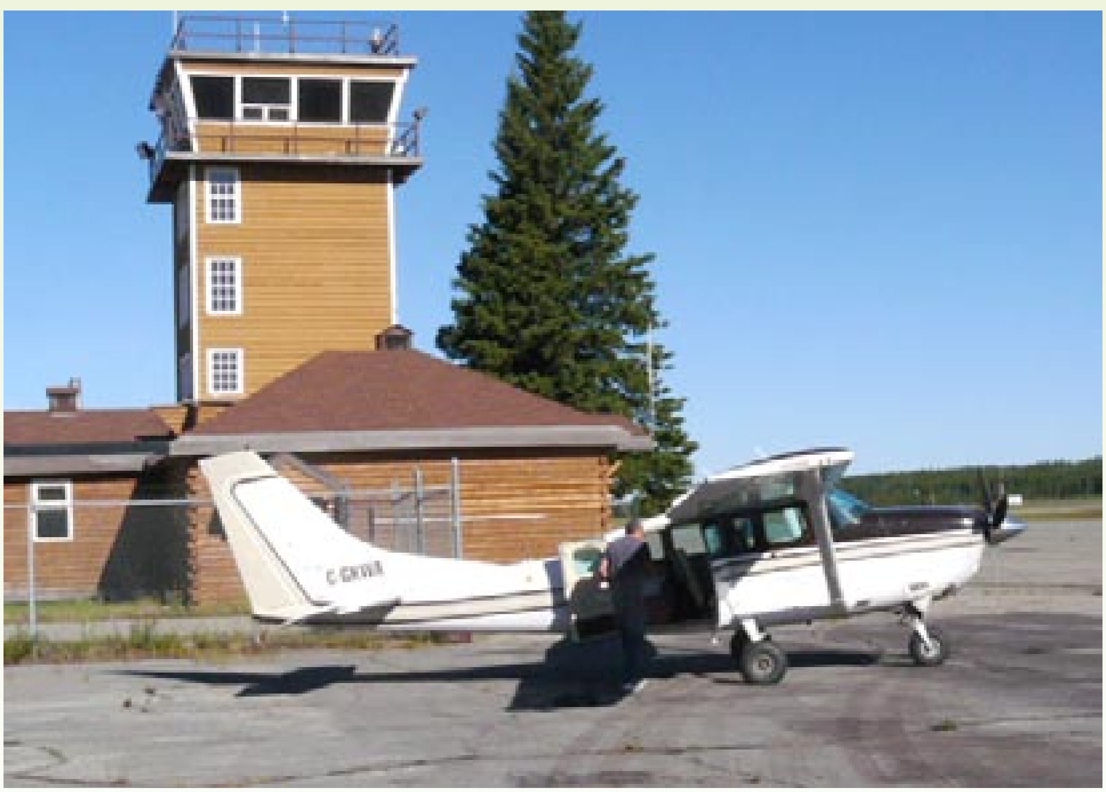


Photo 1: A Cessna 206 at Watson Lake Airport

Summary 2010 Forest Health Initiatives

In 2010, the implementation of FMB's forest health initiatives can be summarized in six components:

Component 1: Began in early June with the presentation of a two-day forest health training course. A one-day classroom session was followed by a second day of field visits to observe a range of active forest insect and disease incidences around Whitehorse. The main focus of this course was to:

1. Enhance forestry and environmental staff in identifying significant insects and diseases that affect Yukon forests; and,
2. Report sightings to FMB to assist in the forest health monitoring of Yukon forests.

Component 2: Occurred in early July (eight-day fixed-wing aerial overview survey of Forest Health Zone 4 conducted in southeast Yukon) to map recent pest disturbances.

Component 3: Occurred in late August with the annual aerial survey to map ongoing spruce beetle infestations in the southwest followed by helicopter flights to selected pockets of infestation for the purpose of ground-based analysis of beetle populations.

Component 4: Occurred in late August with ground visits made to disturbances mapped during the July aerial survey to analyze the cause and extent of the damage.

Component 5: Included the ongoing monitoring of areas of concern from aerial surveys of 2009.

Component 6: Design of forest health pamphlets for 26 pest and disease species that are currently present in Yukon or are believed to possibly arrive in Yukon in the future. These pamphlets are available at the Client Services and Inspections offices in Whitehorse and Yukon communities and are available on FMB's website (www.forestry.gov.yk.ca).

Forest Health Aerial Surveys 2010

In 2010, all but the most northern section of Forest Health Zone 4 was surveyed. The majority of the flying was in an east-west grid pattern with 8 kms between grid lines. There were a total of 46 1:100,000 map sheets surveyed in Zone 4 which included surveying over six million hectares of forested areas. In addition, the spruce bark beetle infestation in southern Yukon was flown in order to map the current spruce beetle activity in this region.

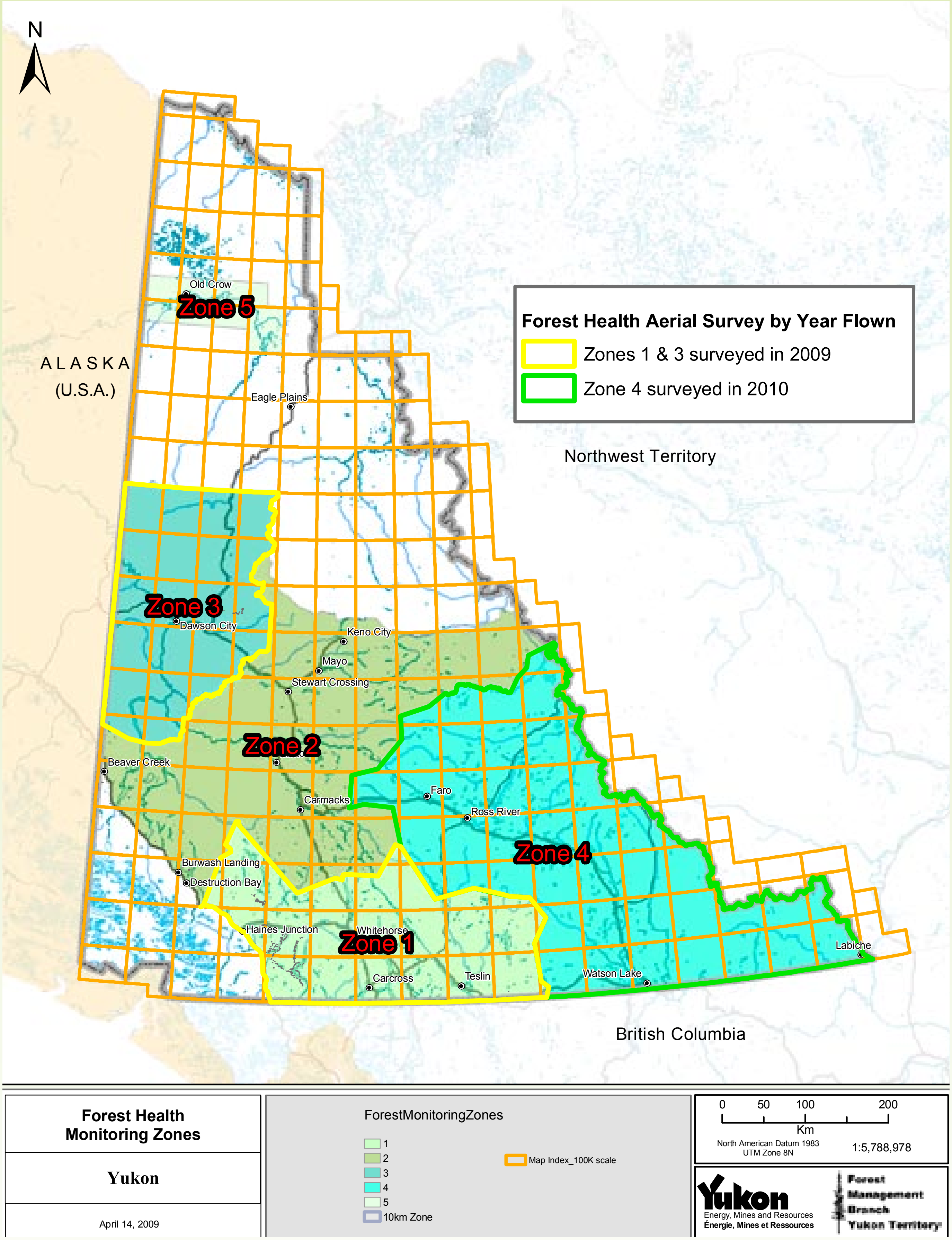
During the course of the survey, biotic and abiotic disturbances were mapped over a total area of 57,200 ha. The mapped areas by pest for Forest Health Zone 4 and a portion of Forest Health Zone 1 (spruce beetle in the southwest) are summarized in Table 1.

