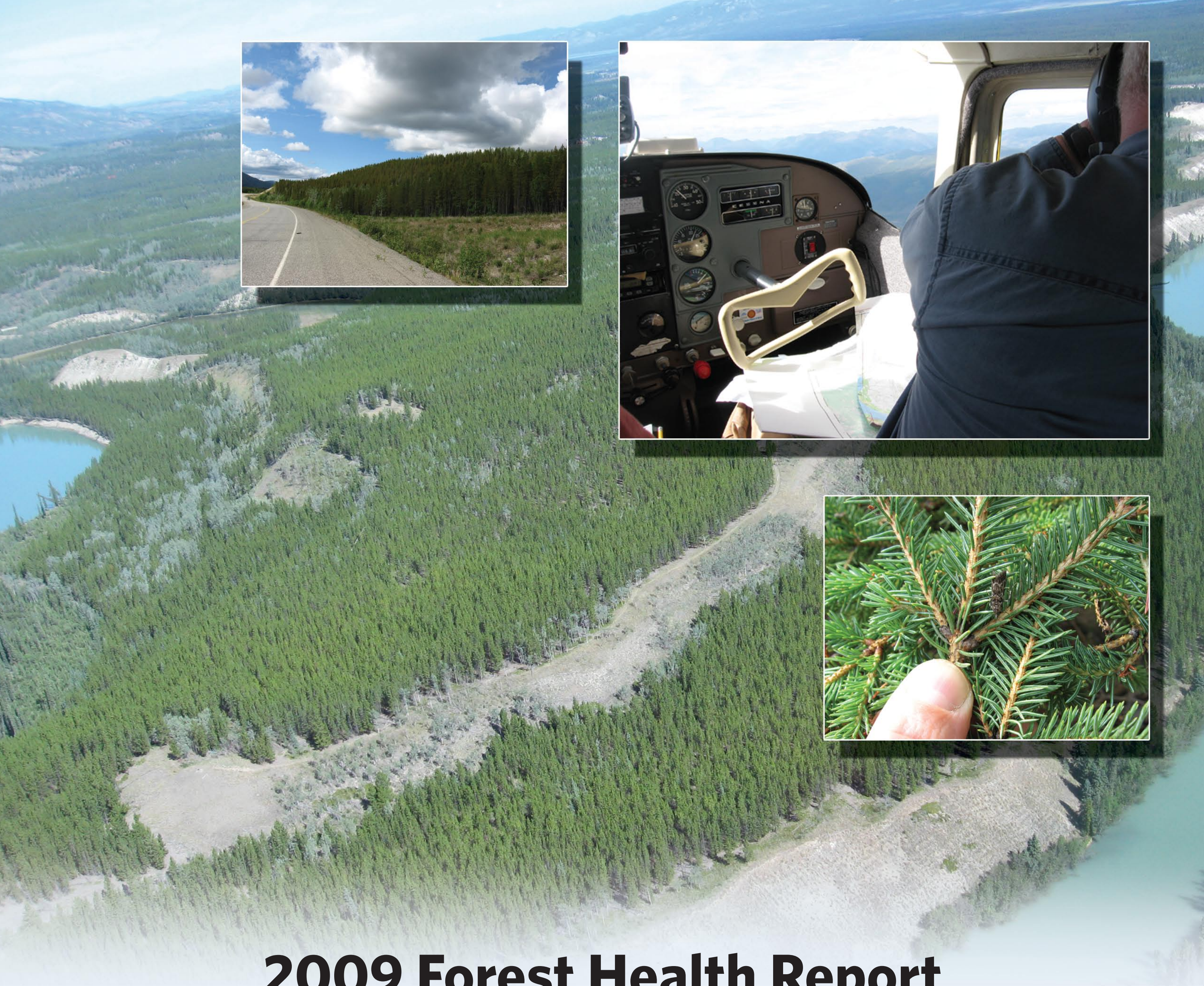
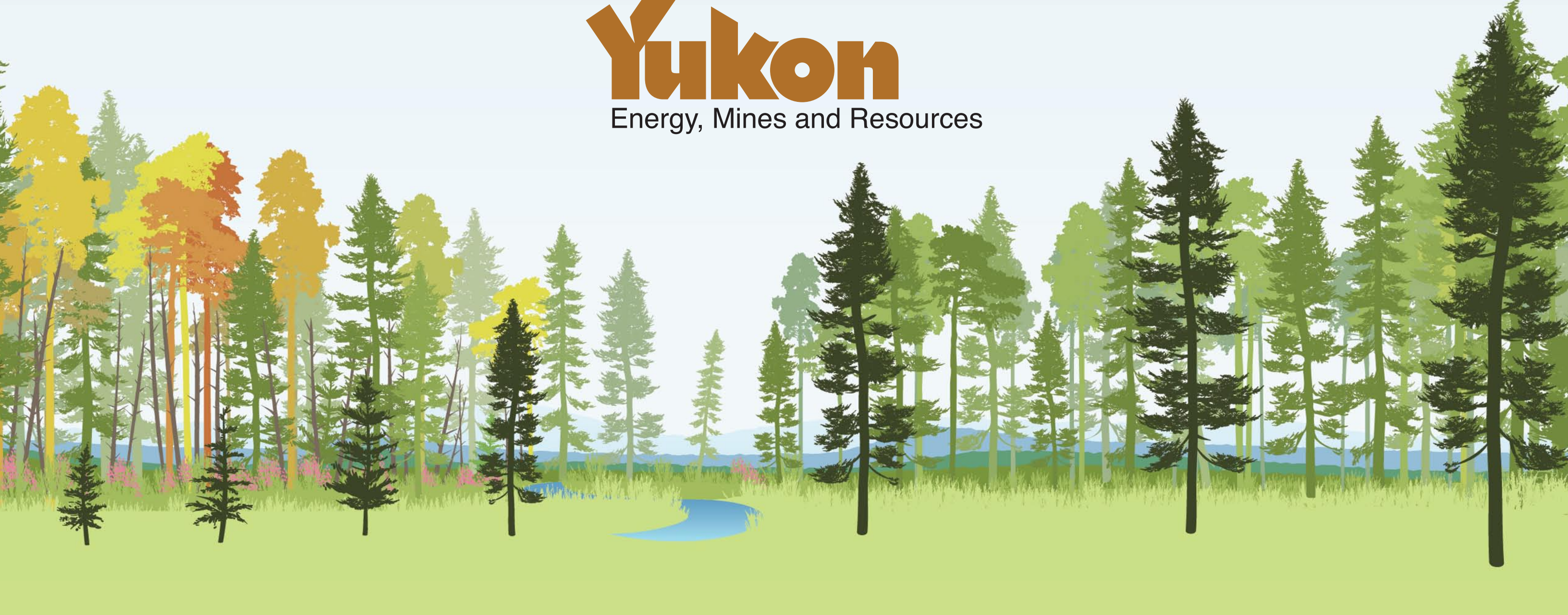


2009 Forest Health Report

Yukon
Energy, Mines and Resources



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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 for the first year in 2009.

Prior to 2009, the Yukon Forest Management Branch 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 the annual forest health report, with FMB funding the field portion of the work. Most of the CFS work centered around the mapping of the spruce beetle *Dendroctonus rufipennis* infestation in southwest Yukon, which is the largest, most intensive spruce beetle outbreak ever recorded in Canada, covering an area of over 350,000 ha. With major restructuring in Canadian Forest Service, and the retirement of Rod Garbutt in 2009, CFS will no longer be assisting Yukon in the same capacity as they provided for so many years.

In 2006, the Canadian Council of Forest Ministers, 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 to identify and assess forest pest risks; and to increase options for, and effectiveness of, the response to forest pest threats (Canadian Council of Forest Ministers, 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 (Canadian Council of Forest Ministers, 2007).

In response to the NFPS, FMB has initiated the development of a risk-based annual forest health monitoring program. The objectives of risk-based forest health monitoring program are three fold:

1. **To provide a Yukon-wide overview of forest health issues.**

   It is intended to provide an overview of forest health across large areas, 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 the 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

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 that can also be effectively monitored as part of a risk-based forest health monitoring program. For this reason, 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 forest 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 rots and heart rots 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 by the Forest Health Advisory Team as an additional forest health agent of concern that will be monitored. The 10 biotic and abiotic forest health agents that will be routinely monitored[2] are:

1. **Spruce beetle** — 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 [*Picea glauca*]) over this 380,000 ha area.
2. **Northern spruce engraver** — 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 across 3,174 ha (Garbutt, 2009).
3. **Western balsam bark beetle** — This beetle attacks subalpine fir (*Abies lasiocarpa*). It has moved north from British Columbia over the last 20 years, and has become an active disturbance agent in the mature subalpine fir stands in southern Yukon.
4. **Budworms** — The budworm guild, comprised 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 to a lesser degree, larch (*Larix laricina*) forests in Yukon. In 2008, eastern spruce budworm damage was mapped across 1,003 ha in interior Yukon, primarily near Stewart Crossing. Historically, eastern spruce budworm damage has been mapped in the extreme southeast portion of Yukon (Garbutt, 2009).
5. **Larch sawfly** — 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** — 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** — 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.

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 be focused 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.

8. **Pine needle cast** — This pathogen is the most common cause of pre-mature needle loss of lodgepole pine (*Pinus contorta*) in Yukon (Garbutt, 2009). Pine stands in southeast Yukon are chronically infected, but the disease is becoming increasingly common in central Yukon. In 2008, pine needle cast occurred from the British Columbia 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).

9. **Mountain pine beetle** — This bark beetle is endemic to North America, but currently it 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 open-canopied 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 consisted of identifying two distinct priority regions:

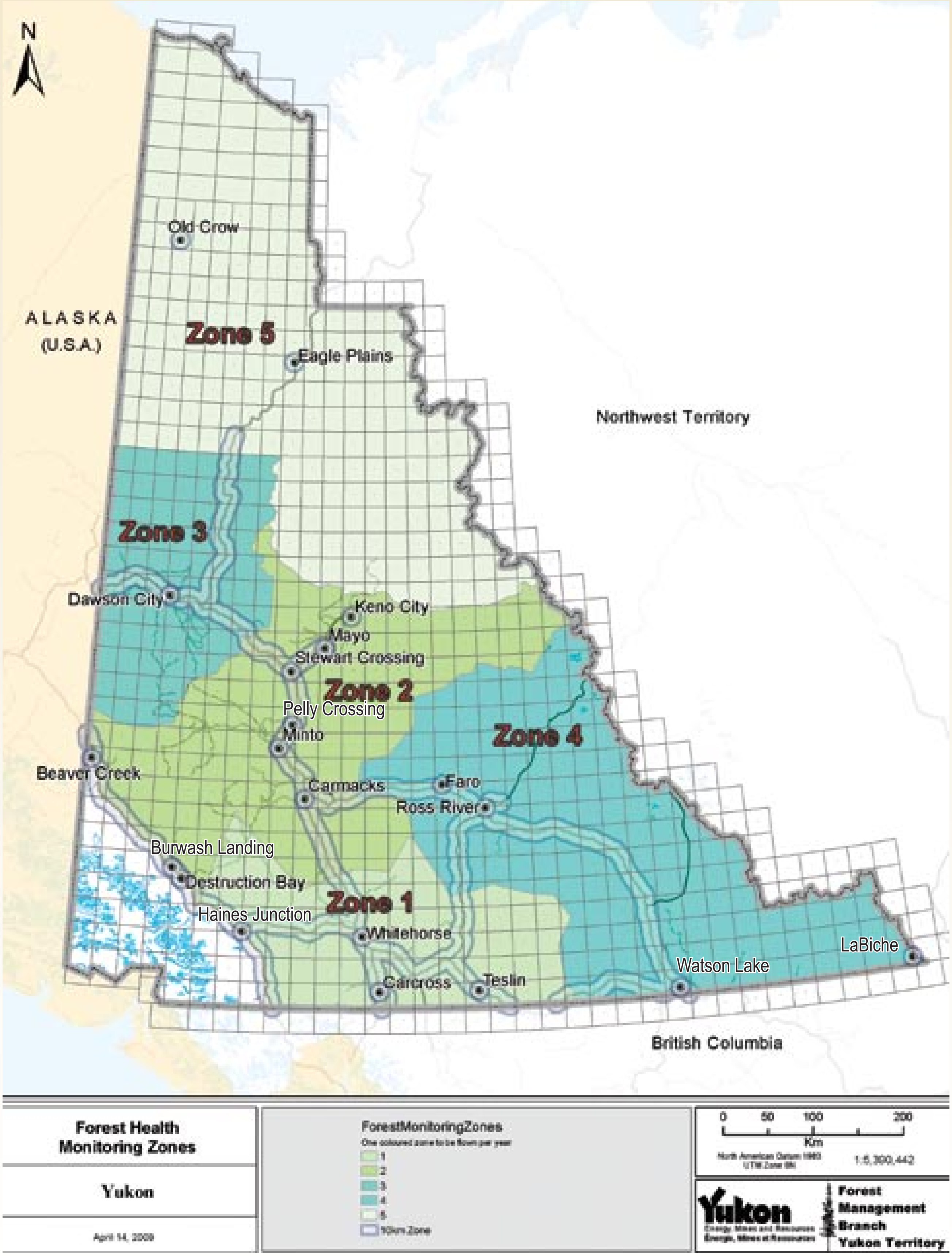
1. **High value forested regions to be monitored on an annual or biannual basis**

   High value forest regions have been identified as areas within a 16 km of highway corridors and 20 km around communities. The majority of accessible commercial forested lands and areas where forest management activities are occurring are within these corridors. Also note that the Kotanelee gas plant located in Labiche in the extreme southeast was treated as a "20 km community buffer" because this area had been host to a number of forest health issues in recent years.

2. **Areas outside of the high value regions to be monitored on a rotational basis**

   Yukon was divided into 5 forest health regions based on high level strategic planning areas. In these areas, monitoring will focus on forest stands that are the most susceptible to the 10 forest health agents of greatest concern. A minimum of one forest health zone will be flown on a five year rotational basis.

Map 1. Yukon map showing 1:100 000 map grid, 5 Zones, highway and community buffers



Aerial Survey the Primary Monitoring Tool

Aerial Overview Surveys 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 and Canadian Forest Service, 2000).

For all of the above reasons, aerial overview surveys will be primary tool to monitor forest health in Yukon. The forest health aerial overview survey standards used by the B.C. Ministry of Forests will be used in Yukon, to assure continuity across their common boundaries.

Standards for conducting aerial surveys include:

- Utilizing Cessna 206 or other equivalent high wing single engine plane.
- Flying height is 800m above ground level
- 1:100,000 scale maps utilized by aerial surveyors
- 2 qualified aerial surveyors positioned on opposite sides of plane
- Each aerial surveyor can see approximately 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
    - 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. Cessna 206 and survey crew at refueling stop at a remote bush strip in the Ogilvie Mountains

Forest Health Aerial Surveys 2009

This year, Zones 1 and 3 were surveyed. The two zones were flown in an east-west grid pattern with an eight kilometer interval between grids. In addition all 16 km-wide highway buffers and 20 km community buffers, with the single exception of Old Crow were flown. The additional 20 km buffer around the Labiche Area (Kotanelee gas plant) in the extreme southeast was added because this area had been host to a number of forest health issues in recent years.