Forest Health Agent	Total Area (ha)
Aspen leaf miner	53,085
Western balsam bark beetle	607
Flood	506
Lightning	1
Fire scorching and secondary bark beetles	469
Poplar decline	11
Porcupine	1
Slide	278
Windthrow	51
Winter wind desiccation	873

Southwest Yukon (Within Forest Health Zone 1)

Forest Health Agent	Total Area (ha)
Flood	8
Spruce beetle	1,311

Table 1. Forest Health Zone 4 – area mapped by pest



Map 2: Yukon map showing 1:100,000 map grid and the five Forest Health Zones.
Note: Highlighted areas indicate the zones surveyed in 2009 and 2010

Summary of Aerial Surveys of Zone 4

During the aerial survey of Forest Health Zone 4, four significant disturbance types were recorded. The most common was the ongoing infestation of trembling aspen by the serpentine leafminer. Scattered small patches of red alpine fir killed by balsam bark beetle were mapped throughout Zone 4, though little mortality was mapped in the La Biche River drainage where significant mortality had been seen in the late 1990s. Ongoing lodgepole pine mortality was mapped on the perimeters of six wildfires, northeast of Watson Lake. This was unusual because the fires had occurred as early as 1996. The cause was found to be a combination of initial fire damage combined with drought and a variety of opportunistic secondary bark beetles. The fourth disturbance was discolored alpine fir mapped over an area of 873 ha in high elevation stands in the Pelly Mountains, southwest of Faro. The damage was caused by cold desiccating winter winds.

Summary of aerial surveys of southwest Yukon (within Forest Health Zone 1)

Recent spruce beetle-caused mortality was mapped over an area of 1,311 ha in 2010 compared to 3,121 ha recorded in 2009. All of the recent damage occurred in areas of ongoing activity but significantly increased mortality was seen on hillsides just north of Kusawa Lake. In addition, 8 ha of flood damage was recorded during the flight.

Biotic Pests

Spruce beetle, *Dendroctonus rufipennis*

Southwest Yukon

In the 20th year of unprecedented continuous infestation, spruce beetles continued to kill mature white spruce in southwestern Yukon. In 2010, red-crowned trees, killed by attacks in 2009, were mapped over a total area of 1,311 ha, (1,191 ha of light[3], 74 ha moderate[4] and 46 ha severe[5]). For the second consecutive year, significant recent mortality was mapped in high elevation stands just north of the confluence of the Aishihik and West Aishihik rivers, though mortality was less than half of that surveyed in 2009. Also ongoing from previous years, a large patch of light activity continued near a small creek just east of Cracker Creek. The most significant active infestations mapped this year occurred in the central reaches of Kusawa Lake and in the north-facing hills at the northwest end of Kusawa Lake. In 2008, only light mortality was mapped in the area. In 2010, the area of recorded mortality had more than doubled and contained a 46 ha polygon of severe intensity; the first of that intensity recorded since 2005.

On north-facing slopes just south of Champagne, numerous small polygons of moderate mortality were mapped. Only a few polygons of light activity were recorded in 2008. Of all areas mapped this year, the Champagne and Kusawa infestations were the only ones that had expanded and intensified. Lesser concentrations of light intensity were also mapped in areas of previous activity, most notably in the Dezadeash River Valley between Champagne and Dezadeash Lake, Frederick Creek and adjacent areas of Kusawa Lake, and just north of Jo-Jo Lake (Map 3).

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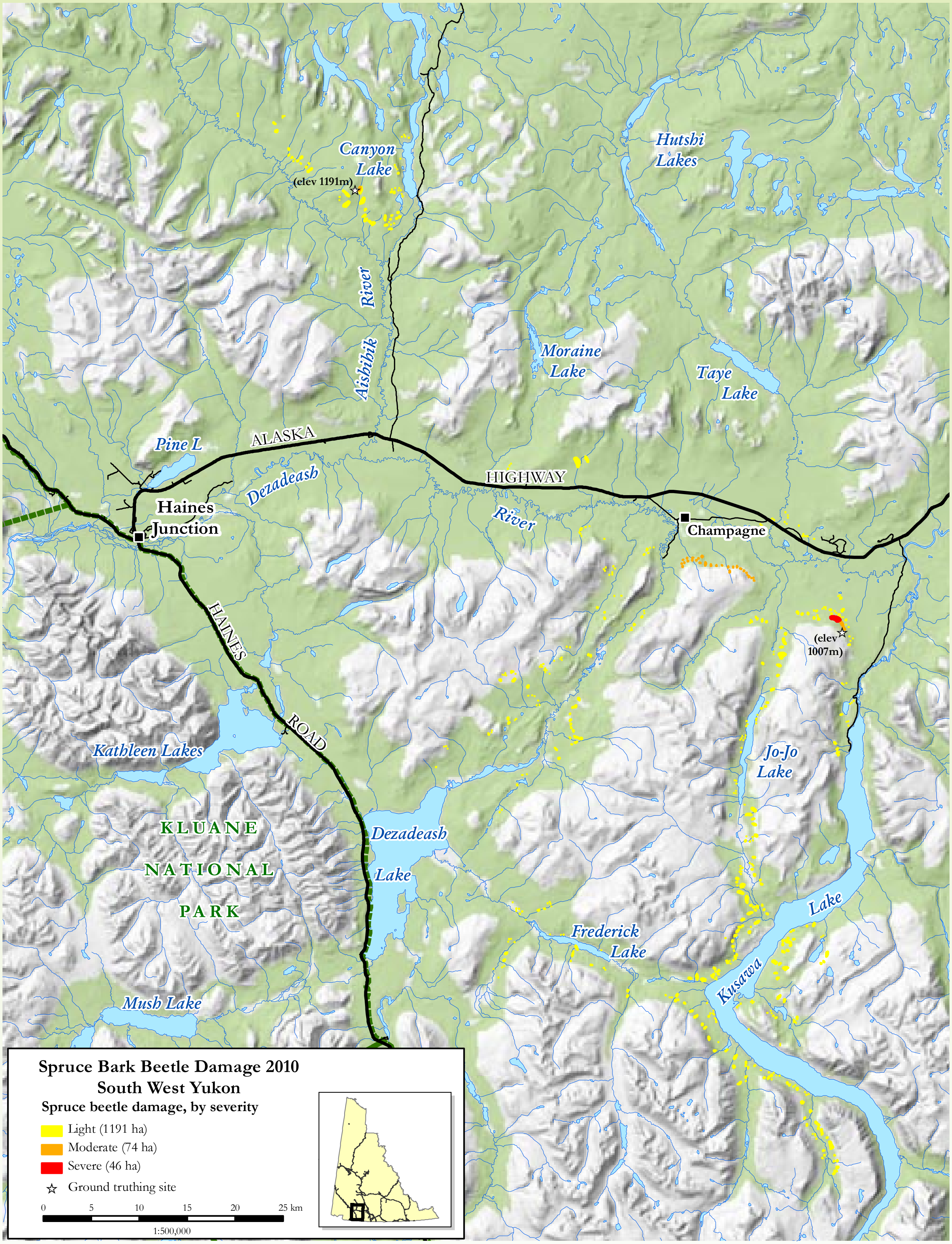
[3] <10% of stand killed the previous year

[4] 10-30% of stand killed the previous year

[5] >30% of stand killed the previous year



Map 3: Recent spruce beetle-caused mortality mapped by aerial surveys in 2010 in southwest Yukon

Ground assessments

Ground assessments were used to verify the cause and extent of spruce beetle disturbance. Both the West Aishihik and Kusawa infestations were accessed by helicopter and infested trees were examined on the ground.