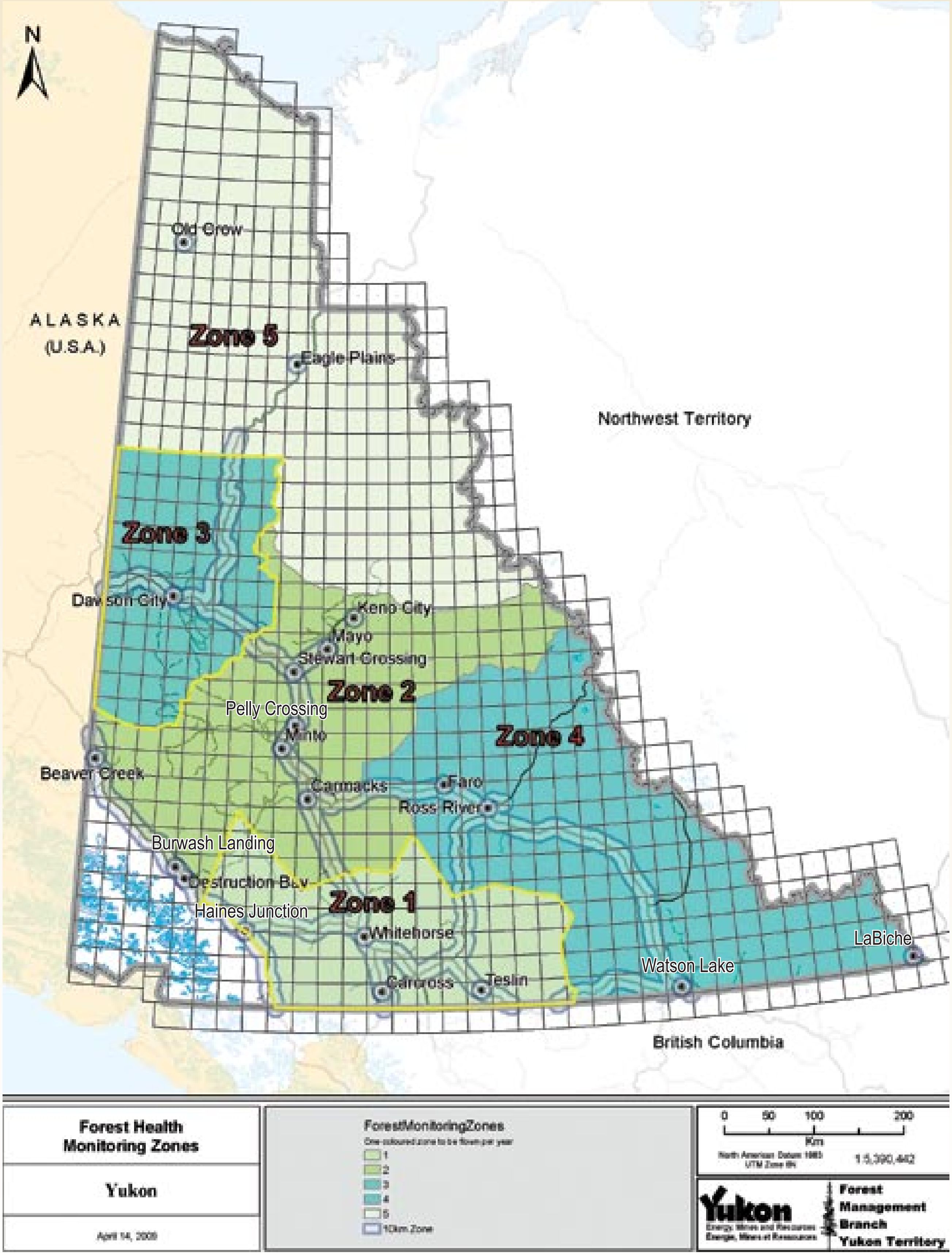
There were a total of 76 1:100,000 scale maps surveyed which includes over 4 million hectares (ha) of forested areas surveyed. During the 18 days required to complete the aerial survey a total of eleven species of biotic (insects and disease) and six types of abiotic (non living such as flood and drought) disturbance were mapped.

The area of mapped disturbance totaled 601,335 ha. A summary of all encountered pest damage in the two zones is contained in Table 2.

The weather during the 18 day survey was generally favorable and no flights were delayed because of rain. Some rain showers were encountered in the mountains east and north of Teslin but only non forested alpine areas were obscured.

Following is a summary of disturbance type broken up by the three coverages of highway buffers, community buffers and zonal grids. This is followed in turn by a more detailed description of each disturbance (forest pest) type, biotic and abiotic, listed in order of their importance to the overall health of Yukon forests.

Map 2. Yukon map showing 1:100 000 map grid, 5 Zones, highway and community buffers
NOTE Highlighted areas indicate the zones surveyed



Aerial Survey of Major Highway Corridors

A corridor 16 kilometers wide was flown between July 6 and July 10 along all nine major highways, with the exception of those that fell within Zones 1 and 3 (Map 2). The highway corridors within the zones were covered by the zonal grid coverage.

A wildfire near Little Salmon Lake prevented completion of that section of the Robert Campbell Highway and smoke from that fire as well as from fires in Alaska significantly reduced visibility between Haines Junction and Beaver Creek. The north Klondike Highway section between Carmacks and Dawson City was completed later in July during flights to and from Dawson. The Haines Road section between Haines Junction and the south end of Dezadeash Lake was flown in mid-August during the annual aerial survey of recent spruce beetle-caused mortality in the southwest. The section between Dezadeash Lake and the B.C. border was not surveyed because spruce beetle activity in this area in 2004/2005 killed most of the mature spruce, and by 2006 beetle populations had collapsed. The results of the survey are summarized by specific highway corridor in Table 1, and linked with the totals from the aerial survey of Yukon communities in an overall summary in Table 2.

Aerial Survey of Yukon Communities

One of the priorities of the 2009 aerial survey was the recording of pest activity in the vicinity of all communities within Yukon. All pest activity was recorded within a 20 km radius buffer (1,256 km^2) around each community. A summary of the survey results is contained in the following maps and tables (Figure 1) and an overall summary of results linked with those from the highway corridor survey are contained in Table 2. Haines Junction and Champagne fell within the area covered during the annual survey of spruce beetle in the southwest and the results are included in the summary table for Zone 1a.

Aerial Survey of Zone 1a

For the purpose of this year's survey, Zone 1 (Map 1) was divided into east and west sections. Only the eastern section (1a) was flown in a grid pattern during the July aerial survey. All flights were based out of Whitehorse. Zone 1a covered an area bounded by the B.C. border on the south and extended north almost to the Pelly River. To the west the Zone ended just west of Whitehorse and extended eastward as far as the continental divide in the Cassiar Mountains. Zone 1b extended westward to the Kluane National Park boundary and north as far as the north end of Kluane Lake. Much of Zone 1b was flown in August during the annual assessment of recent spruce beetle mortality in the southwest, but the coverage focused on areas of recent spruce beetle activity so was not as intensive as Zone 1a coverage. The combined results of both Zone 1a and Zone 1b surveys are summarized in Table 2.

Aerial Survey of Zone 3

The survey of Zone 3 was based out of Dawson City. This was a large area bounded on the south (approximately) by latitude 62° 45′ North, extending northward to latitude 65° 30′ North. To the east it was bounded by the Hart River in the northern portion and the Stewart River in the south. To the west it extended to the Alaska border. Much of this Zone, especially north of the Ogilvie Mountains was alpine tundra with only narrow strips of forested land in the river drainages. Only abiotic disturbances such as flood mortality or landslides were mapped in this area. In the south the dominant feature of forested areas was the pattern of recent forest fires. Up to 80% of the forests had been burned within the past 30 years. Here again pest activity, biotic as well as abiotic, was limited primarily to the major water courses and their tributaries. A summary of the survey results is contained in Table 2.

Table 1. Summary of biotic and abiotic forest damage within highway corridors from 2009 aerial survey

Highway buffer 1: Robert Campbell Highway	
Forest Health Agent	Total Area (ha.)
Aspen leaf miner	59 947
Balsam bark beetle	2
Flood	61
Poplar decline	557

Highway buffer 2: Whitehorse - Watson Lake	
Forest Health Agent	Total Area (ha.)
Aspen leaf miner	15 514
Balsam bark beetle	483
Drought - pine	34
Drought - spruce	1
Flood	161
Pine needle cast	21
Slide	6
Spruce beetle	1
Windthrow	5

Highway buffer 3: Whitehorse - Haines Junction	
Forest Health Agent	Total Area (ha.)
Aspen leaf miner	38 604
Flood	49
Porcupine	3
Spruce beetle	57

Highway buffer 4: Haines Junction - Beaver Creek	
Forest Health Agent	Total Area (ha.)
Aspen leaf miner	9 421
Birch leafroller	1 480
Poplar decline	939
Slide	1
Spruce beetle	5

Highway buffer 5: South Canol Road	
Forest Health Agent	Total Area (ha.)
Aspen leaf miner	5 277
Balsam bark beetle	16
Drought - pine	20
Flood	30
Slide	8

Highway buffer 6: Whitehorse - Carmacks	
Forest Health Agent	Total Area (ha.)
Aspen leaf miner	61 180
Drought - spruce	10
Flood	79
Porcupine	8
Willow blotch miner	38

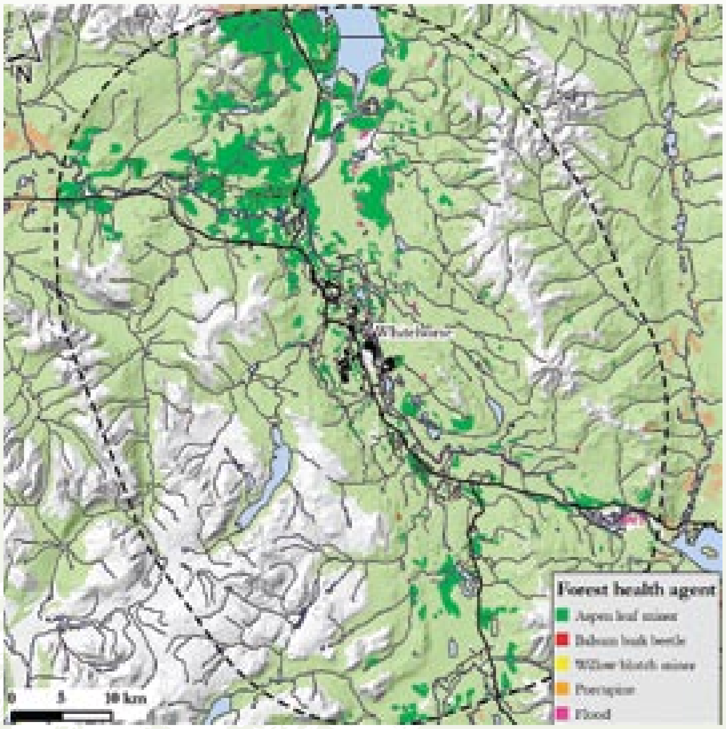
Highway buffer 7: Carmacks - Dawson	
Forest Health Agent	Total Area (ha.)
Aspen leaf miner	132 106
Drought - spruce	2
Eastern spruce budworm	1 067
Flood	31
Poplar decline	288
Willow blotch miner	1 157

Highway buffer 8: Whitehorse - BC border (via Carcross)	
Forest Health Agent	Total Area (ha.)
Aspen leaf miner	6 139
Balsam bark beetle	38
Drought - pine	7
Flood	94

Highway buffer 9: Stewart Crossing - Keno	
Forest Health Agent	Total Area (ha.)
Aspen leaf miner	25 743
Eastern spruce budworm	1 154
Flood	3
Willow blotch miner	226

Figure 1. Maps and summary tables of pest damage around 18 Yukon communities

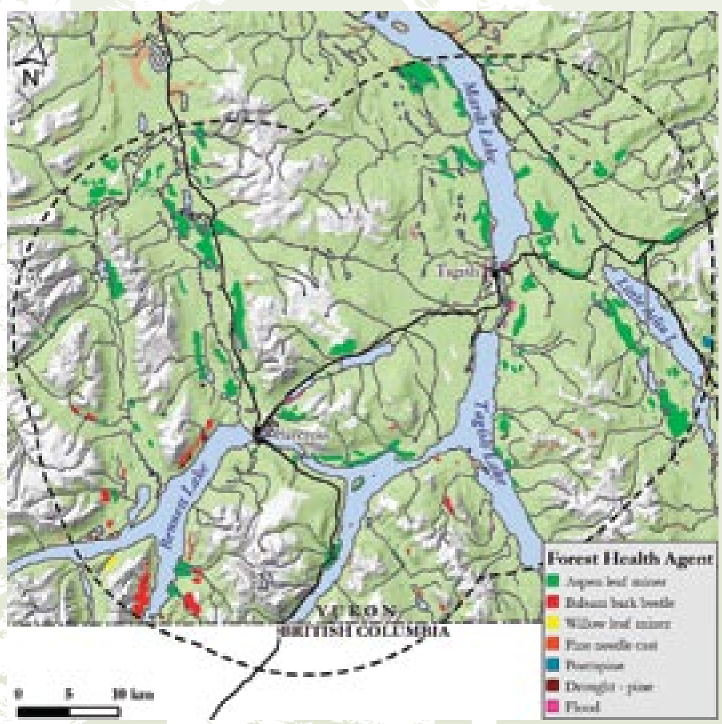
Whitehorse 20 km Buffer



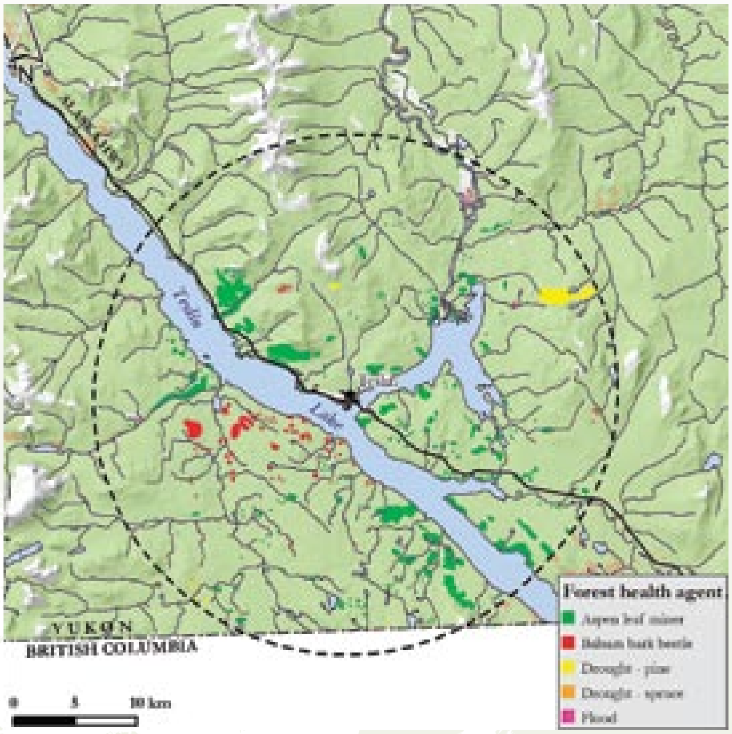
Community 1: Whitehorse	
Forest Health Agent	**Total Area (ha.)**
Aspen leaf miner	20 877
Balsam bark beetle	4
Flood	137
Porcupine	8
Willow blotch miner	38

Carcross Tagish 20 km Buffer

Community 2: Carcross - Tagish	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	8 846
Balsam bark beetle	766
Drought - pine	15
Flood	186
Pine needle cast	9
Porcupine	70
Willow leaf miner	75



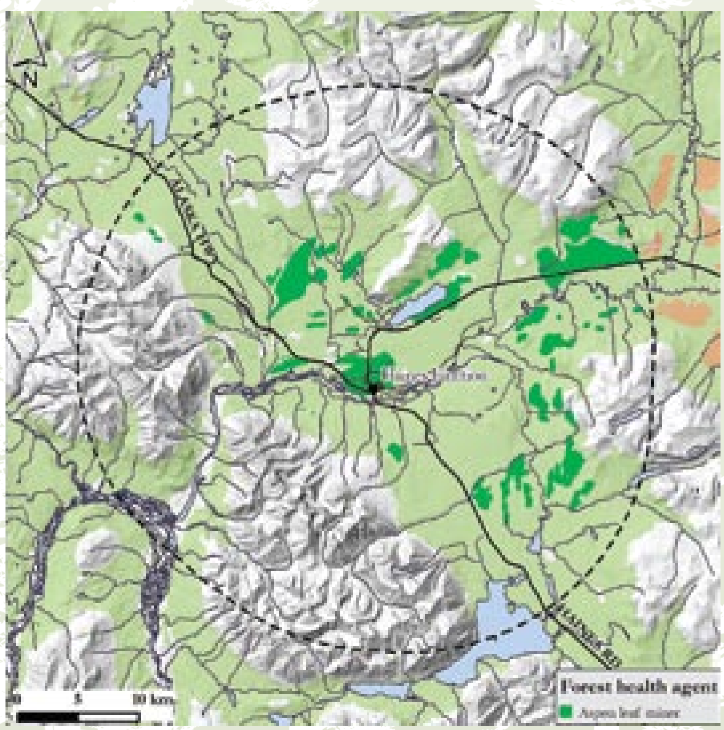
Teslin 20 km Buffer



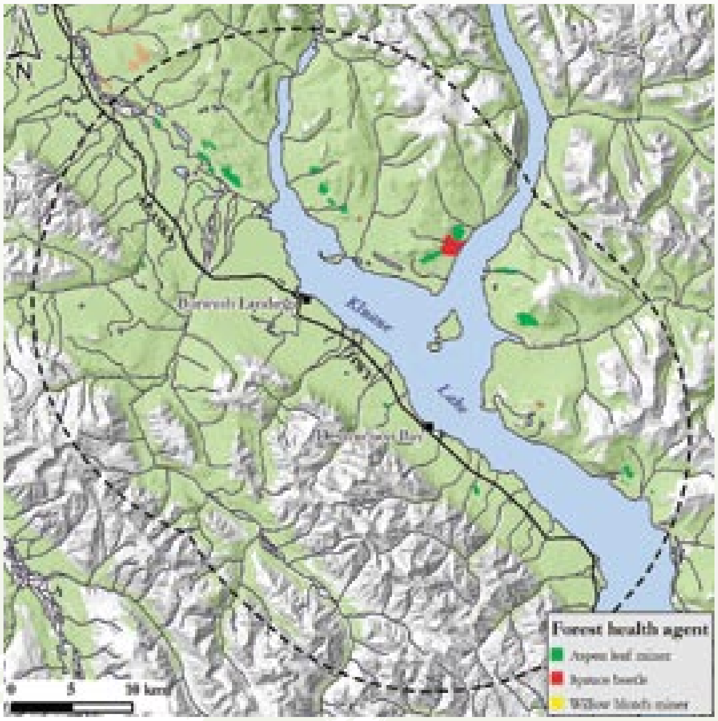
Teslin Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	3 321
Balsam bark beetle	390
Drought - pine	392
Drought - spruce	1
Flood	35

Haines Junction 20 km Buffer

Haines Junction Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	8 365



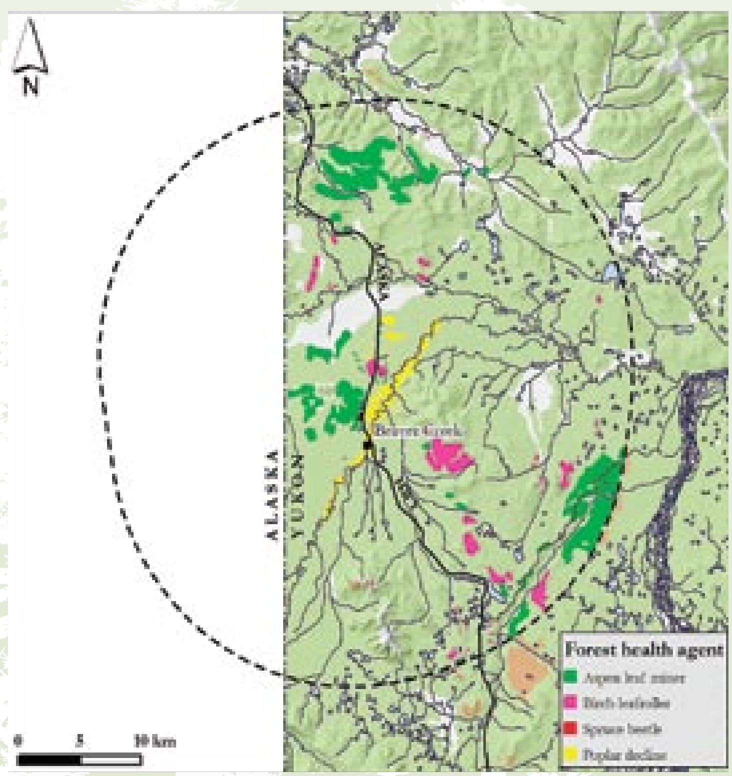
Destruction Bay & Burwash Landing 20 km Buffer



Destruction Bay & Burwash Landing Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	579
Spruce beetle	209
Willow blotch miner	26

Beaver Creek 20 km Buffer

Beaver Creek Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	5 113
Birch leafroller	1 346
Poplar decline	1 108
Spruce beetle	2

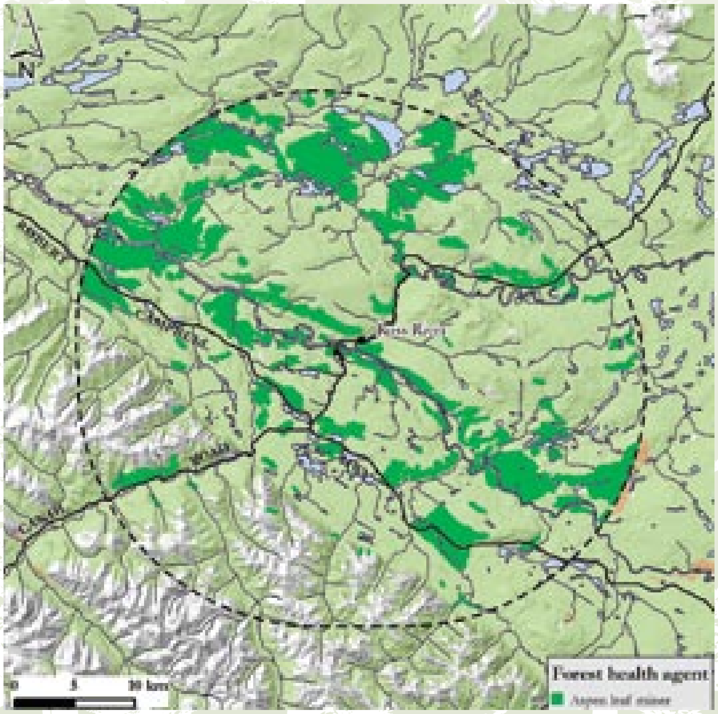


Watson Lake 20 km Buffer

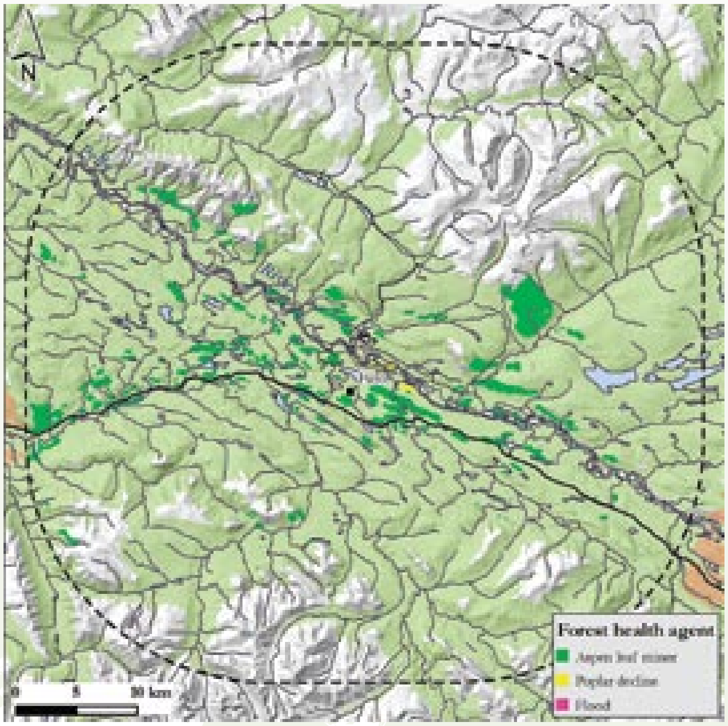
Watson Lake Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	4 658
Balsam bark beetle	9
Drought - pine	1
Flood	96

Ross River 20 km Buffer

Ross River Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	27 826



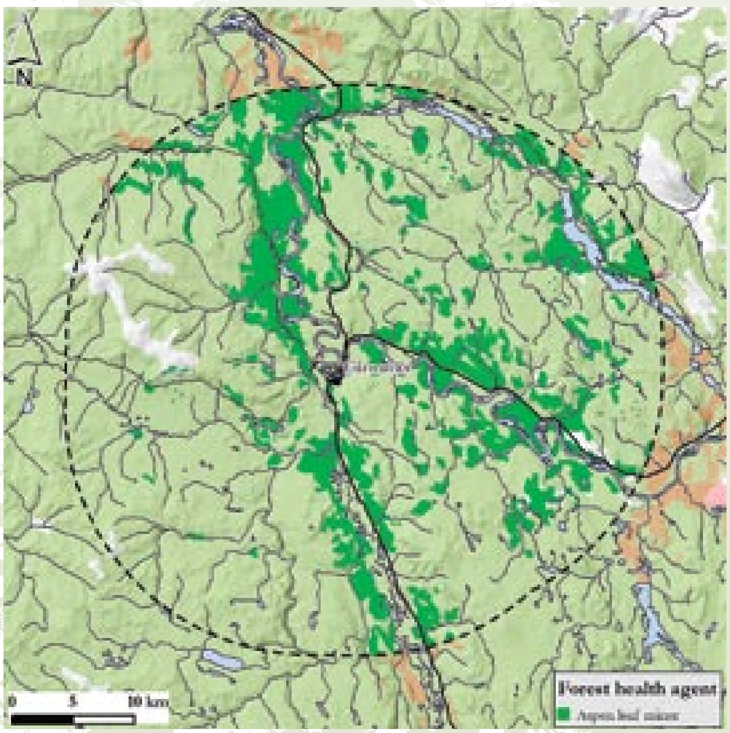
Faro 20 km Buffer



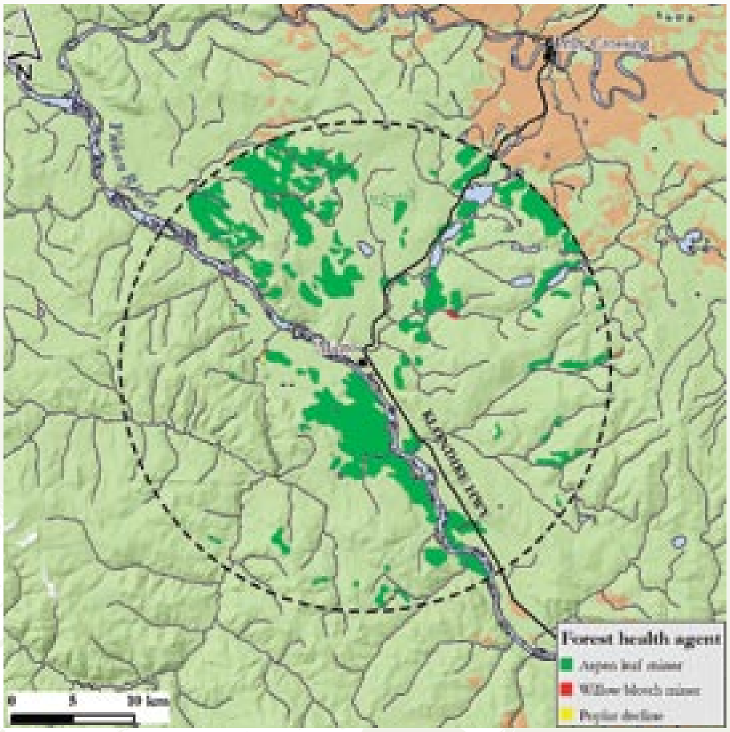
Faro Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	5 578
Flood	8
Poplar decline	140

Carmacks 20 km Buffer

Carmacks Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	26 528



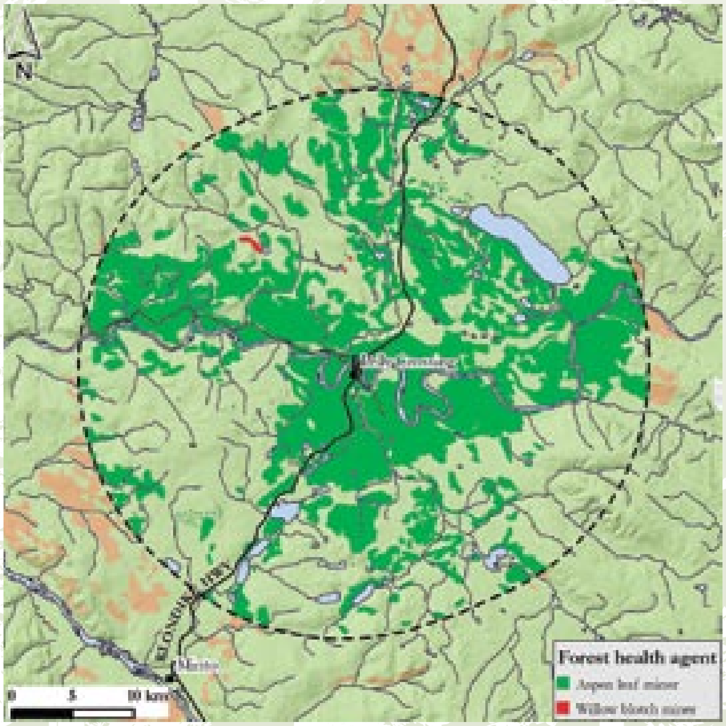
Minto 20 km Buffer



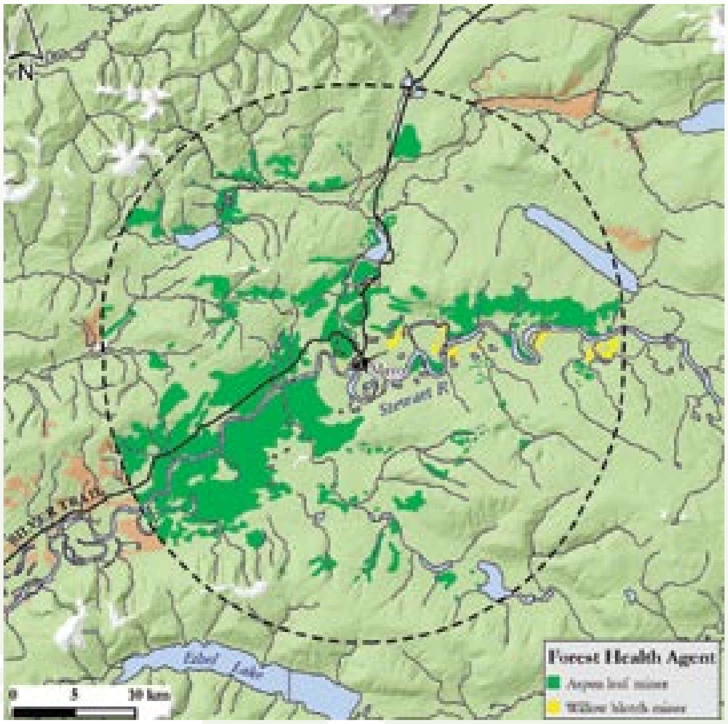
Minto Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	14 296
Poplar decline	43
Willow blotch miner	23