West Aishihik: Limited helicopter access resulted in landing in an area where light mortality had been mapped (Photo 2). As a result, only the highest elevation trees in the infested stands, at just under 1,200 m elevation, were examined for spruce beetle brood activity.

Photo 2: Light spruce beetle-caused mortality at high elevation in the West Aishihik River valley

The examined site was typically very open with scattered spruce, willow and buck brush (Photo 3). Crown closure averaged less than 5%. Even at this elevation, the effects of the warm dry summer were evident. By late August, the crowns of currently-attacked trees were already beginning to fade. Trees killed the previous year had already shed most of their needles and appeared more grey than red.

Larvae pass through a total of four instars or growth stages before pupating and metamorphosing into adults. Trees attacked in 2010 (Photo 4) contained low to moderate numbers of third instar larvae with some fourth instar. These development stages this late in the season signaled the population to be developing on a normal two-year cycle.

Photo 4: Already fading current attack beside a grey tree killed in 2008

Red trees contained relatively low numbers of young adult beetles. These beetles would likely have bored out through the bark, probably in September or early October 2010. Then they re-entered the trees at the root collar to overwinter under the snow, protected from the extremes of cold. The low populations found suggest that this particular infestation will continue to decline in intensity.

These high elevation attacks were typical of spruce beetle behavior throughout the course of the larger infestation. The deeper soils and more available moisture in stands lower on the slopes rendered them less susceptible to attack.

Photo 3: Typical open subalpine stand in West Aishihik

Kusawa: Limited helicopter access required an alpine landing site and descending on foot into the upper reaches of the infested stand. The accessed stands were a mix of approximately 60% spruce and 40% trembling aspen at an elevation of about 1,000 m (Photo 5). Stands here were significantly moister and richer than the Aishihik site. Trees were more resistant to beetle attacks and most of the examined current attacked trees had either pitched-out the initial attacks or flooded the galleries and drowned the adults and early developing larvae. The number of attacks suggested a large population of attacking beetles in the spring but an overall low success rate. An estimated 60% of trees were unsuccessfully attacked and the remaining 40% housed low numbers of brood. The surviving broods had developed through to the fourth instar stage and would remain on the normal two-year cycle.

Red trees from attacks in 2009 outnumbered current attacks by a factor of more than 2:1, but grey trees, which supplied the attacking beetle population in 2010, were uncommon at this elevation (top of photo). It appeared that most of the attacking beetles of 2010 came from lower on the slope (bottom of photo). Most of the red trees had been heavily attacked by a much larger population

Photo 5: Red trees from 2009 attacks with some fading 2010 attacked trees

of beetles in 2009. However, an estimated 80% of the broods had been preyed upon by woodpeckers. Debarking by woodpeckers stretched as high as 7 m on some trees (Photo 6). The remaining broods were at the base of the trees and consisted of young adults which will spend the winter at the root collar and will emerge to attack new hosts in the spring of 2011 (Photo 7).

Photo 6: Heavy woodpecker predation on spruce beetle larvae at Kusawa

Risk of future spread

All evidence from aerial and ground surveys indicated that 2010 represented a significant decline from 2009. Not only did overall infested areas decline but population assessments within individual infested trees showed relatively poor survival of broods in trees attacked in 2009 in areas of intense recent activity in the West Aishihik and Kusawa areas. Current attacks by broods emerging from trees attacked in 2008 were also reduced and attack success was generally low. Though there is additional mortality from 2010 attacks, the mapped area is expected to decline even further in 2011.

Photo 7: Young spruce beetle adults at base of a red (2009 attacked) tree

A Brief Summary of the Historic Spruce Beetle Infestation

Rod Garbutt

This brief summary of the spruce bark beetle infestation in southwest Yukon was written by Rod Garbutt. Rod worked for the Canadian Forest Service as a Forest Health Specialist from 1981 to 2009. Continuously since 1991, Rod has worked with FMB personnel (formerly the federal Department of Indian and Northern Development (DIAND)) surveying and reporting on a broad range of Yukon forest health issues. He has been responsible for surveying and assessing the outbreak of spruce beetle in southwest Yukon since 1994. Since his retirement, Rod has continued to do forest health work under contract to FMB as RG Forest Pest Solutions and is one of the main contributors to this report.

From 1990 onward, as the Forest Insect and Disease (FIDS) ranger responsible for the monitoring and reporting on the various disturbances affecting Yukon forests, I was well positioned to detect and follow the course of the spruce beetle outbreak. However, because the spruce beetle infestation started deep within the Alsek River drainage within Kluane National Park and Tatshenshini Provincial Park, the early stages of the outbreak in the early 1990s went undetected. Unlike in British Columbia where overview surveys were conducted annually to detect and map instances of forest pest outbreaks, there was no such practice in Yukon. This was due, first to a lack of resources to fund such overviews (aerial surveys in B.C. were funded from provincial coffers through the Ministry of Forests) and second because of the limited history of damaging insect outbreaks, which included periodic brief infestations of aspen by the large aspen tortrix, *Choristoneura conflictana*, (a leaf-rolling defoliator) and the occasional small spruce beetle outbreak. Prior to the 1990s, most of the reported damage to Yukon forests was in the form of chronic climatic injury caused by the long cold winters and late spring frosts.

In Haines Junction in the summer of 1994, I aerially mapped a small outbreak of spruce beetle along the Haines Road (across the B.C. border). At that time there were also active infestations in the adjacent Chilkat River drainage in Alaska. On the flight south, the distant red glow in the west beyond Kathleen Lake within Kluane National Park was the first indication that the infestation was not confined to just B.C. and Alaska. Both Parks Canada and DIAND (then responsible for forest management in Yukon) recognized the significance of the observations and jointly funded aerial surveys of all affected areas. The first year, I mapped severe spruce beetle-caused mortality over an area in excess of 32,000 ha in the Alsek River drainage. That was also the year white spruce mortality started showing up in the Shakwak Trench between Haines Junction and Kluane Lake. Aerial overview surveys have been conducted every year since. Since devolution in 2003, funding for the flights has been provided by the Yukon government.

Right from the start, it was evident that this infestation was different from any that I had seen or read about. One difference was tied to the composition of the forests themselves. In southwest Yukon, white spruce is not only the dominant conifer, it is the only conifer. Although the climate and soils would seem to suit the silvical profile of lodgepole pine even more than white spruce, the closest natural pine stand is 50 km east of Haines Junction. This area is too dry for black spruce and the closest alpine fir occurs at the south end of Kusawa Lake. Another difference was the forest structure. Small average volumes and remote markets have attracted little industrial logging activity and this coupled with a low incidence of wildfires (compared to the rest of Yukon) has resulted in a landscape covered with relatively uniform, mature and over-mature stands of spruce. These conditions have existed on the landscape since the forests re-established themselves following the last ice age. Forest composition and structure however, comprised only the background for the infestation, not the cause.

It is difficult to determine when climate warming began to play an active role in the health of these stands, but with respect to the survival and success of the spruce beetle, the balance was likely tipped sometime in the late 1980s with a series of warmer than average summers and milder than average winters. The warmer summers caused increased moisture loss through needle transpiration (Dr. Ed Berg pers. com) and trees across the landscape began to experience drought stress. This lowered their resistance to attack by local indigenous spruce beetle populations as well as those from pre-existing coastal outbreaks that were carried in by the strong prevailing northwesterly winds. The warmer weather also favoured beetle progeny development under the bark of successfully attacked trees. Concurrently, the milder winters allowed for greater survival of this progeny through the normal two-year life cycle.

Spruce beetle populations which had historically survived at very low levels in scattered windthrow and senescent trees suddenly had an unprecedented opportunity for success causing beetle populations to explode over the course of a few generations. The drought-stressed trees had little resistance to attacks as evidenced by an almost complete absence of pitch that trees normally exude at the point of attack to prevent the beetles from gaining entry and establishing broods. When I removed the bark of infested trees in July 1994, developing larvae spilled out everywhere. Population growth was further accelerated in that year by the extended period of warm dry weather that allowed at least 25% of the developing broods to mature in one year instead of the normal two years. Until this time, this had not been considered as a possibility north of 60° N latitude.