Pelly Crossing 20 km Buffer

Pelly Crossing Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	52 469
Willow blotch miner	64



Mayo 20 km Buffer

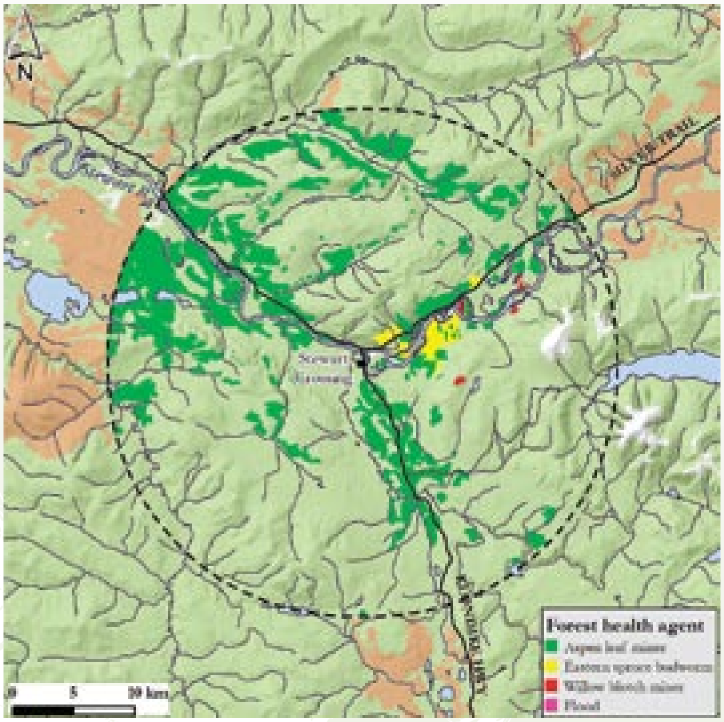


Mayo Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	21 017
Willow blotch miner	327

Keno 20 km Buffer

Keno Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	3 633

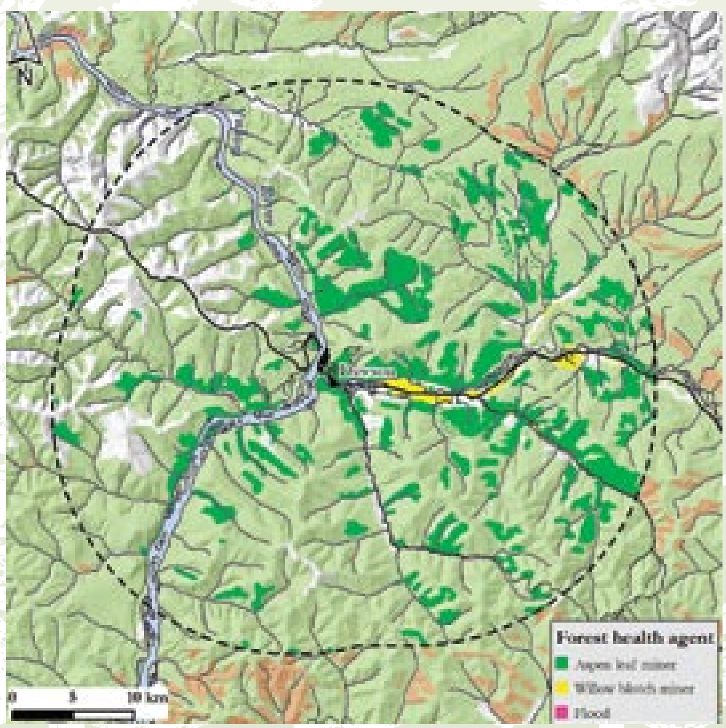
Stewart Crossing 20 km Buffer



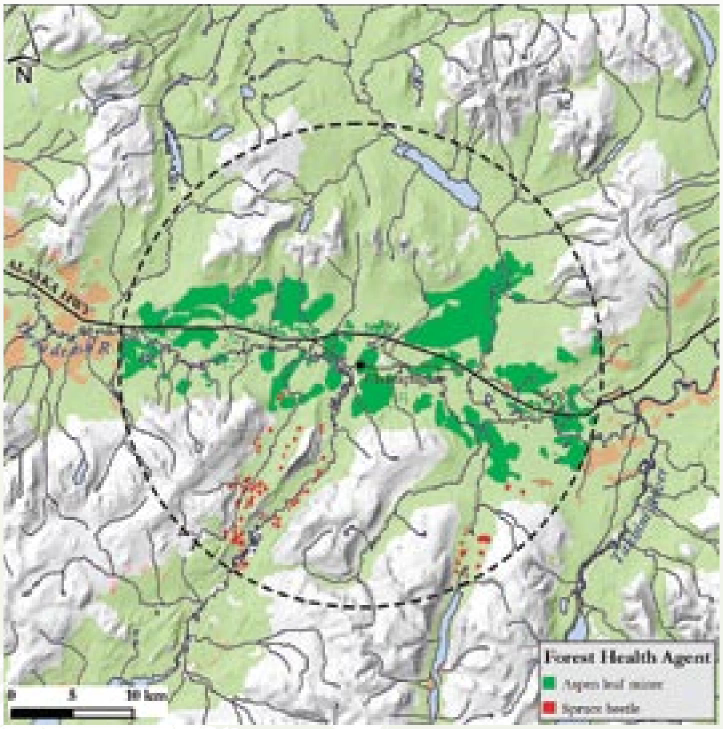
Stewart Crossing Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	19 014
Eastern spruce budworm	1 155
Flood	3
Willow blotch miner	99

Dawson City 20 km Buffer

Dawson City Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	23 089
Flood	9
Willow blotch miner	899



Champagne 20 km Buffer



Champagne Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	13 831
Spruce beetle	275

LaBiche 20 km Buffer

LaBiche Summary Table	
Forest Health Agent	**Total Area (ha.)**
Aspen serpentine leaf miner	9 722
Balsam bark beetle	24
Flood	21
Poplar decline	2
Spruce beetle	587
Windthrow	24

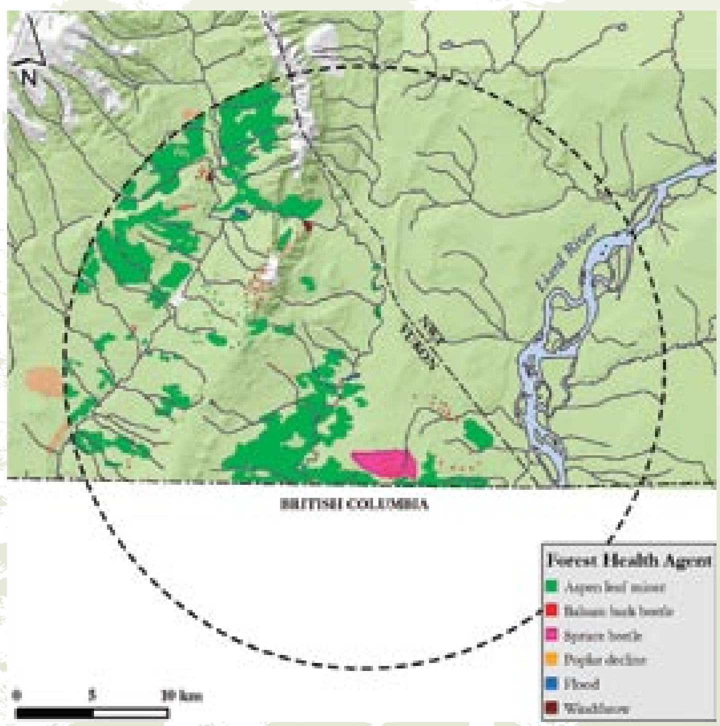


Table 2. Summary of pest damage mapped in Yukon during the 2009 overview aerial survey.

Forest Health Zone 1	
Forest Health Agent	**Total Area (ha.)**
Aspen leaf miner	111 717
Avalanche	2
Balsam bark beetle	1 465
Drought - pine	431
Drought - spruce	21
Flood	638
Pine needle cast	1 604
Poplar decline	2
Porcupine	182
Slide	60
Spruce beetle	3 126
Willow blotch miner	66
Willow leaf miner	75
Windthrow	37

Highways and communities outside Forest Health Zones 1 & 3	
Forest Health Agent	**Total Area (ha.)**
Aspen leaf miner	292 288
Balsam bark beetle	50
Birch leafroller	1 744
Drought - pine	16
Drought - spruce	55
Eastern spruce budworm	1 155
Flood	175
Poplar decline	1 882
Slide	1
Spruce beetle	800
Willow blotch miner	626
Windthrow	30

Forest Health Zone 3	
Forest Health Agent	**Total Area (ha.)**
Aspen leaf miner	180 118
Drought - spruce	613
Flood	259
Poplar decline	602
Slide	23
Spruce beetle	32
Willow blotch miner	1 429
Windthrow	13

Report on Forest Pest Activity by Disturbance Type

Biotic Pests

Spruce Beetle, *Dendroctonus rufipennis*

In addition to the ongoing spruce beetle infestation in the southwest, small pockets of recent spruce beetle-caused white spruce mortality were mapped over an area of 32 hectares (ha) on the hillsides above Aussie Creek, northeast of Dawson City during the aerial survey in Zone 3. Spruce beetle attacks were also found in flood-killed trees near Tagish (see Supplementary Report).

Southwest

Recent mortality was mapped over an area totaling 3,121 ha, a further reduction from the 5,000 ha mapped in 2008 (Map 3).

Currently, the infestation is active only on the fringes of the original infested area, particularly adjacent to the north end of Dezadeash Lake and upper portions of the Dezadeash River. From here beetle populations have migrated east through Frederick Lake pass, and fanned out along the western shore of Kusawa Lake, south beyond Devilhole Creek and north through the Jo-Jo Creek Pass to the Jo-Jo Lakes area. With the exception of newly-extended mortality toward the southwest end of Kusawa Lake, all of the mapped mortality was in areas previously infested, and all mortality was light[1].

The only other area of significant mortality was 1,140 ha mapped near the confluence of the West Aishihik and Aishihik rivers. Most was in stands of immature trees that had regenerated following a wildfire. It was here that the only polygon of moderate[1] mortality was mapped over 144 ha. The infested stands were bordered by much older stands containing grey trees from prior attacks, but no recent mortality (Photo 3). An adjacent stand containing light attacks was ground checked on August 15th. It was the only site that offered safe landing for the helicopter. An estimated 5% of trees in this stand were killed by attacks in 2008 and had turned red earlier in the season. All broods in these trees had been killed by last winter's extreme cold. The current attacks (<1% of stand trees) were largely repelled by tree defenses. The few successful attacks were probably not sufficient to kill the trees. Some mature larvae, pupae and immature adults were found in these trees indicating that much of the brood would cycle in a single year instead of the normal two years. Approximately 10% of stand trees had been killed by attacks in 2006, the peak year of infestation in this particular stand. Most of the broods in these trees had been preyed upon by woodpeckers (above) and squirrels (below). Squirrels had removed most of the bark at the base of the trees (Photo 4) and fed upon the immature adults that over wintered at the base in their second year of development.

Elsewhere, mortality was limited to single and small groups of trees in the valley between Champagne and Haines Junction and though none could be accessed, previous ground checks in this area had found the majority of trees to have been attacked by the engraver beetle, *Ips perturbatus* with only minimal spruce beetle involvement.

This infestation is now 20 years old and though in decline, appears not yet ready to collapse completely. Historically, spruce beetle infestations peaked quickly and collapsed after three or four years. The intensity and duration of the current infestation are related directly to climatic stress induced upon southwest Yukon spruce stands by the significant increase in temperature during the late 1980s and into the 1990s. The effects of this are described in more detail in the 'Drought' section later in this report. It is by far the largest and longest lasting spruce beetle outbreak ever recorded in Canada. Nearly half of the infested area is contained within Kluane National Park, with most of the remainder within the Shakwak Trench and West Aishihik River Valley. Nearly all of the mature spruce within Tatshenshini Wilderness Park in B.C. were also killed.

Prior to this period there was no history of annual aerial surveys anywhere in Yukon, so, when it was first detected in 1994, it was already 32,000 ha in size. Annual aerial and ground surveys have been conducted ever since. The infestation peaked in 1998 when 107,000 ha of recent mortality was mapped. It then went into decline and when in 2000 and 2001 the drought ended abruptly with a succession of wet, cool summers, it was expected to follow historical precedents and collapse completely. However, the increased moisture proved to be a net benefit to the beetle by improving the conditions for survival of beetle progeny, and, instead of a collapse we witnessed a resurgence of the infestation, particularly in the south, peaking in 2004 with 98,000 ha of recent mortality. Following the resurgence, the beetle killed more than 80% of available host trees over an area of more than 350,000 ha and since 2004, host depletion has been the primary cause for the rapid and continuous decline.

1 - Severity classes for bark beetle (and porcupine)-caused tree mortality Light: ≤10% of trees killed in the previous year Moderate: 10-30% of trees killed in the previous year Severe: ≥30% of trees killed in the previous year

Map 3. Current spruce beetle-caused white spruce mortality in southwest Yukon

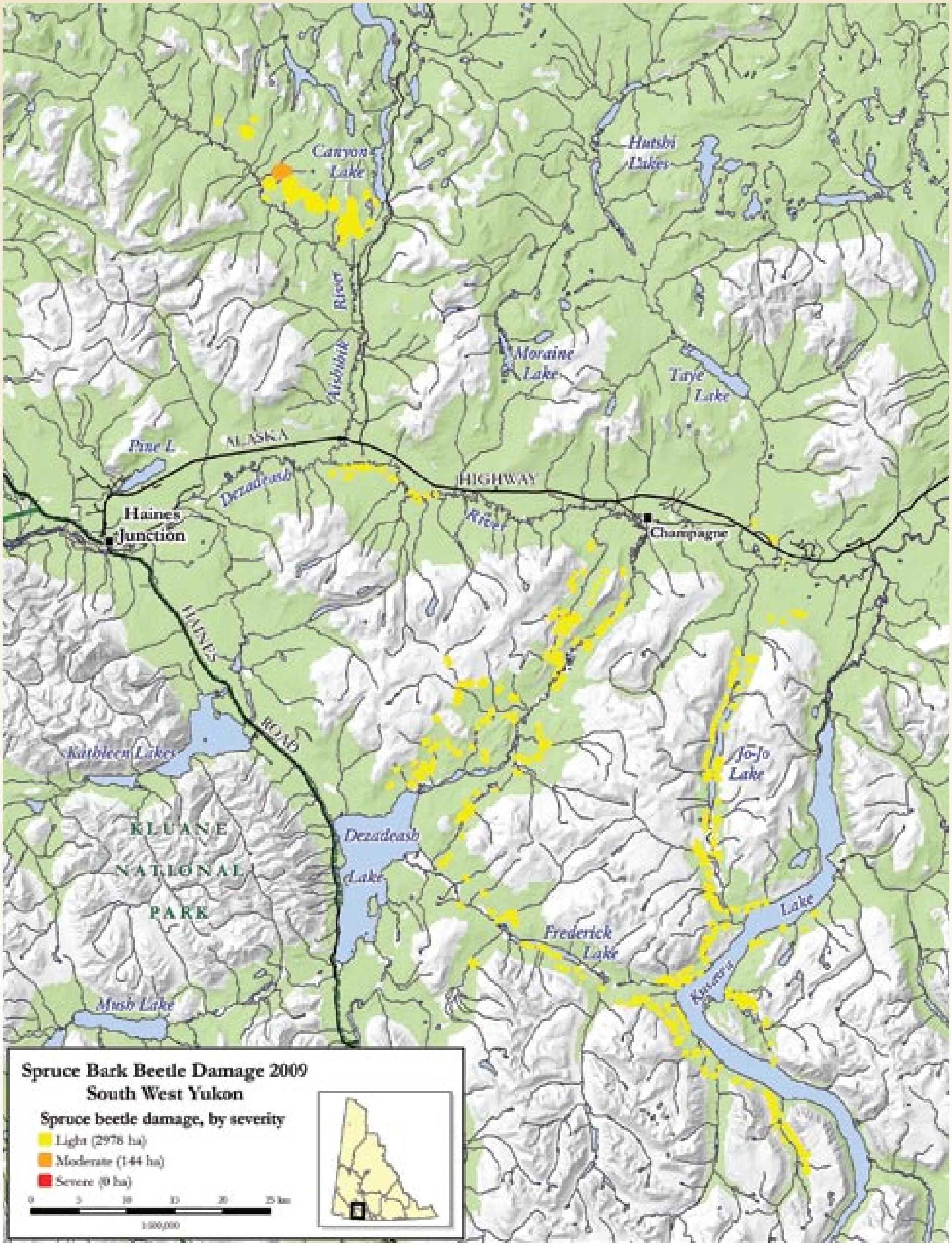


Photo 2. Recent spruce beetle-caused mortality of immature spruce in West Aishihik River valley bordered by old mortality in mature/overmature stand

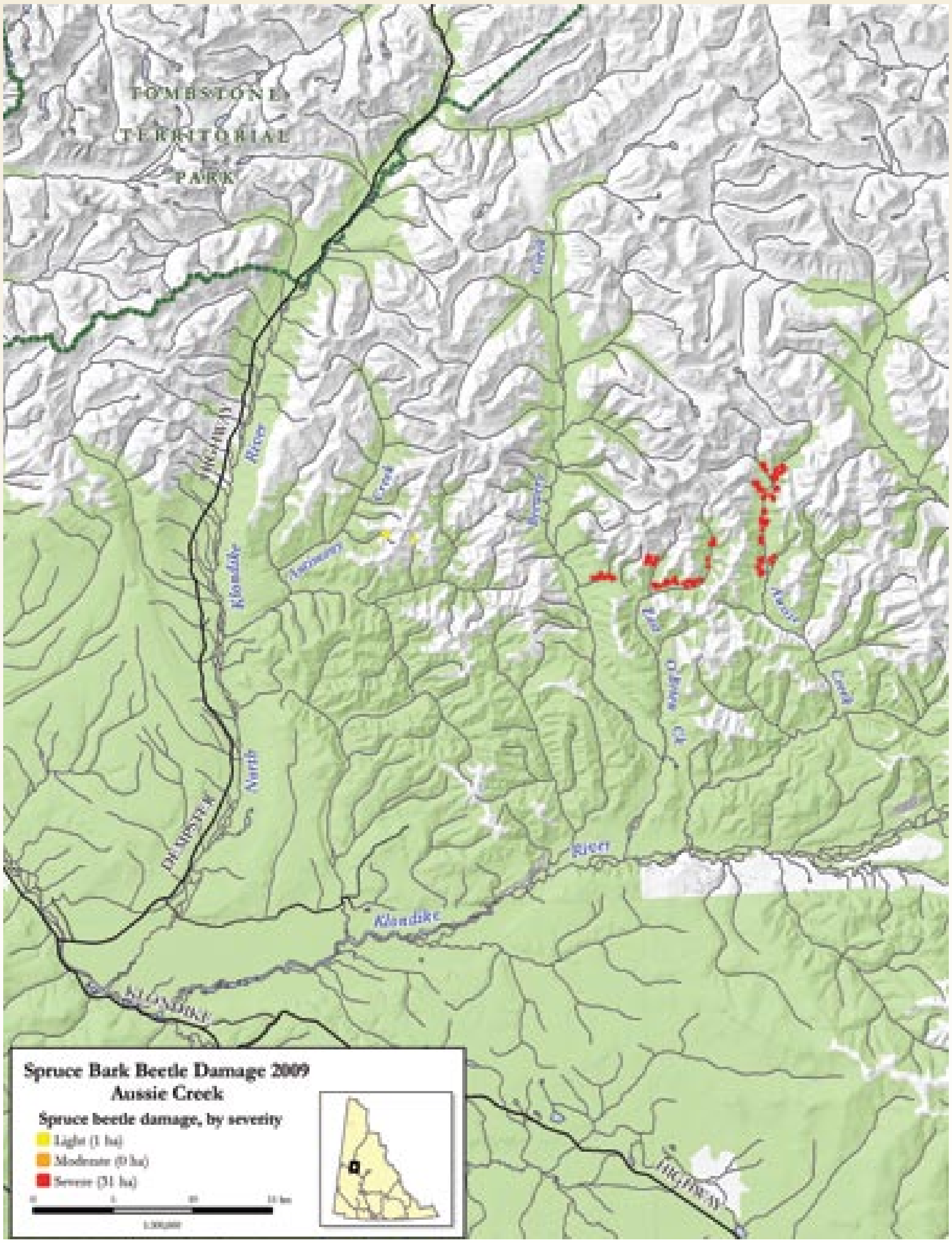
Photo 3. Spruce debarked by squirrels in search of overwintering spruce beetle progeny

Aussie Creek

During the aerial overview survey recent white spruce mortality was mapped in the upper reaches of Aussie Creek, a tributary of the South Klondike River northeast of Dawson City. The infested areas were mapped in more detail by helicopter in August with recent mortality mapped over an area of 32 ha in Aussie and a tributary to adjacent Brewery creeks (Map 4, Photo 4). A suitable landing site was found in a meadow in the upper Brewery Creek tributary allowing for the ground assessment of one of the infested stands. Spruce beetle were identified to be the cause of the mortality.

One tree had been currently attacked and the tree crown was already fading just over two months after the attack. Almost all attack sites were below breast height (1.3 m), near the base of the bole. Progeny were in a late instar larval stage at the time of the assessment. At that stage of development they would overwinter as mature larvae or pupae and continue development for another year before emerging as mature adults in 2011. Two additional trees had been attacked in 2008 and the crowns were in a more advanced stage of discoloration, though the needles had not yet been shed. These trees

Map 4. Current spruce beetle –caused white spruce mortality Aussie and Brewery creeks



were also attacked only at the base and the few surviving progeny were in an immature adult stage. They would later relocate to the root collar of the trees in September to overwinter and emerge in the June of next year to attack a fresh host. No grey trees were seen on the site suggesting that this infestation began recently.

low on the boles. This means that, by standards farther south where beetle attacks extend well up the bole, a single tree will absorb a smaller proportion of the population. Therefore, a population the same size as one in the south will potentially attack and kill many more trees. Though populations on the assessed site were relatively low and attacks were scattered and light in intensity, the infestation was spread over a large area. A continuation of drought conditions over the next few years could result in a much intensified infestation. This area will be closely monitored.

Photo 4. Recent spruce beetle-caused white spruce mortality near Aussie Creek

The early fading of the currently attacked trees suggests that drought conditions had returned following a brief period of relief with last year's cool wet conditions. Drought stress had likely been the initial cause of the infestation with the trees being both more attractive to beetle attacks and less able to defend themselves. Drought stressed trees attract and concentrate local populations of beetles that would ordinarily disperse into slash or scattered decadent trees. A single cycle of breeding success under these conditions can increase a population significantly and if conditions for their success persist an outbreak can occur.

Spruce beetle-caused damage in the north is magnified by the adapted habit of the beetles to attack only very

Additional scattered incidences of recent mortality seen farther east in the Hamilton Creek drainage and adjacent to the South Klondike River. This mortality was attributed to drought because it was limited to scattered individual trees rather than groups of trees characteristic of beetle-caused mortality. If the drought stress continues, however, increased mortality may result from a concentration of local beetle populations like that seen in Aussie Creek.

Western balsam bark beetle, *Dryocoetes confuses*

Alpine fir mortality attributed to attacks by the balsam bark beetle was mapped throughout the range of alpine fir in the southern Yukon. Red trees attributed to beetle attack were mapped over an area totaling 1,514 ha. Most of the mortality was in the form of scattered individual and small groups of red trees, and rarely amounted to more than 1% of the stand. Significant areas of light mortality were seen in the hills south of Teslin Lake, in the LaBiche River drainage and as far north as the Pelly Mountains. The most concentrated mortality was seen along the east-facing slopes above Bennett Lake (Map 5, Photo 5).

Map 5. Recent balsam bark beetle-caused alpine fir mortality mapped near Bennett Lake

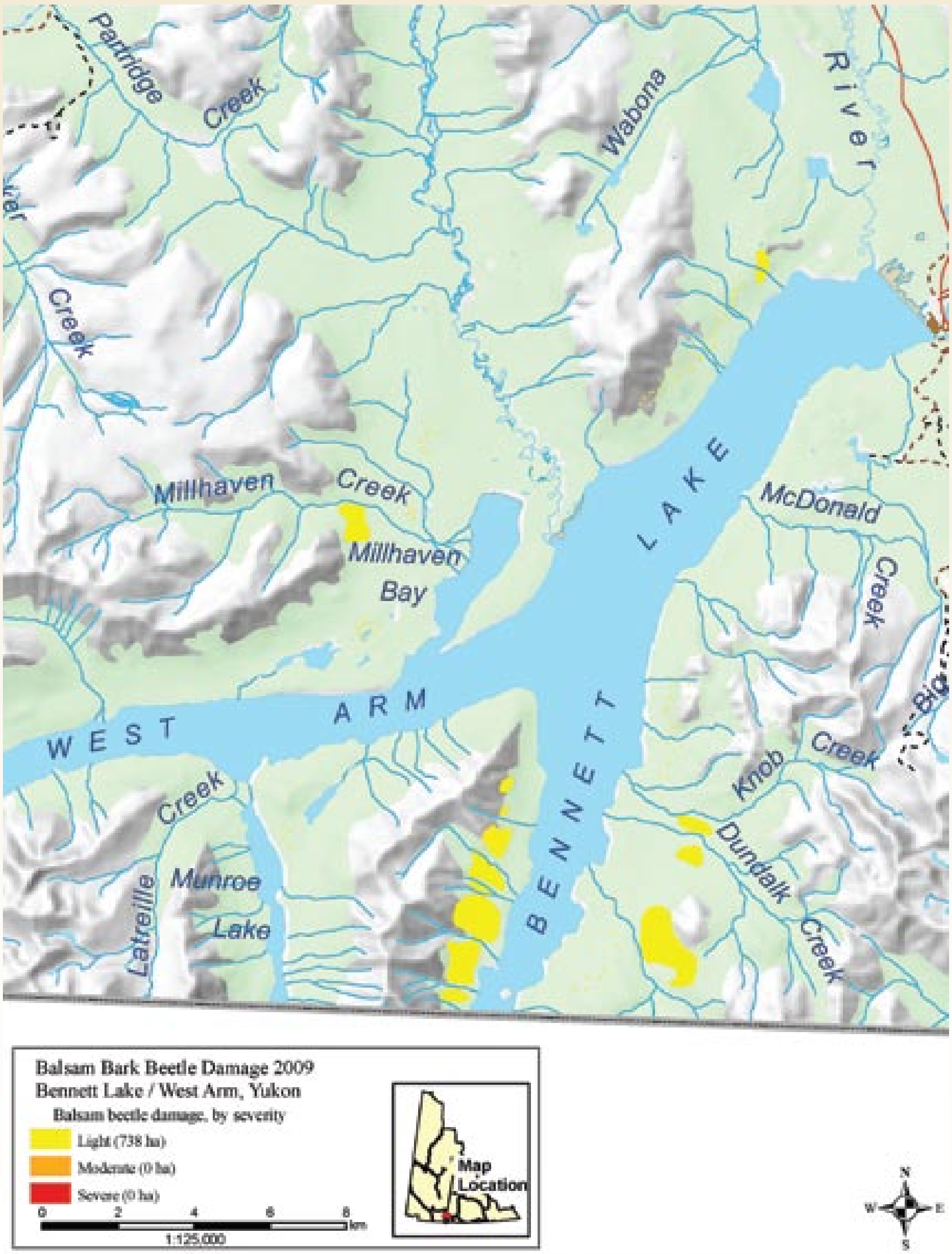


Photo 5. Unusual concentration of attacks by balsam bark beetle above Bennett Lake

Though the damage in Photo 5 appears to be severe, little, if any occurred within the past year. Alpine fir characteristically retain needles up to five years after they are killed by the beetle. Newly-killed trees turn a yellowish-red colour in the year after they are killed and then the colour fades to a dull brick red in subsequent years. Most of the trees in the photo have been dead for three or more years.

The life cycle of the western balsam bark beetle has never been studied in Yukon but in central B.C. it normally takes two years to complete (Stock 1991). Like other bark beetles it carries a pathogenic fungus, *Ceratocysyis dryocoetidis* with which it infects the tree phloem. Studies have shown the fungus is particularly virulent and is responsible for about 65% of the mortality attributed to the bark beetle (Molnar 1965). Attacks normally occur above two meters on the bole (Stock 1991), a characteristic which makes the insect difficult to study. Consequently there is much that is not understood about its life history and biology.

Alpine fir mortality resulting from attack by balsam bark beetle was first recorded in Yukon in 1995 during an aerial survey in the extreme southeast on the south-facing slopes of Mount Martin in the LaBiche River drainage. That it was first detected at that time however, reflects the historical rarity of aerial surveys rather than the recent introduction of the beetle into the area. The presence of grey trees as well as red crowns suggested that the infestation had been active for some time. Balsam bark beetle attacks mapped during the 2009 aerial survey of the same area, though still present as scattered small patches, were much reduced from 1995 levels.

The beetle is thought to have migrated north from B.C. into Yukon in the late 1980s. In 1998 I participated in an aerial survey within Atlin Provincial Park sponsored jointly by the B.C. Forest Service and B.C. Parks. On the steep mountain slopes near the southwest end of Atlin Lake, red trees accounted for as much as 10% of the total stands. This was an almost unprecedented level of attack and indicated a large population that in subsequent years continued to press northward into Yukon. Some of that population may have accounted for the extensive red tree patches mapped in the hills on both sides of Teslin Lake in 2006. Those levels were much reduced this year as only scattered small patches were mapped in the same area.