The infestation continued to grow through the 1990s peaking in 1997 (Figure 1), when over 72,000 ha of red trees (those attacked and killed by beetles during the previous year) were mapped. The intensity of the infestation in the mid-1990s is illustrated by Photo 8. By 2000, more than 50% of trees had been killed over a cumulative area of more than 250,000 ha. The summers of 2000 and 2001 were cool and wet and the infestation which was already in decline was expected to end quickly with the re-hydration of the forests and consequent increase in resistance to attack. However, instead of the expected collapse, populations rebounded with a vigour not seen since 1994.

In 2004, at the peak of this resurgence, nearly 100,000 ha of new attacks were mapped, mainly in the Mush Lake area and south to the B.C. border. At this time, I concluded that there was still a sufficient population to overcome and even the more resistant trees and those that were re-hydrated provided a much more conducive environment for the development and health of the beetle progeny. It is also likely that following many years of drought stress, the trees were slow to rebound to full resistant vigour. The long warm summer of 2004 was so favourable to progeny development that an estimated 80% of the population cycled in one year. Unfortunately for the beetle, the past few years of infestation had been so severe that there was little remaining host and the population declined quickly once more. Since that time there has been little activity within the 350,000 ha core of the infestation within Kluane National Park and the Shakwak Trench, where few susceptible host trees remain. Exceptions have been scattered infestations of northern spruce engraver (*Ips perturbatus*) because it has a much shorter life cycle and can survive in the smaller, younger trees.

Many trees attacked by *Ips* also harbour remnants of the diminished populations of spruce beetle. This pattern likely reflects the endemic condition, with the two species in a co-dependent relationship with each relying on the other for success and survival.

There have also been some unprecedented spruce beetle flare-ups in younger stands (as young as 50 years old) on rich sites that were passed over when the infestation first went through the area in the mid-1990s. In the intervening years, the stands grew quickly and have recently attracted scattered populations from surrounding areas and become severely infested. It is only in these instances that the Yukon infestation has mirrored the historical pattern of infestations farther south, where beetles specifically targeted the healthiest trees on the rich river bottom sites.

Ordinarily when spruce beetle populations reach outbreak levels, usually following a blowdown event, or more recently following logging or right-of-way clearing when large amounts of slash becomes available, they target the largest and healthiest trees, most often found in the soil-rich river bottoms. These fast growing, well hydrated trees provided the beetles with the best opportunity to successfully complete their two-year life cycle.

Continuing on the theme of the singularity of this infestation during the early years of the outbreak, instead of attacking spruce in the Alsek river-bottom stands, beetle populations were drawn to stands high on the mountain slopes to the tree line. In the Alsek River valley,

Photo 8: Stand level mortality in Alsek River valley in 1996

the altered pattern of attack was due in part to a series of geological events which saw the Lowell Glacier advance across the Alsek River and dam the waters forming a massive lake known as Neoglacial Lake Alsek. The two most recent events were thought to have occurred approximately 150 and 250 years ago. The earlier one was estimated to have been over 200 m deep at the glacier wall (Clague and Rampton, 1982) and over 100 km long. It was probably the largest neoglacial ice-dammed lake in North America. The more recent lake was more modest in size, reaching only as far as Haines Junction.

It is estimated to take 50 to 60 years for spruce to become re-established on a floodplain (Kindle, 1952), leaving valley bottom spruce in the Alsek and Kaskawulsh rivers less than 100 years old. These young trees would have been more vigorous than the older trees farther up the slopes and more able to defend themselves against beetle attacks. Pursuant to the law of gravity which dictates that water flows downhill, they would also have been much less subject to drought stress. In addition, the stands above the glacial floodplain were much older, some as old as 400 years, and would have housed a small but thriving indigenous beetle population. Finally, as would become evident following the winter of 1995-1996 when cold weather extracted an enormous toll on the beetle population, the upper slopes benefited from winter temperature inversions and progeny survival was much higher. The result was that even though nearly 100% of the population in the Shakwak Trench was killed (with the exception of Bear Creek and Boutallier summits), the infestation continued and even increased the following year.

Since 2005, the infestation, though much diminished in size, has refused to collapse and has continued to flourish on the eastern fringes, most notably in the West Aishihik River valley, the Dezadeash River valley south of Champagne and the central reaches of Kusawa Lake. Figure 1 illustrates the progression of the infestation from 1994 through 2010.

In 2008, after four years of continuous drought, white spruce trees along the Yukon, White and Stewart rivers south of Dawson City began to die. Fortunately, because the stands were relatively young (due to recurring wildfires and the relentless fuel wood harvest during the riverboat era), there was only a small resident population of *Ips* and spruce beetles in the areas and only a few trees were lightly attacked. Since then, the trees have regained some vigour and there is no immediate threat of escalated infestation.

These examples have served to emphasize that the greatest threat to Yukon forests still lies with the climate, but instead of winter cold being the dominant disturbance agent, drought is now the leading threat. However, unlike winter cold that negatively affects the survival of damaging insects as well as trees, drought seems capable of fostering a variety of secondary effects (recent epidemics of aspen serpentine leafminer and willow blotch miner). For this reason the importance of the southwest spruce beetle infestation cannot be over-emphasized. By itself it has forced a complete revision of infestation behavior in the face of the new reality of climate change. It has also emphasized the role of climate stress, in this case drought, on the survival and success of only one of a myriad of insects capable of inflicting severe and lasting damage on our vital boreal resources, and in doing so, promoting ecological change that we have yet to see the limits of.

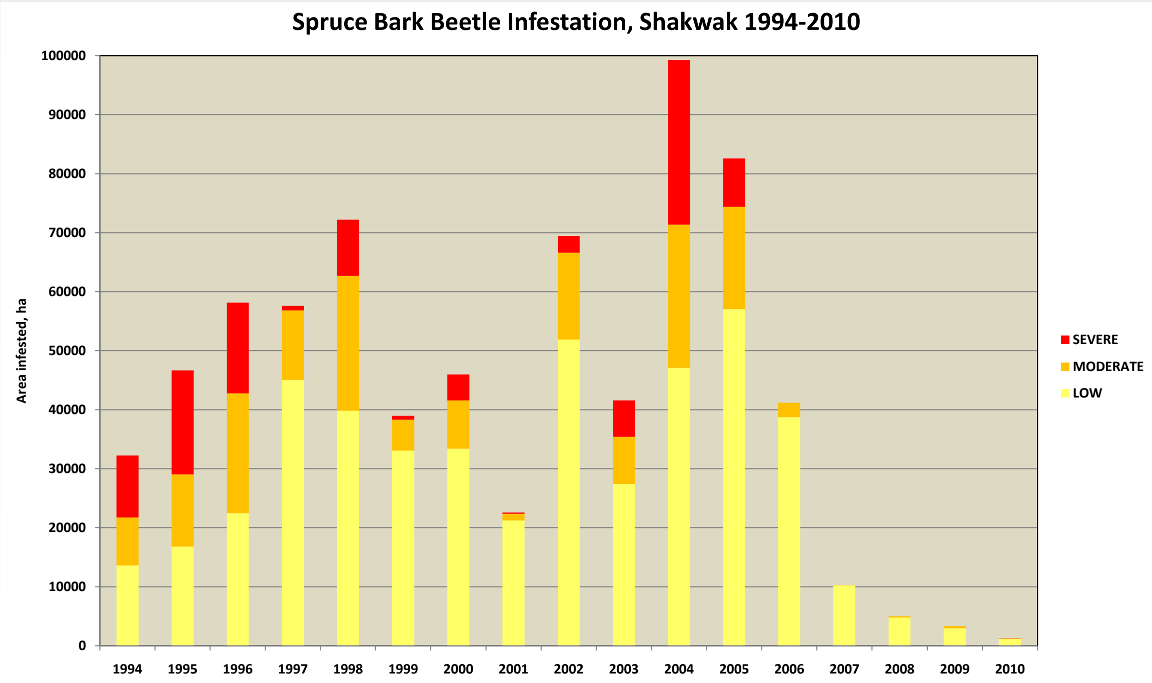


Figure 1. Areas of recent mortality by severity mapped from the air between 1994 and 2010

Western balsam bark beetle,

Dryocoetes confusus

Small scattered patches of alpine fir mortality from attacks by western balsam bark beetle were recorded at approximately 1,000 locations throughout Forest Health Zone 4 (over a total area of 607 ha). Typically, trees were killed in small clustered groups with an average area size of 0.5 ha or less. Only a few areas were larger than 10 ha in size. All attacks were recorded as light, as the beetle rarely kills more than 1% of any stand in a given year. The crowns of alpine fir will remain red for up to four years following tree death, so annual mortality is difficult to determine from the air.