Aspen serpentine leaf miner, *Phyllocnistis populiella*

Leaf mining of trembling aspen by the aspen serpentine leaf miner was once again widespread throughout surveyed areas of Yukon. Aspen discoloration accounted for about 97% of the total area where disturbances were recorded during this year's extensive aerial surveys. A total of 584 120 ha of defoliation was recorded. This total reflects only those areas covered by the aerial survey and represents only a small fraction of the total area of defoliation in Yukon. Where previously the severity of damage was greatest in stands in the Mayo and Dawson City, severe discoloration was mapped almost throughout the surveyed areas (Photos 6+7) with the exception of the extreme south i.e. the Tagish-Carcross area where infestation levels were significantly lower.

Photos 6 & 7. Discoloration of aspen by the aspen serpentine leafminer near Whitehorse and Dawson

Adult leafminer moths in response to rising temperatures in May emerge from their overwintering sites in the upper organic layer of soil. Following mating, females lay their eggs on expanding aspen leaves. When the eggs hatch tiny larvae enter the epidermal cells of the leaf and commence feeding. Mature larvae emerge from the leaves in mid-July and pupate in a fold at the leaf edge. The tiny moths emerge in late July/early August and fly for a short period before seeking sites to overwinter. Only the surface epidermal cells are consumed while internal mesophyll containing the photosynthetic tissue of the cell remains undamaged. Leaves continue to photosynthesize even after the entire surface cell layer has been consumed. Damage to the tree results from the severely mined leaves being shed, on average four weeks earlier than un-mined or lightly mined leaves (Wagner et al 2008). In severe infestations, the bottom surface of the leaf is mined as well as the top. When this occurs it results in damage to the stomata, the gas exchange organs of the leaf. Without functioning stomata the entire machinery of the leaf, including photosynthesis becomes impeded (Wagner et al 2008) resulting in further decreased growth.

The limited damage to the trees over time despite the severity of feeding can be explained by it's relatively limited impedence to photosynthesis. No aspen mortality has yet been attributed directly to the affects of leafminer activity. However, there is visual evidence, especially in the Mayo/Dawson City area that stand health has been severely affected. In some stands especially dense young stands there has been significant crown thinning and mortality of trees growing beneath the canopy. These effects have been compounded by drought and in some instances by the ongoing impact of past defoliation by the large aspen tortrix, *Choristoneura conflictana*.

Willow blotch miner, *Micrurapteryx salicifoliella*

For the third consecutive year willows were severely defoliated by this tiny blotch mining insect, primarily on low lying boggy sites adjacent to the Yukon, Klondike and Stewart rivers.

Photo 8. Willow discoloration caused by willow blotch miner near the Dawson City Airport

The insect larvae mine extensively below the epidermis within the integument of the leaf, causing large characteristic reddish necrotic blotches (Photo 8). Single or multiple blotches will often cover the entire leaf (Photo 9). When larvae mature in mid July they are approximately 7 mm in length. They exit though small slits cut in the underside of the leaf and migrate, usually to the upper leaf surface where they spin a cellophane-like cocoon. They pupate within this cocoon and emerge as adults in early to mid-August and are thought to overwinter in that stage. In early summer of the following year, the adults lay eggs singly on the newly-flushed leaves and the cycle begins again.

The insect attacks all species of willow with the exception of felt leaf willow *Salix alaxensis* (Furniss et al 2001). It is thought to have migrated up the Yukon River from Alaska where it has caused intermittent extensive defoliation over hundreds of thousands of hectares since it was first seen in 1991. Prior to 1991, it was unknown in Alaska (Furniss et al 2001). It was first identified in Yukon in 2007 near Stewart Crossing but this year was mapped from the air over a total of 2,158 ha. Since first seen, it has continued to migrate southward and this year was seen causing light defoliation of roadside willows just south of Carmacks.

Photo 9. Damage to willow by the willow blotch miner near Dawson

Though some mortality has been reported in Alaska in areas of repeated severe defoliation, mortality has yet to be seen in Yukon. Shoots that have been damaged by the defoliation normally re-sprout in the following year.

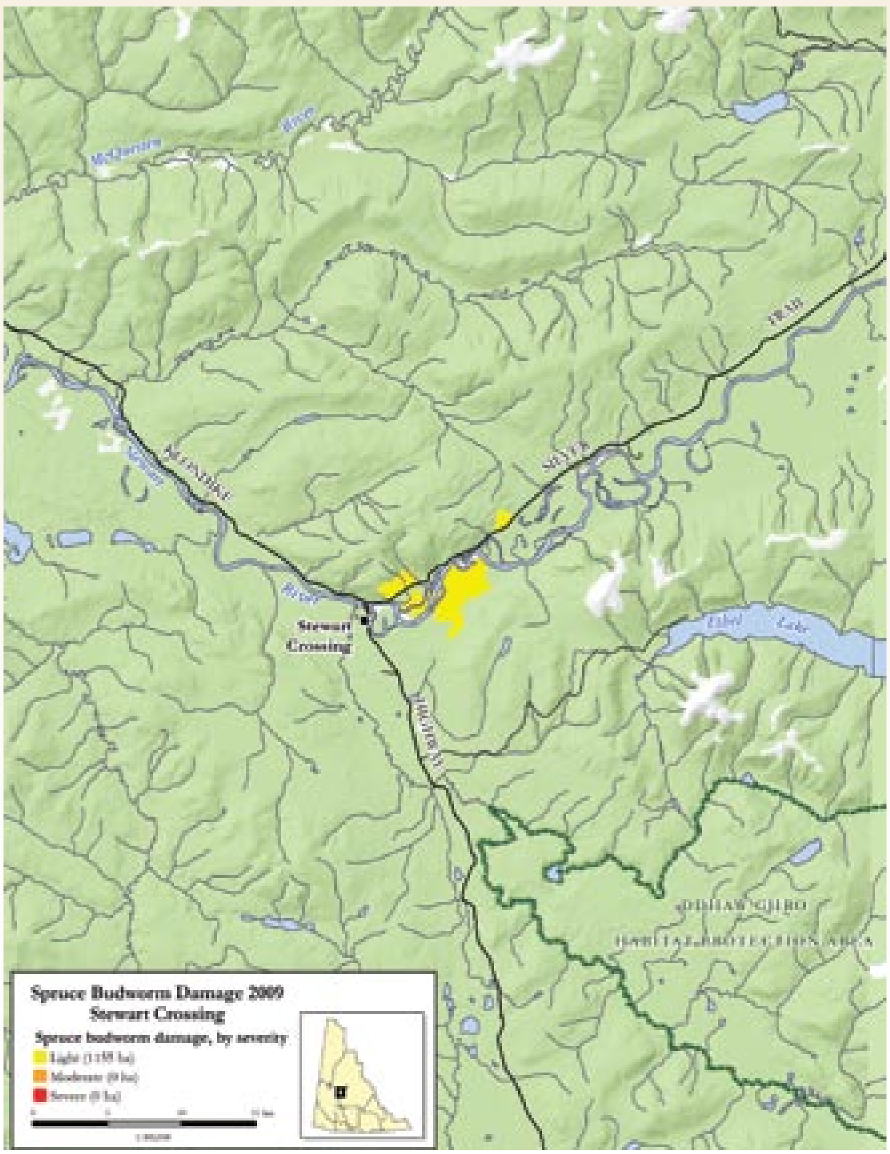
Eastern spruce budworm, *Choristoneura fumiferana*

Light eastern spruce budworm defoliation of white spruce (Photo 10) was mapped over an area of 1,155 ha, just east of Stewart Crossing (Map 6). This was the first time spruce budworm defoliation had been recorded from this area. Historically, significant damage by this insect has been confined to southeast Yukon in the LaBiche and Beaver rivers area and, more recently, in the upper Liard River drainage around Watson Lake, though no damage has been seen in these areas in the past four years. The success of this insect so much farther north is yet another indication of the effects of climate moderation.

The previous July, the parent females of the current generation laid their eggs on spruce needles in the crowns of the trees. The eggs hatched near the end of the month and the tiny first instar larvae did not feed but instead sought shelter in bark crevices where they spun a small cocoon-like web enclosure called a hibernacula. At the onset of winter the larvae 'winterized' by replacing the water in their cells with ethylene glycol (anti-freeze) as protection from winter cold. Emergence of the larvae from hibernacula was timed to the swelling of the buds in the following spring. At this time, they had rehydrated their tissues and were vulnerable to late spring frost which was probably the main factor limiting their past success. In the past these frost events were so common and severe that they often caused the death of newly flushed needles. The death of these needles was in the past one of the most frequently reported types of forest damage.

On August 16, we accessed the infested stand by helicopter to collect samples for egg mass counts. The number of egg masses per unit area laid on the underside of needles would help us determine the health of the budworm population, and predict the level of defoliation that could be expected in 2010. The sampling protocol, developed by the Canadian Forest Service, required the collection of two 45 cm long branches from the mid-crowns of each of 10 trees. Without access to specialized telescoping pole pruners we had to fell the trees in order to sample mid-crown branches. After felling two trees and finding no egg masses we decided against felling the remaining eight because it was evident that the budworm population was in decline, if not complete collapse. The remaining population will likely be too small to cause noticeable defoliation next year.

Map 6. Eastern spruce budworm defoliation mapped near Stewart Crossing



To reduce the trees attractiveness to secondary bark beetle such as spruce beetle and spruce engraver beetle, the bark was removed by chainsaw in alternating strips and the trees were than bucked into short lengths to promote drying (Photo 11).

Photo 10. Spruce budworm defoliation near Stewart Crossing

Photo 11. Peeled and bucked logs from budworm infested trees to prevent bark beetle attack

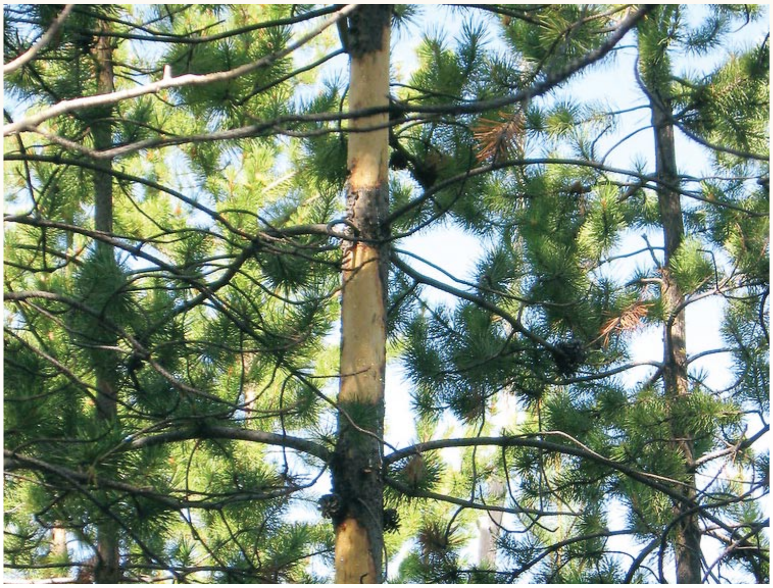
Porcupine, *Erethizon dorsatum*

Damage to primarily young lodgepole pine attributed to porcupine feeding was seen in numerous areas within Zone 1a but was concentrated primarily in two areas. The first area was mid-slope on Flat Top Mountain, just north of Whitehorse where severe tree mortality was mapped at several locations totalling 9 ha in area (Map 7, Photos 12 & 13). The second area comprised scattered light mortality over approximately 40 ha on the lower slopes of White Mountain near Little Atlin Lake. Both areas were accessed by helicopter in late summer to confirm the causal agent. Both were rocky mountain slopes, favoured by porcupines for the abundance of potential denning sites. Areas like these allow for the relatively large populations that are required to cause the degree of damage observed this year. Additional pine mortality attributed to porcupine feeding (but not confirmed by ground checks) was limited to scattered individual and small groups of trees mapped in several additional areas within Zone 1a, including the Takhini Lake area southwest of Whitehorse and east of Whitehorse near the Teslin and Nisutlin rivers.

In the winter, when their favoured foods are scarce, porcupines feed on the inner bark of the trees. Some of the trees are girdled by the feeding and subsequently die. Feeding damage was also observed to a lesser extent on white spruce, willow and aspen.

Map 7. Areas where porcupine feeding killed lodgepole pine

Photos 12 & 13. Young pine killed by porcupines near Flat Mountain, northwest of Whitehorse



Yellowheaded spruce sawfly, *Pikonema alaskensis*

This insect is a native defoliator of white and black spruce throughout the host range across Canada (Mason and Huber 2001). For the first time, in the summer of 2009 defoliation by this sawfly was recorded on ornamental white spruce planted in two areas of downtown Whitehorse. All trees were in the sapling stage of growth. Damage ranged from light to severe (Photo 14) with the smallest trees sustaining the greatest damage. This pest has commonly caused similar damage in northern cities across the continent, most notably Anchorage Alaska and Edmonton and Calgary Alberta.

Sawfly larvae feed in groups, and consume most or all of the new foliage before consuming the older foliage. Damage to young trees is often magnified because the new foliage accounts for a high proportion of the overall crown. In late summer, larvae spin cocoons in the soil at the base of the tree where they overwinter. Pupation occurs in the spring and adults emerge in June to mate and lay eggs in slits cut in the newly flushed needles.

Damage to the trees from larval feeding will vary with the degree of defoliation. One of the severely defoliated trees in downtown Whitehorse lost more than 80% of its foliage and may not survive. Other affected trees sustained only light damage, losing most of their current needles but will recover. Longer term consequences will depend upon whether there is a repeat of defoliation in 2010. The trees will be inspected in June for the presence of larvae. If found in the smaller trees, the larvae can be physically removed and destroyed. In the larger trees the application by spray of an insecticidal soap will help to control insect populations. Populations can be both assessed and controlled at the stage of development 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 than be collected, counted and destroyed. This method can also serve as a check on the efficacy of other control efforts.

Photo 14. Spruce sawfly defoliation on the bank of the Yukon River, Whitehorse

Pine needle cast, *Lophodermella concolor*

There was no repetition this year of the widespread defoliation caused by this needle disease in 2008. No current defoliation was mapped anywhere in the aerial survey coverage area which included all areas where defoliation was recorded in 2008. The drop can be attributed to the relatively dry conditions that prevailed this year preventing the passing of infectious spores to current needles at the time of bud break on the pine trees. Spore transfer is facilitated by the splash of raindrops on spore laden year-old needles.

During the aerial survey of area 1 this year, a number of young pine stands were mapped, particularly in the Little Atlin Lake area, that displayed an unusual reddish hue (Photo 15). Later ground checks found this to be due to the red needles from last year's infection that had been shed from the trees and covered the ground beneath them. Other instances were mapped at Minto where significant needle cast defoliation was recorded in 2008, and in numerous young pine stands around Stewart Crossing and Mayo.

Photo 15. Reddish hue near Little Atlin Lake from shed pine needles infected with pine needle cast in 2008

Pests of minor significance

Birch leafroller, unidentified

Rolled birch leaves were common in all age classes of birch at two locations. An average of 40% of birch leaves were rolled in scattered stands of primarily young trees in the hills just northwest of Whitehorse. Similar damage, but to a slightly lesser extent, affected all age classes of birch on the Midnight Dome at Dawson City (Photo 16). The damage in both of these areas was confirmed by ground visits. Thinned birch crowns attributed to leafrollers were also mapped from the air just southeast of Beaver Creek but these were not confirmed from the ground. By the time ground surveys were done in late July and August the insect had completed its life cycle and could not be identified, though it is likely that either the birch-aspen leafroller, *Epinotia solandriana* or the obliquebanded leafroller, *Choristoneura rosaceana* were responsible. Both of these insects commonly feed on both birch and trembling aspen, yet the aspen in both of these areas remained unaffected. This was likely because of prior infestation by the aspen serpentine leafminer.

By rolling the leaves the insect larvae are afforded some protection from predators and the elements while feeding on the leaf surface within the roll. Some minor photosynthetic capacity is sacrificed to the insect but overall, damage is negligible.

Photo 16. Rolled white birch leaves on the Midnight Dome, Dawson City

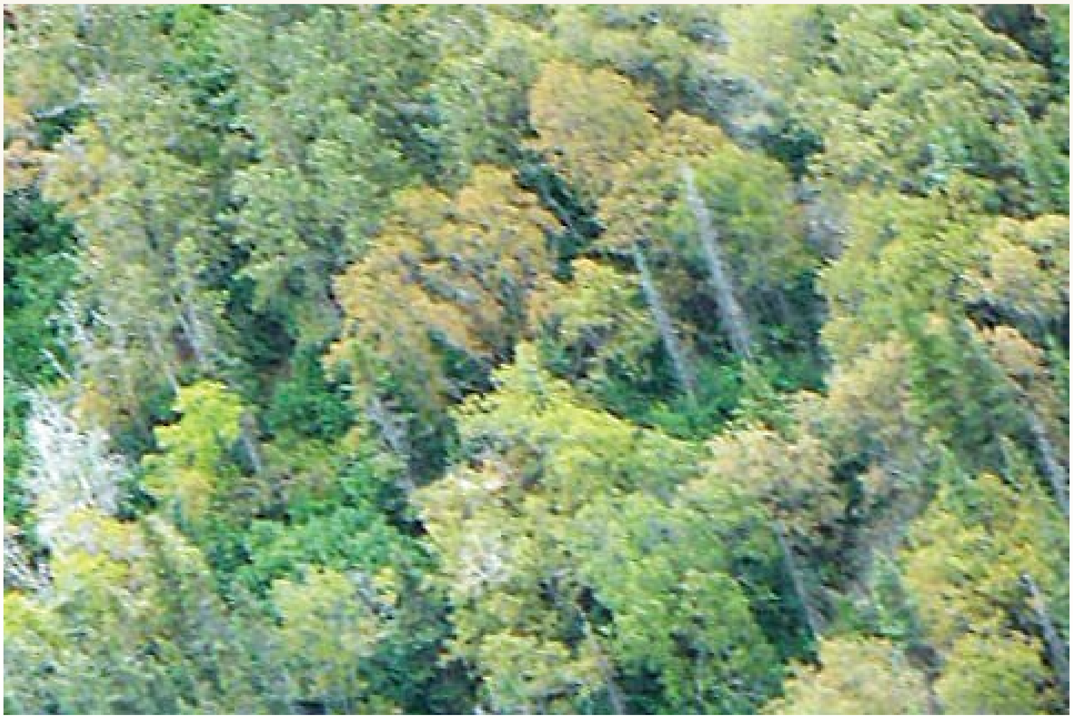
Willow blotch, possibly caused by the birch-willow blotch miner, *Lyonetia saliciella*

Severe willow discoloration was mapped from the air on the shore of Bennett Lake in mid July during the fixed-wing aerial survey. The site was accessed by helicopter later in the month, but by that time the causal insect had completed its life cycle and was not seen. The damage resembled that caused by the earlier described willow blotch miner (Photo 17) but the scene was far removed from that more northern infestation, and larger species such as Scouler willow, *Salix scouleri* and white willow, *Salix alba* were affected (Photo 18).

The birch-willow blotch miner is common farther south in B.C. but is known more as a defoliator of white birch rather than of willow species. Positive species identification will be attempted by an earlier site visit in 2010, if the damage recurs.

Photo 17. Damage caused by unidentified blotch miner at Bennett Lake in southern Yukon

Photo 18. Defoliation of willow by unidentified blotch miner at Bennett Lake



European rosette gall midge, *Rhabdophaga rosaria*

The distinctive rosette in Photo 19 was formed on a what appears to be felt leaf willow, *Salix alaxensis* in response to attack by a tiny midge, or fly. The female midge, lays its eggs in a willow bud. The willow forms the roseate gall in response to the attack, presumably in an effort to isolate and contain the irritant. Instead it forms a protective chamber in which the midge larvae can feed and complete their life cycle. The insect was presumably introduced from Europe and now can be found throughout North America, though it is much more common in the north where there is an abundance of susceptible host.

Photo 19. Distinctive rosette on willow sp. caused by the European rosette gall midge

Abiotic Damage

Drought

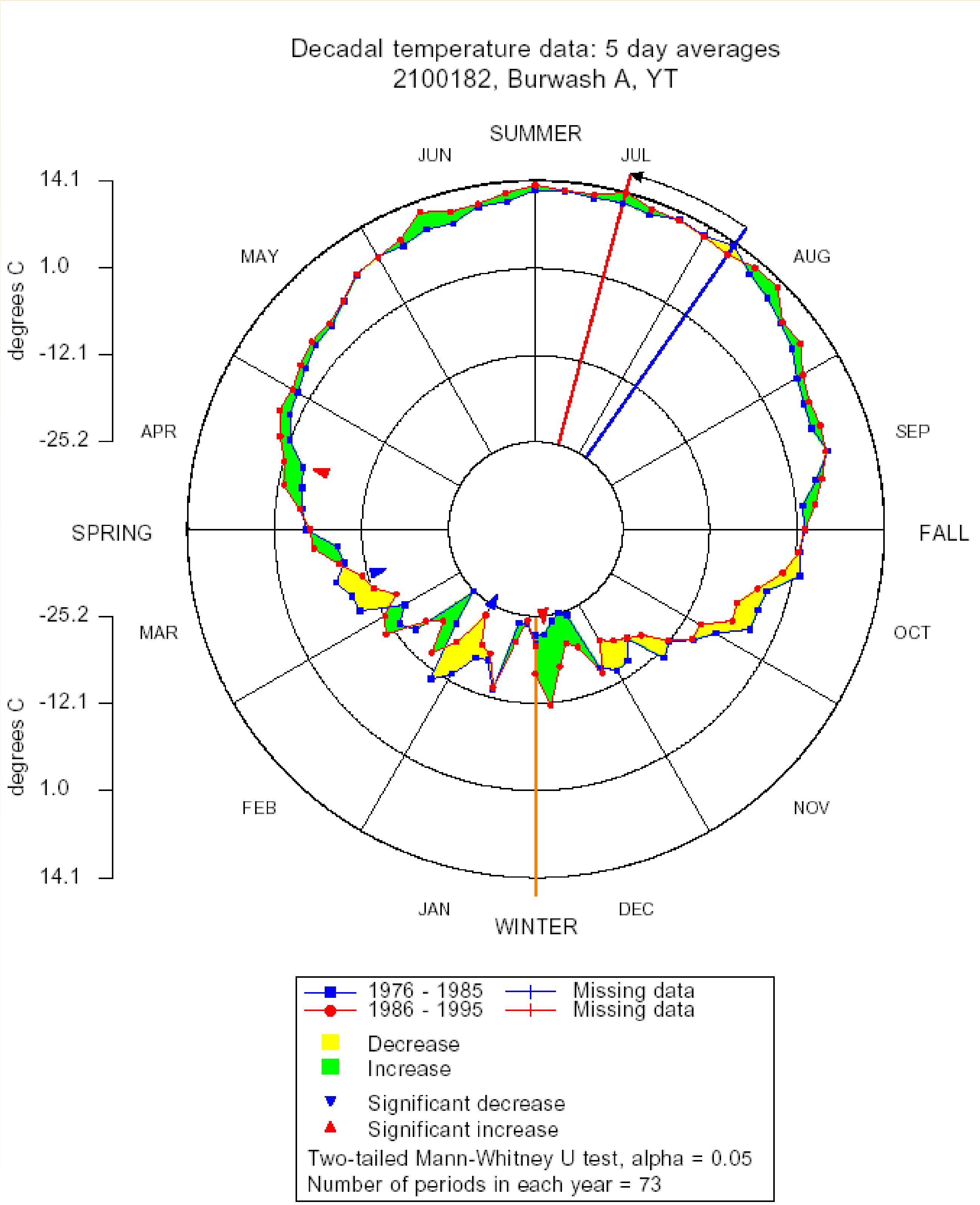
Despite the recent impact of forest pest activity on Yukon forests, one thing that has not changed is that the over-riding driver of forest health in Yukon remains the extremes of the northern environment. What has changed, however, is that drought has replaced winter cold as the most important environmental driver. Drought was the silent stressor that triggered the unprecedented spruce beetle infestation that began in 1990 and continues today. It has more recently killed spruce in scattered stands along the Yukon, White (Photo 20) and Stewart rivers south of Dawson. Opportunistic bark beetles, including the northern spruce engraver and to a lesser extent the spruce beetle, attacked stressed trees in this area in 2006 and 2007. However, by 2008 populations had largely collapsed. The cool wet spring and summer of 2008 brought a temporary end to the drought and no recent drought induced mortality was mapped during the recent aerial surveys.

Determining the onset of drought stress is not simply a matter of reviewing rainfall in the weather records. Rainfall did not change significantly in the two decades 1975-85 and 1985-95 (Whitfield 2001). However, during this time temperatures during the growing season did increase significantly (Whitfield, 2001) (Figure 1), especially in the early spring and mid winter. The increase in temperatures, in turn, increased the rate at which trees transpired (i.e. lost moisture). With there being a limit beyond which the already chronically dry soils in Yukon are unable to replace that moisture, drought stress ensued (Dr. Ed Berg pers. comm.). Recent climate moderation has had a magnified impact on northern forests both because the changes have been more acute than areas farther south and because Yukon forests already exist at the edge of climatic habitability.

It is too early to state categorically whether the increase in activity of other formerly quiescent or altogether absent forest pests such as balsam bark beetle, aspen serpentine leafminer or the willow blotch are directly related to climate moderation. It seems clear however that we have entered a new period of change in pest activity, and that continued trends in climate change will probably result in more surprises and less predictability in the future.

Photo 20. Drought-killed spruce on hillsides above the White River near the confluence with the Yukon River

Figure 2. Graphic representation of average temperatures at Burwash over two decades, 1976-1985 and 1986-1995. From Paul H. Whitfield, Environment Canada Meteorological Service



Drought-caused "flagging" in white spruce and lodgepole pine

Though drought-caused branch loss was not severe and was not mapped from the air it was common in spruce and pine in many stands throughout areas that were ground surveyed this year. It was a response to the unusually hot and dry spring and summer weather. Red branches were seen in all age classes but were most prominent in young stands, particularly in the Mayo area, and between Carcross and Tagish (Photos 21 & 22).

It is primarily a conservation mechanism that trees employ to reduce crown volume and moisture loss during periods of stress. The reduction of crown mass would likely limit the current growth potential of the trees but, unless the drought was prolonged over successive years, would have little long term impact on stand health.

Photos 21 & 22. Flagging on young roadside spruce and pine branches between Carcross and Tagish

Flood

At the opposite extreme, high snow packs in 2007 and heavy rains in 2008 resulted in unusually high water along many creeks and rivers and on the edges of some lakes. In many cases the water spilled into adjacent stands of timber smothering the roots of, mainly white spruce trees and causing the trees to die. Flood-caused mortality was mapped from the air at many locations throughout the surveyed parts of the Territory. Most of the incidences of mortality involved small patches of trees at the bend of a water course but around some southern lakes and Marsh Lake in particular with adjacent low-lying land, the damage was much more widespread. Flood damage and subsequent secondary bark beetle activity around the Village of Tagish is described in a supplement to this report. Also on Marsh Lake significant stands of spruce were killed at the Army Breach subdivision and near the outlet of the Yukon River. Farther downriver at Whitehorse most of the willow brush was flood-killed on islands in the river (Photo 23). Significant mortality involving spruce, pine and willow was also mapped on the edge of Nares Lake at Carcross.

Photo 23. Flood-killed willows on islands in the Yukon River at Whitehorse

Red Belt

An elevational band of lodgepole pine foliage discoloration known a “red belt”, was mapped from the air on south-facing slopes near the LaBiche River in southeast Yukon (Photo 24). This is a phenomenon normally associated with temperature inversions. It occurs in the late winter and early spring and is thought to result from unusually warm temperatures that sometimes occur during inversions. The warm temperatures induce the trees to become physiologically active and lose moisture through transpiration. Because soil moisture remains bound in the frozen soil the water cannot be replaced and desiccation results. This is a temporary condition resulting in the loss of some foliage but trees normally recover quickly.

Photo 24. Red belt affecting lodgepole pine near the LaBiche River

Balsam poplar decline

Though neither an insect, disease or environmental disturbance, the decline of balsam poplar was mapped from the air in numerous locations during the aerial survey. This, purely physiological condition affected mature and over-mature poplar growing beside or on islands in major water courses. The most significant examples covered an area of nearly 2,000 ha in numerous stands near Beaver Creek. Up to 30% of trees in some stands were standing dead and the remaining trees supported thin crowns and top dieback. Most of the damage was in stands beside Beaver and Snag creeks (Photo 25). Similar but less damage was mapped along the Pelly River near Faro.

Photo 25. Balsam poplar decline beside Beaver Creek.

Landslides

Stands that grow on steep mountain slopes are sometimes subject to the forces of gravity, especially when the soils that support them become saturated by snowmelt or heavy rains. Recently some slope failure could also likely be attributed to the ongoing melting of perma-frost. A number of instances of slide damage were recorded in mountainous areas during the aerial survey, principally in the Cassiar Mountains east of Whitehorse (Photo 26).

Photo 26. Creekside slide cut a swath through a white spruce stand in the Cassiar Mountains

Windthrow

Windthrow has never proved to be a significant cause of tree mortality in Yukon. The results of the aerial survey confirmed this as only small patches of mainly white spruce blow down were mapped in scattered stands throughout the surveyed area. None of the affected stands was more than 10 ha in size and none of the damage was recent.

Report on Forest Health Ground Surveys

Monitoring the Northward Movement of the Mountain Pine Beetle *Dendroctonus ponderosae* - Bait Trees

Yukon is concerned about the northward expansion of the range of the mountain pine beetle (MPB) 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. In the summer of 2009 a series of 15 mountain pine beetle 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. No mountain pine beetles were attracted to the bait trees.

This year's results will serve as a baseline for future trap studies at the same sites.