Alpine fir mortality from western balsam bark beetle was not recorded in Yukon before the mid-1990s. Since then beetle-caused mortality has spread throughout the range of the host in southern Yukon from the La Biche in the east to Bennett Lake in the west and all areas between. In 2010, mortality was mapped near the upper Pelly River at 62° 26′ N latitude. This is the most northerly finding of balsam bark beetle mortality to date in Yukon.

The recent addition of this pest as a serious threat to Yukon forests is another effect of a moderating climate. Beetle-killed alpine fir were first observed in the Cassiar Mountains north of Dease Lake in the late 1980s. Up to that point it was the farthest north beetle-caused alpine fir mortality that had ever been mapped. Unusually severe recent damage was mapped within Atlin Provincial Park in the early 1990s. When alpine fir mortality was first seen in the La Biche area in 1995 there were no grey trees; only red trees. In the intervening 15 years, this has changed and much of the mature and semi-mature alpine fir on the slopes of Mount Martin between the La Biche and Beaver rivers is now grey.

Aspen serpentine leafminer,

Phyllocnistis populiella

The widespread defoliation of aspen by this leafminer has been observed and reported throughout surveyed areas of Yukon since the mid-1990s. During aerial surveys that occurred in southeast Yukon in 2010, light to severe crown discoloration was mapped within almost every aspen stand over a total area of 53,085 ha. This was down from 584,120 ha in 2009, but the decrease reflected the reduced aerial survey coverage and a reduced aspen component, rather than a reduction of insect prevalence. Notably, during a helicopter flight in late August, large stands of pure green aspen were observed in the Stewart River valley downstream from Stewart Crossing, which suggested that they were either very lightly infested or not infested at all (Photo 10). These same stands were mapped as severely infested during the 2009 aerial survey. This apparent reduction is significant, particularly as aspen stands in this central belt have been among the most severely infested for many years. Whether this was just an isolated anomaly or the beginning of a trend toward an overall reduction in leafminer populations in Yukon will be determined in subsequent years.

Photo 10: Lightly leafminer-infested aspen in Stewart River Valley

Willow blotch miner,
Micrurapteryx salicifoliella

For the fourth consecutive year, discoloration of willows was widespread and severe around Dawson City and in the Stewart River corridor (Photo 11). The damage was seen during limited helicopter surveys of the region and was likely far more widespread. For the first time this year, damage of light-to-severe intensity was seen along the Robert Campbell Highway between Ross River and Watson Lake and light damage was also seen along the Alaska Highway south of Watson Lake to the B.C. border. However, no damage was mapped during aerial surveys suggesting that overall populations are still relatively light in the southeast. Close examination of mined leaves in all areas along the highway corridors indicated successful larval development with many pupal sites on individual leaves (Photo 12).

The insect originally entered central Yukon via the Yukon River corridor from Alaska where damage has been widespread since it was first identified in 1991. Though damage from the insect was first reported in Yukon in Stewart Crossing in 2007, it had likely been present for some years prior while populations built to a level that damage became visibly evident. From the Yukon and Stewart rivers, it is simply a matter of adult moths penetrating adjacent willow-rich corridors for the infestation to continue its advance. It can be expected that the blotch miner's range will continue to expand in the coming years.

Photo 11: Severe discoloration of willow in Stewart River corridor near Stewart Crossing

Photo 12: Blotch miner pupations sites on upper surface of willow leaves

Northern spruce engraver beetle, *Ips perturbatus*

The northern spruce engraver is the second most important bark beetle affecting spruce in Yukon forests. In 2010, tree mortality caused by the northern spruce engraver was detected at only one location affecting a handful of trees along the Mayo Road (Photo 13). The beetles had bred in the adjacent slash left from right-of-way widening. This is one of the most common causes of *Ips* outbreaks and is also the most preventable. Infestations of this type can be avoided simply by felling the trees after the early June beetle flight period and disposing of the slash by burning before the flight period in the following year.

This single small pocket of northern spruce engraver attack marks the lowest detected incidence of disturbance by this insect in over 10 years. Since the completion of powerline projects in central Yukon, the apparent reduction of drought stress and the reduction in spruce beetle populations, *Ips* beetles have had relatively limited breeding opportunities. Drought remains the greatest threat, especially in southwest and central Yukon (i.e. Dawson City). Considering the trend towards increasingly warm summers, the hiatus from direct drought-caused mortality and drought initiated beetle infestations is likely to be brief.

Photo 13: Ips-attacked spruce adjacent to a slash pile, the source of the population

Comandra blister rust, *Cronartium comandrae*

An unusually high incidence of this disease was seen in young lodgepole pine near Km 10 on the Kusawa Lake road. About 50 young trees were infected, many supporting multiple cankers (Photo 14). Other, less intensive incidences of the disease were seen in scattered trees in the Gunnar Nilsson Mickey Lammers Research Forest, north of Whitehorse, where reports of infection date back as far as 1986.

This is the most common stem rust affecting lodgepole pine in Yukon. It is native to all forests in North America where both two and three needle pines and the alternate host, bastard toad flax, *Geocaulon lividum*, occur. The disease causes the formation of perennial cankers or lesions on branches and stems. In the early summer, the aeciospores produced by the fungus mature forming the bright yellow orange pustules that burst and disperse the millions of spores to infect the alternate or telial host. Teliospores are then produced on the undersides of the bastard toad flax leaves and when mature are propelled by the wind to re-infect the lodgepole pine. In the years following initial infection of the pine, the margins of the cankers grow both radially and longitudinally (Allen et al 1996), feeding on and killing the living tissues within the canker margins. Over time cankers often assume the shape of an elongated diamond.

Pines of all ages are affected, the most severe effects of the disease are seen in young trees where cankers often completely encircle the stems and kill the trees. Most of the infected trees on the Kusawa Lake road will likely die within the next five years. Nearly identical cankers are produced by another species of stem rust known as stalactiform blister rust, *Cronartium coleosporioides*. The alternate host for this rust is paint brush, *Castilleja miniata*. This rust is also found in Yukon but is less common than Comandra largely due to the abundance and widespread distribution of the alternate host, toad flax.

There is no effective control for this disease. In some situations such as tree nurseries where high values are at risk, the disease cycle has been interrupted through the physical removal of the alternate host. This has afforded only short term protection at very high cost because as soon as programs have ended, the toad flax has readily reseeded within the control areas.

The intensity of the infections this year was probably due to a coincidence of conditions, the availability of abundant susceptible hosts and alternate hosts, plus conditions such as wind and abundant moisture to facilitate cross infection.

Photo 14: Three fruiting stem rust cankers on a single tree at Km 10 Kusawa Lake Road

Western gall rust, *Endocronartium harknessii*

This rust disease commonly forms galls on the branches (Photo 15) and stems of all age classes of lodgepole pine but causes the most damage in young trees. It can be found in stands of two and three needle pines throughout North America. Though not as common in Yukon as in pine stands farther to the south, rust galls were seen this year in young trees in the Gunnar Nilsson Mickey Lammers Research Forest and the disease has been reported in young pine stands at numerous locations in southern Yukon.

Infection occurs through the succulent tissues of elongating shoots (Allen et al 1996) and results in the formation of globose galls at the point of infection. These galls continue to increase in diameter as the host tree grows with the result that they can completely encircle a branch or stem. When this occurs the host dies above the gall and the galls themselves become inactive. Young trees are most susceptible to branch and stem mortality because of their small diameter.

Photo 15: Western gall rust gall on young lodgepole pine stem

Ongoing Monitoring of Areas of Concern

Follow-up surveys from 2009

An important segment of the Yukon forest health monitoring program is the ongoing monitoring of selected disturbances from previous years' surveys that have the potential to pose further risk. Ongoing monitoring was carried out in Aussie Creek northeast of Dawson and Stewart Crossing where spruce beetle and eastern spruce budworm damage was mapped in 2009. Also included was an aerial overflight of areas along the Yukon, White and Stewart rivers where drought stress had placed spruce stands at risk of infestation by both spruce and engraver beetles. Results of these follow-up surveys are summarized in Table 2.

Location and Pest	Area mapped in 2009 (ha)	Area mapped in 2010 (ha)
Aussie Creek spruce beetle	32	No new incidence
Drought and secondary bark beetle mortality south of Dawson City	613	No new incidence
Eastern spruce budworm at Stewart Crossing	1,156	17

Table 2. Results of ongoing monitoring areas of concern from 2009

Aussie Creek spruce beetle, *Dendroctonus rufipennis*

During the August 2010 ground-truthing survey, a site near Aussie Creek was visited because a localized infestation of spruce beetle was discovered in 2009. At that time, scattered recent mortality was found to have been lightly infested and, in addition to some red trees attacked the previous year, some light current attacks were found. In 2010, no new red trees could be detected from the air and no new current attacks were seen on the ground. Trees lightly attacked last year had not succumbed to the attacks and no surviving broods were found. Though the infestation appears to have collapsed, the area will be re-flown in 2011 to ensure that no new mortality has occurred.

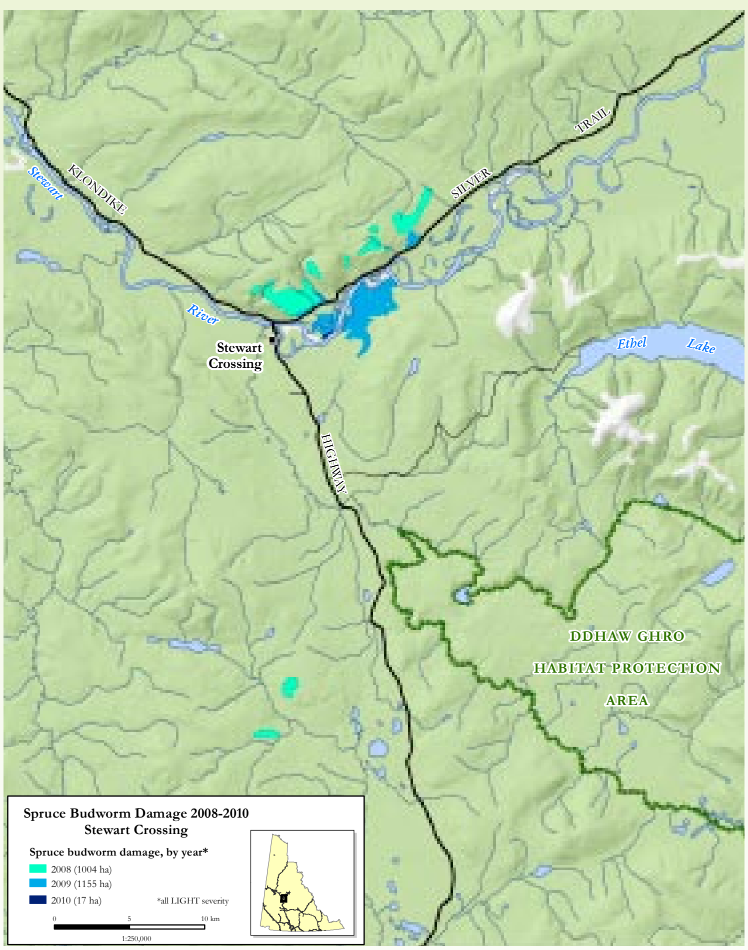
Drought mortality and secondary spruce bark beetle activity south of Dawson City

An aerial survey of the lower Stewart and Yukon rivers between the Stewart River confluence and Dawson City as well as the lower White River was carried out in late August 2010. Drought stress in 2008 had resulted in spruce death in many scattered patches totaling more than 2,500 ha. Ground-based surveys at a number of sites found a small proportion of the trees to have been secondarily attacked by northern spruce engraver beetles and to a lesser extent by spruce beetles. Aerial surveys of the affected areas in 2009 and 2010 found no incidence of recently-killed spruce and unless there is a return to the same drought conditions that had earlier killed the trees, there is no risk of further infestation by bark beetles.

Stewart Crossing eastern spruce budworm, *Choristoneura fumiferana*

For the third consecutive year, white spruce near Stewart Crossing was lightly defoliated by spruce budworm (Photo 9). Defoliation was mapped over an area of 17 ha; well down from the 1,155 ha mapped in 2009. Limited late season sampling of budworm egg masses which defoliated the previous year suggested that there would be no recurrence. Rather than collapsing however, the population moved southward into adjacent previously uninfested stands. In fact, the three year history of this infestation has been marked by a progressive migration of the population (Map 4). This movement, whether by wind or impulse, seems unusual as moths normally move about and lay their eggs within the infested stand rather than migrating out of it. Conversely, this infestation is unusually small (infestations commonly cover tens of thousands of hectares) and only a short flight was required.

Photo 9: Light defoliation of white spruce near Stewart Crossing by eastern spruce budworm



Map 4. Eastern spruce budworm at Stewart Crossing

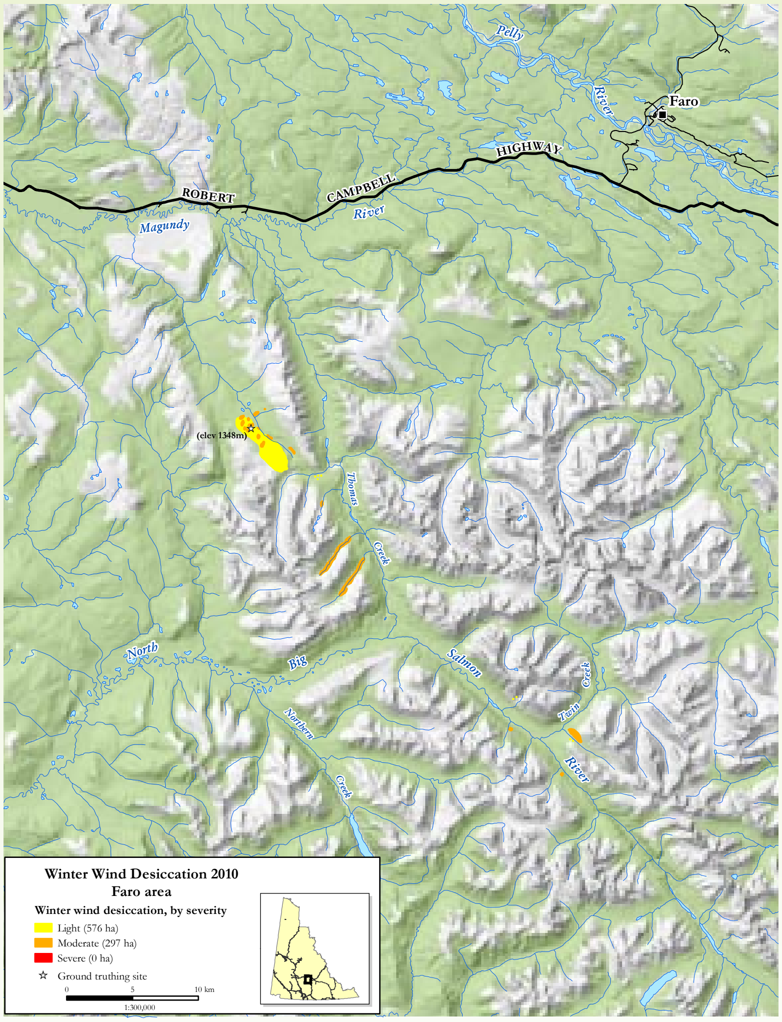
The isolated nature of this infestation is unusual. Ordinarily eastern spruce budworm populations increase in more than one geographic location as if on some coordinated biological imperative. However, there has been no sign of increased defoliation in the traditionally infested stands in the Liard River drainage in the southeast. No defoliation was mapped during aerial surveys and ground assessments south of Watson Lake found almost no feeding damage.

Abiotic Pests

Winter drying

During the aerial survey in July 2010, discoloured alpine fir was mapped over an area of 873 ha in high elevation stands near Thomas Creek in the Pelly Mountains, south of Faro (Map 5). It was not until the site was ground-checked in late August that the cause of the damage was determined. The elevation of 1,220 m was just below the alpine with alpine fir as the only tree species. They were distributed across the landscape as scattered single and small clumps of small trees. Most trees were discoloured to varying degrees with an average of 50% of the upper crowns affected. There was significantly more discolouration on the north sides of the trees (Photo 16) which leaned to the conclusion that the damage was caused by extremely cold north winds that had desiccated the needles. Damage was confined to exposed needles. Lower branches that were covered with snow remained green. Though needle water content in alpine fir is reduced in winter, it is still maintained at 85-95% (Berg and Chapin, 1993).

Photo 16: Discoloured crowns of alpine fir caused by cold north winds



Map 5: Areas where discoloured alpine fir were mapped during 2010 aerial surveys

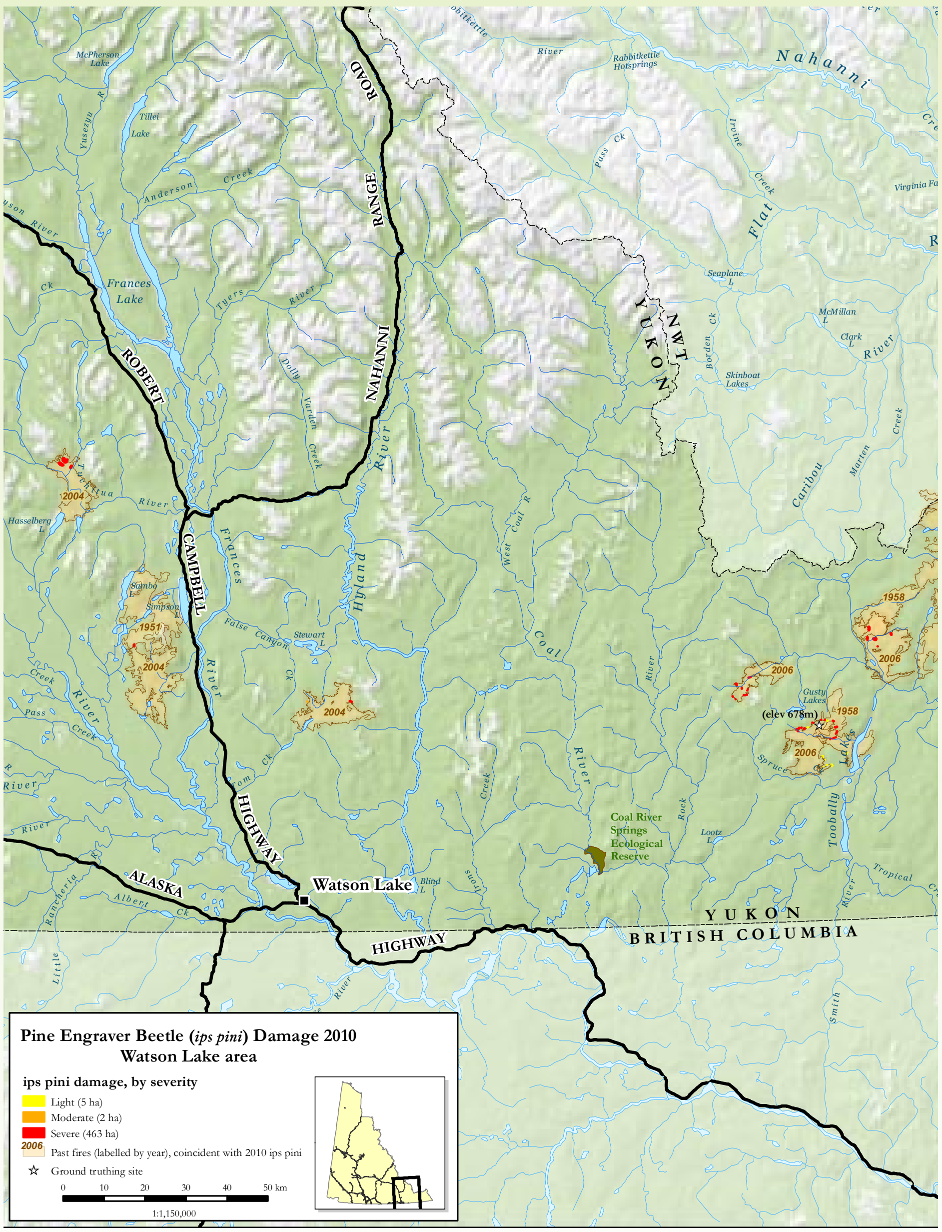
The physiological mechanisms linked to these environmental effects are not yet understood (Hadley and Smith 1983). Suggested causes have included unusually thin needle cuticles (the waxy coating on the surface of the needles) due to the short growing seasons on high elevation sites and cuticle abrasion by wind and blowing snow, both leading to reduced resistance to moisture loss (Hadley and Smith, 1983). Whatever the mechanism, it seems clear that moisture loss on frozen ground is the main cause of needle death.

One of the interesting features of these sparse stands was the almost complete absence of Krummholz forms (small bushy and stunted trees that normally inhabit subalpine sites that are chronically exposed to bitter winter winds). The trees on this site, although not large, were typically conic in form, suggesting that they were not shaped by the same harsh conditions that form Krummholtz stands. This leads to the conclusion that desiccation damage of this severity is unusual in these stands. Whether there is a link between the damage and recent changes in the northern climate is unknown.

Recent secondary bark beetle mortality around the perimeter of old wildfires

During the aerial survey, numerous instances of lodgepole pine mortality totaling 469 ha were mapped within and around the perimeter of six wildfires northeast and northwest of Watson Lake (Map 6). Perimeter mortality is common around most wildfires. When fire intensity lessens on the flanks there is no longer enough heat to sustain crowning (fire in the tree crowns). When this occurs, the fire drops to the ground and continues to burn outward consuming ground fuels while continuing to kill trees in its path by scorching the roots and stems. Large areas of recent pine mortality were seen this year around the perimeter of the 2009 Little Salmon River fire; the result of scorching. The mortality mapped this year was at the perimeter of fires that occurred in 2006 or earlier (Photo 17).

Photo 17: Recent mortality at the perimeter of a 2006 wildfire northeast of Watson Lake



Map 6: Areas where lodgepole pine mortality was mapped within and adjacent to old wildfires

In the ensuing years, the area has greened-up with herbs and shrubs and no signs of the perimeter ground fires could be seen from the air. A visit to one of these areas of mortality in late August confirmed ground fires to be the underlying cause of the damage. All dead trees were severely scorched along the leading edge of the fire in 2006. Fifty percent of the trees along the perimeter of the fire remained alive. All of the recently-killed trees had been attacked by a mix of secondary beetles including pine engraver beetles (Photo 18), lodgepole pine beetles (Photo 19) and another engraver beetle, *Ips latidens*. All of these beetles had been attracted to the injured trees whose stress was likely compounded by last year's drought.

Photo 18: Characteristic X-shaped ***Ips pini*** galleries

Photo 19: *D. murrayanae* larvae in fire damaged pine

"Flagging" in white spruce and lodgepole pine

For the second consecutive year, reddening and shedding of older needles in the interior of crowns of both white spruce and lodgepole pine was common throughout drier parts of Yukon (Photo 20). This is a natural phenomenon commonly known as flagging. It is simply the trees' late summer response to unusually warm dry conditions. By shedding older needles, the trees reduce the crown volume and thus moisture loss through transpiration. It is strictly environmental and is not an indication of the presence of a needle disease.

Photo 20: "Flagging" in white spruce

Death by lightning

During the July 2010 aerial survey northeast of Watson Lake, a small (<0.5 ha) circular patch of recently-killed lodgepole pine was mapped (Photo 21). There were two possible causes for this mortality: either a small lightning-caused fire or lightning kill in the absence of fire. The small size, circular shape and the absence of obvious charring on the tree boles suggested a high likelihood of the latter cause.

Lightning as a direct rather than an indirect cause of tree death (i.e. lightning-generated fire) is unusual, but does occur under certain circumstances. Normally when lightning strikes a tree, the charge is dissipated through the soil. Transmission of the charge is facilitated by particles suspended in soil moisture droplets. However, when lightning strikes during periods of drought, there is not enough soil moisture to transfer the charge from the tree roots to the soil (Dr. J. Hopkins, CFS pathologist ret'd., pers. comm.). The charge instead is transferred through the roots and by root contact to surrounding trees. During transmission the fine feeding roots of the trees are killed and the trees die. Because the charge is transmitted radially the damage assumes a circular shape.

Photo 21: Small circular patch of pine mortality thought to have been directly caused by lightning

Pests of Concern in Urban Areas

Aphids

Along with the aspen serpentine leafminer, aphids were the one forest pest that almost everyone in Yukon noticed in 2010. They infested the leaves of deciduous species such as balsam poplar, white birch, willow and trembling aspen with unusually high intensity (Photo 22). It was not so much the aphids themselves that attracted notice but the sugar-rich "honeydew" which they exuded. Honeydew was produced in such abundance that it dripped from the leaves onto cars, walkways, lawns and anything else under the tree canopies.

Aphid mouthparts are designed to pierce the leaves and suck the leaf juices for food. The honeydew was simply the excess of these sugar-rich juices excreted by the aphids. Many trees, especially birch, were so heavily infested that the leaves became discoloured and many were prematurely shed. The honeydew-laden leaves also provided a medium for the growth of sooty molds that proliferated and turned many leaves black later in the season. The aphids and their exudate also attracted a host of other insects such as ants that fed directly on the honeydew as well as ladybugs (*Coccinellidae*) and flower flies (*Syrphidae*) that preyed on the aphids themselves. Also common was the birch bug, *Elasmostethus interstinctus* (Photo 23), a type of shield bug that is known to feed on birch catkins, but may also feed on birch leaf juices. Thus with the success of aphid populations, a whole ecosystem of associated insects was congregated.

Aphid success is tied very closely to extended periods of warm dry weather, especially early in the season. Populations likely increased in the summer of 2009 and with the second successive favourable season reached outbreak proportions this year. Numerous aphid species benefited from these conditions and participated in this year's outbreak. One of the most common was likely *Pterocomma bicolor*, which is widespread and common on willows and poplars. Footit and Maw (1997) list 53 species of Aphidoidea (aphids) that have been collected in Yukon and cite 55 more that are almost certainly found in Yukon. Aside from those seen this year are a number that feed exclusively on herbs, shrubs and conifers and a number are gall formers on deciduous species.

Control

Whether the aphid infestation will continue in 2011 will depend upon moisture levels early in the growing season. Abundant rain in late May or June would serve to wash aphids from the leaves and significantly reduce the chance of reoccurrence. Similarly, homeowners can affect some control over aphid populations on their herbs, shrubs and small ornamental trees by liberally spraying newly emergent foliage with water. Another commonly used alternative is an insecticidal soap such as "Safers" which is available at all garden supply outlets. Some have found success with home-made soap remedies by mixing about 3 tablespoons of dish soap in a gallon of water and spraying the tops and undersides of the leaves. Soap reduces the surface tension of water and facilitates the soaking of the insects. It also dissolves the waxy coating on the outside of the exoskeletons effectively interfering with their moisture regulation and ultimately killing them.

Photo 22: Aphids on a birch leaf *(USDA photo)*

Photo 23: Birch bug on birch leaf with ladybug in background

Yellowheaded spruce sawfly,
Pikonema alaskensis

Young ornamental white spruce at various locations in downtown Whitehorse were once again defoliated by spruce sawfly larvae. The most severe damage occurred in Shipyards Park where small trees lining the parking lot were fed upon and a single 2 m tall tree was almost completely stripped of foliage (Photo 24). This is the second consecutive year of this small localized outbreak of spruce sawfly.


Photo 24: Young spruce defoliated by yellowheaded spruce sawfly at Shipyards Park in downtown Whitehorse

Some of the same affected trees had been severely defoliated by sawfly larvae in 2009. When examined in June 2010, the trees appeared to have recovered almost completely from the previous year's damage. Unlike most other conifer species, spruce and balsam fir have the ability to produce epicormic buds in response to various types of defoliation disturbance including, and probably, most specifically, as a result of insect feeding (Piene 1998). Normally conifers produce only lateral and apical buds at the branch tips and the top of the stem. Epicormic buds are produced from pre-formed suppressed buds at various points along the apical meristem and are stimulated to grow in response to a loss of foliage. Piene (1998) suggests that this mechanism evolved over thousands of years to counter repeated outbreaks of the eastern spruce budworm, *C. fumiferana*. With repeated defoliation however, trees will eventually become weakened and those unable to replace lost foliage will die.

Control

Control of sawfly populations in localized urban settings can be accomplished in various ways. If found in smaller trees, larvae can be physically removed and destroyed. In larger trees the application by spray of an organic insecticidal soap will help to control insect populations. Populations can be both assessed and controlled when mature larvae drop to the ground prior to pupating in the upper organic layer of the soil (duff layer). If a catchment sheet covered with needles is placed under the tree in late July, larvae will collect on the sheet and pupate in the needle layer. They can then be collected and destroyed.

Ambermarked birch leafminer,
Profenusa thomsoni

This insect was introduced to eastern North America from Europe sometime early in the last century. In Canada, it was first identified in Quebec in 1959, having previously been mistaken for another earlier introduced species, the birch leafminer, *Fenusa pusilla*. The damage is caused by larval feeding within the leaf resulting in the formation of characteristic blotches (Photo 25).

It was recognized in Anchorage, Alaska for the first time in 1996 and since then has spread widely within the state. Its presence in Yukon was first recognized in 2003 by Dr. David Langor, an entomologist from the Northern Forest Research Centre in Edmonton, who was conducting research on leafminer distribution. That year he identified *P. thomsoni* in ornamental birch in Whitehorse as well as native birch at Watson Lake and Dawson City. Since that time, leafminer populations have increased in these areas and are now causing significant damage to both native and ornamental trees in all of the above locations.

Control

Effective control of the leafminer in Alaska has recently been accomplished through the introduction of a parasitic wasp, Lathrolestes luteolator (MacQuarrie, 2008). Using a long stinger-like ovipositor, the parasite punctures the leaf and injects its eggs into the larval body cavity. When the eggs hatch, the young wasp larvae feed on and eventually kill the leafminer host.


Photo 25: Opened leaf blotch showing mature ***P. thomsoni*** larva (B.C. Ministry of Forests, Lands and Mines photo)

Minor Pests

Porcupine, *Erithizon dorsatum*

While investigating the fire perimeter kill northeast of Watson Lake, staff landed in a meadow comprising mostly scrub dwarf birch. Within the meadow was scattered mature lodgepole pine that had been missed by the 2006 wildfire. Many of these pines had recently been killed by porcupines (Photo 26). Porcupines often resort to debarking trees in the winter when their favoured foods are scarce. The nutrient-rich inner bark provides sustenance during these lean times.

Photo 26: Lodgepole pine debarked by porcupines

Pine leaf chermid, *Pineus pinifoliae*

Although not a significant pest in Yukon, damage caused by pine leaf chermid is common in southern stands. It infests branch tips and stimulates them to deform into characteristic cone-like galls (Photo 27). The galls house the developing young adelgids in interconnecting chambers with one or two per chamber (Furniss and Carolin 1977). Although called the pine leaf chermid, it occurs mainly on spruce species in the west. The name simply reflects the work that needs to be done with this notoriously difficult group of insects, as the species that occurs on spruce is likely distinct from that which occurs on pine.

Photo 27: *Pineus pinifoliae* gall on white spruce branch tip near Ross River

Monitoring the Northward Movement of the Mountain Pine Beetle

The Yukon government is concerned about the northward expansion of the range of the mountain pine beetle and has set up a long-term monitoring program to track its northward movement. One of the main avenues of expansion has been the Rocky Mountain Trench. In northern B.C., the trench includes Williston Lake, the Findlay River and the Kechika River/Liard River Valley. FMB is continuing with setting up and monitoring a series of 15 mountain pine beetle pheromone bait tree stations.

In 2010, as in 2009, these pheromone bait tree stations were established at numerous locations along the Alaska Highway, Tagish area and Annie Lake road to detect local populations in mature pine stands. In 2010, no mountain pine beetles were attracted to the bait trees and these results will serve as a baseline for future trap studies at the same sites.

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