Table 3. Mountain Pine Beetle Pheromone Bait Tree Locations

Site	Zone	Easting	Northing	DBH (cm)	Plot Type	General Dirstict Location
Bd1-1	9	459804	6669420	21	Triangle	Watson lake
Bd1-2	9	459790	6669381	34	Triangle	Watson lake
Bd1-3	9	459772	6669401	27.5	Triangle	Watson lake
Bd2-1	9	502290	6657034	27.2	Triangle	Watson lake
Bd2-2	9	502245	6657029	31.6	Triangle	Watson lake
Bd2-3	9	502266	6657066	25.2	Triangle	Watson lake
Bd3-1	9	567473	6652627	36	Triangle	Watson lake
Bd3-2	9	567518	6652618	29.5	Triangle	Watson lake
Bd3-3	9	567469	6652610	30.3	Triangle	Watson lake
Bd4-1	9	570557	6652345	28.5	Triangle	Watson lake
Bd4-2	9	570545	6652355	26.5	Triangle	Watson lake
Bd4-3	9	570555	6652376	20.9	Triangle	Watson lake
Bd5-1	9	556565	6648577	26	Triangle	Watson lake
Bd5-2	9	556614	6648591	29.5	Triangle	Watson lake
Bd5-3	9	556801	6648560	26.3	Triangle	Watson lake
Bd6-1	9	545095	6646792	29	Triangle	Watson lake
Bd6-2	9	545115	6646829	31	Triangle	Watson lake
Bd6-3	9	545148	6646802	21	Triangle	Watson lake
Bd7-1	8	651683	6659102	28	Triangle	Teslin
Bd7-2	8	651720	6659087	27.5	Triangle	Teslin
Bd7-3	8	651672	6659014	33.8	Triangle	Teslin
Bd8-1	8	552695	6688194	24	Triangle	Southern Lakes
Bd8-2	8	552666	6688223	24.5	Triangle	Southern Lakes
Bd8-3	8	552647	6688177	21.6	Triangle	Southern Lakes
Bd9-1	8	534263	6676913	37.6	Point	Southern Lakes
Bd10-	8	565685	6663479	28.3	Tandem	Southern Lakes
Bd10-2	8	565711	6663486	23.8	Tandem	Southern Lakes
Bd11-1	8	565717	6657350	34.5	Tandem	Southern Lakes
Bd11-2	8	566737	6657317	35.4	Tandem	Southern Lakes
Bd12-1	8	507368	6700889	39	Tandem	Southern Lakes
Bd12-2	8	507325	6700895	29.4	Tandem	Southern Lakes
Bd13-1	8	619999	6675619	35	Tandem	Teslin
Bd13-2	8	620009	6675673	29.6	Tandem	Teslin
Bd14-1	8	598092	6702532	30.5	Tandem	Teslin
Bd14-2	8	598144	6702545	25.4	Tandem	Teslin
Bd15-1	8	597076	6703629	27.4	Tandem	Teslin
Bd15-2	8	597089	6703684	34.9	Tandem	Teslin

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YUKON
FOREST HEALTH REPORT 2009
SUPPLEMENT

Pest Risk Analysis of Flood Damage and Subsequent Infestation of White Spruce by Bark Beetles Near Tagish

Yukon
Energy, Mines and Resources

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Tagish Pest Risk Analysis

Introduction

This report is about the Yukon Forest Management Branch's Pest Risk Analysis of the beetle infestation resulting from the Tagish flood.

In the summer of 2008, during a roadside survey, many dead and dying white spruce were seen within the Carcross Tagish First Nations Campground at Tagish. At that time it was evident that the area had experienced significant flooding in the spring, and, by late August there was still standing water in the low-lying areas. A brief reconnaissance survey by Canadian Forest Service (CFS) and Forest Management Branch (FMB) personnel found many of the trees to be infested by the spruce engraver beetle, *Ips perturbatus*, and, to a lesser extent, by the spruce beetle, *Dendroctonus rufipennis.* At the time the infestation was discovered it was too late to attempt mitigation as the engraver beetle broods had matured and were emerging from the trees in preparation for over-wintering in the upper organic layer of the forest floor. FMB therefore decided to survey the area more extensively in 2009 and photograph and map the extent of flood damage within the Campground and any other areas in the vicinity that may be similarly affected.
On the basis of on-site analysis of bark beetle attack frequency and population densities, FMB would then decide if treatment was necessary to mitigate the future threat of infestation.

Since the late 1980s, significant climate moderation has placed the forests of Yukon under increasing threat of attack by both of these beetles, acting both independently and in concert with one another. Under National Forest Pest Strategy guidelines both pests are subject to a Pest Risk Analysis (PRA), a formalized process for the management of existing and potentially threatening forest health issues. The process is broken into four separate phases;

1. **Initiation phase** where the forest health issue are identified and questions are posed as to what is at risk;
2. **Assessment** phase during which surveys are methods discussed and survey results determine the future risk;
3. **Response** phase where management decisions are made and mitigation procedures carried out;
4. **Communication** phase where the results of the PRA are communicated to all parties directly or indirectly affected.

The flood damage and subsequent beetle infestation at Tagish is the first such forest health issue for which the Pest Risk Analysis template has been formally applied. This report, in part, constitutes the **Communication** phase of the PRA.

1. Initiation

This phase began in 2008 with the recognition of bark beetle infestation resulting from 2007-2008 flood. The flooded area at the campground was identified to have many of the flooded trees infested with the spruce engraver beetle, *Ips perturbatus*, and, to a lesser extent, by the spruce beetle, *Dendroctonus rufipennis*.

Photo 1 Flood damage in Tagish campground

Determining the risk or threat

The initiation phase is where the questions are posed.

What is the probability of continued infestation of bark beetles from the flooded areas?

Spruce beetle and spruce engraver beetles behave normally as secondary bark beetles, attacking trees recently killed or under stress. If, through a disturbance such as the flood at Tagish, an abundance of suitable host material becomes available, both species are capable of breeding in this material and then emerging as a much greater population to attack adjacent healthy trees.

What are the values at risk?

The flooded area and adjacent surroundings are comprised of mature spruce forested lands which can be available host material for bark beetles. The area was determined to have high socio-economic values, because of the proximity to both private and commercial properties as well as First Nations settlement lands and crown lands.

Due to the potential threat of continued infestation to Yukon Government, Private/Commercial and First Nations Settlement lands, FMB initiated a PRA of the Tagish Campground and adjacent flooded areas in the summer of 2009.

Study Area

In July 2009 the areas of flood damage were mapped and photographed from the air (Map 1). The flood damage was recognized at that time to be far more widespread than was initially seen the previous year, with additional larger areas of tree mortality south of the campground and on the west side of Marsh Lake.

During the aerial survey eight discrete areas of mortality were mapped and, for reporting purposes, have been numbered 1 through 8 (see Map 1). The site locations are listed below:

Map 1. Study Area showing Flooded Area's

Table 1. Tagish Flood

Area Number	Location of Flood Area	Flood Area in Hectares (ha)
Area 1	Tagish Campground	2 ha
Area 2	West Side of Marsh lake, northern portion	14 ha
Area 3	East Side of Marsh lake, southern portion	17 ha
Area 4	Km 2 Pennycook Lane	1 ha
Area 5	Km 4 Pennycook Lane	0.6 ha
Area 6	Km 2 Pennycook Lane	9 ha
Area 7	Km 2 Pennycook Lane	3 ha
Area 8	Km 2 Pennycook Lane	0.5 ha

2. Assessment

From the mapping we knew the extent of the flood damage but we did not yet know the extent to which flood-damaged trees had become host to resident populations of spruce bark beetle and northern spruce engraver, and what risk these populations posed for ongoing mortality. Initially the greater concern was the engraver beetle because their population cycles in a single year. The 2008 reconnaissance had found some of the flood-killed trees to be heavily infested, and brood production was high. If these broods survived the winter we could have witnessed up to a tenfold increase in the population. Spruce beetle was less of an immediate concern because last summer's cool wet weather would almost surely have confined them to their normal two-year cycle. The 2009 spruce beetle population would therefore have been limited to those that survived attack in 2008 and remained in the trees as maturing brood, as well as current attacks by local populations drawn in from mature spruce stands in the surrounding area.

With co-operation from the Carcross Tagish First Nation, surveys were conducted in mid- August.

Method of survey

The beetle population assessment survey comprised of two elements:

- Attack frequency i.e. numbers of successful attacks per tree
- Attack success i.e. number of living progeny (offspring) per attack

These two parameters comprise a decision matrix, used to determine the risk of continued infestation. They are summarized in Table 2.

The number of successful attacks per tree[1] and the number of progeny per attack[2]
= Probability of continued infestation

Table 2. Criteria for determining probability of continued infestation

Attack frequency[1]	Progeny success[2]	Probability of continued infestation
very low 0 - 5	very low	nil
	low	nil
	moderate	very low
	high	very low
low 5-11	very low	nil
	low	very low
	moderate	low
	high	moderate
moderate 11-25	very low	very low
	low	low
	moderate	moderate
	high	high
high 25+	very low	very low
	low	low
	moderate	high
	high	very high

[1]attack frequency = average number of successful attacks per tree

[2]progeny success = average number of living progeny per attack

< 4 = very low
4-8 = low
8-15 = moderate
15+ = high

Surveys would involve examining spruce trees for any signs of current attack; indicators of current attack on spruce trees in the flooded areas were identified mainly by pitch tubes (photo2), and boring dust (photo 3). Once the current attack trees were identified then the bark was peeled at the entrance holes and examined for any presence of living progeny (larvae, pupae, or young adult beetles) The decision matrix (see table 2) was then utilized to determine the probability of further infestation.

The results of the surveys would determine which of two management options would be pursued in the response phase:

1. Implement active control measures to mitigate future risk.
2. Take no action but continue to monitor in the future.

Because of the values at risk the parameters were set conservatively with "very low" risk of continued infestation being the only acceptable outcome for implementation of Management Option 2.

Photo 2. Pitch tubes- Indicator of beetle attack. The tree's defense mechanism is to attempt to pitch out the beetle by flooding the point of attack with resin. NOTE dark color of pitch tube is the frass and boring dust resulting from the beetle successfully boring into tree.

Due to the high socio-economic significance of the Campground (Area 1) we decided, to examine all living and dead white spruce within its boundaries and determine the identity and size of the brood within infested trees. Roadside reconnaissance surveys were also conducted along Pennycook Lane at Areas 4, 5 and 6 (see Map 1, Table 1). Infested trees were found in Area 4, and, because it was only one hectare in size, it was surveyed with the same intensity as the Campground. No insect attacks were seen at sites 5 and 6. The largest areas of mortality, Areas 2 and 3, were located on the west side of Marsh Lake and accessed by boat. Access along the west shore of the Lake proved impossible because of deep, wide marshes, but at the south end of both areas were deep inlets that were bounded at some points with drier ground. These access points arbitrarily determined the commencement of the walkthrough survey. This proved beneficial because the largest and most attractive (to the beetles) trees were found on these relatively drier sites. Results of the 100% surveys of Areas 1 and 4 as well as the walkthrough surveys of Areas 2 and 3 are detailed in the appendix section.

Photo 3. Boring dust at base of tree -Indicator of beetle attack

Results from Surveys

Area 1, Tagish Campground

In the spring of 2008 the deep ditch between the road and the Campground was not able to adequately handle the extreme runoff in the spring of 2008, and overflowed into the Campground. Water up to one-half meter deep covered about half of the four hectare area for up to two months, smothering the roots and killing an estimated 2400 trees (Photo 4). Aside from spruce beetle broods retained in the flood-killed trees from last year our concern centred on adjacent green trees that were stressed but not killed by the standing water. These trees were vulnerable to attack by the build-up of engraver beetle populations from last year's attacks as well as to spruce beetle populations from stands up to a few kilometers distant that were attracted to the chemical signals of stress.

Photo 4. White spruce mortality within Tagish Campground

Table 3. Summary of Results from Tagish Campground (2ha)

Type of Survey	# of Tree's Assessed and # of Tree's Attacked	Attack Frequency	Progeny Success	Probability of continued infestation
100% survey All trees examined for current attack	2400 tree's assessed 31 tree had current attack	very low - low 3-6 attacks per tree	very low - low < 4-8 larvae or pupae per attack	nil- low risk

Survey Results

Almost all of the recent attacks were caused by spruce beetle, most of which (87%) had been attacked in June of the current year. The remainder had been attacked in 2008. Of the 31 (.19% of stand trees) successfully attacked trees, 75% of the attacks were v. low in frequency and 25% were low. Many of the 2009 spruce beetle attacks were unsuccessful (Photo 5). Some (Photo 6) were initially successful but the broods fails to mature .The fact that no pupal chambers were developed is evidence that the broods failed to mature. Brood survival ranged from v. poor to moderate (Photo 7).

The unusually warm summer had accelerated brood development in four (13%) of the earliest-attacked trees, and, at the time of the survey they had reached the pupal stage. These progeny along with the progeny from the 2008 attacks will mature and fly in June of 2010. Larval broods in the remaining majority of 2009-attacked trees will cycle in the normal two years and will not mature until 2011. This mixed cycling will result in a fragmentation of the population and lessen the chance of ongoing successful attacks.

When attack frequencies and brood numbers were applied conservatively within the matrix (Table 2), even without population fragmentation and mitigation, the threat of ongoing infestation was determined to be very low.

It became evident early in the assessment that little of the engraver beetle brood had survived the winter. Engraver beetle broods mature in mid-late August and crawl down the outside of the bark and bury themselves in the upper organic layer of the forest soil. There they spend the next nine months, before emerging the following June to attack a fresh host. It is during this prolonged period of inactivity that they are most vulnerable to disease and predation by other soil inhabitants. The poor survival was, perhaps, due to the prolonged high water table that continued to saturate the duff after the surface water receded. Such a condition would have encouraged the proliferation of fungi that possibly proved pathogenic to the overwintering adult beetles. As a result very few engraver beetle attacks were seen this year.

Photo 5. Unsuccessful spruce beetle attacks
NOTE no larvae galleries formed only a partially developed parent gallery

Most of the trees that were attacked by spruce beetles this year died in the summer of 2008. This was unusual as the beetle normally prefers trees that are either freshly-killed or under stress. The explanation lies in the manner in which they were killed. Ordinarily, in the months following death, trees lose moisture rapidly. Because of their normal two-year life cycle spruce beetles have evolved to attack only trees with sufficient moisture to sustain their tender larvae, which would become desiccated in an overly-dry environment. In the case of flood-killed trees the problem was an over-abundance of moisture and tree desiccation was less of a factor. This, coupled with the wet cool summer of 2008, delayed the drying of the trees to such an extent they were still attractive to the beetles in 2009.

To view the data from Area 1, see Appendix 1

Photo 6. Successful attack with initial larval gallery establishment, broods failed to mature NOTE no pupal galleries.

Photo 7. Spruce beetle pupae. A rare case of moderate brood survival

Area 2: West Side of Marsh Lake (north)

Mortality was mapped over an area of 14 ha along the low-lying western fringe of the Lake (Photo 8). Last year's flood was a direct result of unusually high lake levels in the spring and summer of 2008 and much of the northern end of this narrow strip was still flooded at the time of the survey. The assessment targeted the largest area of mortality at the south end where there was a dominant component of large white spruce mixed with a smaller component of trembling aspen. This was a mature stand with large widely-spaced trees on a rich site. More than half of the spruce and all of the aspen had survived the flood. A total of 50 living and dead white spruce were examined for signs of beetle attack.

Photo 8. Most of areas 2 and 3; West Side of Marsh Lake

Table 4. Summary of Results from West Side of Marsh Lake north Area 2 (14 ha)

Type of Survey	# of Tree's Assessed and # of Tree's Attacked	Attack Frequency	Progeny Success	Probability of continued infestation
walk thru sampled a portion of area	50 trees (living and dead) were assessed 12 trees current attack 4 by spruce beetle 2 by northern spruce engraver 6 by secondary beetles (Scolytus)	very low <5 attacks per tree	very low Brood survival of spruce beetle was very low Found secondary beetles (Scolytus) which pose no threat	nil- very low Risk

Survey Results

Approximately 30% of the white spruce in this area remained green. None of the green trees had been attacked. All attacks were in red trees killed by the 2008 flood. Of the 50 trees assessed, four (8%) were attacked by spruce beetle with <5 attacks at the base (v.low frequency).

Brood survival was low. One tree had been unsuccessfully attacked in 2008. Current engraver beetle attacks were found in two (4%) additional trees, one at low levels and the other moderate. One tree had been heavily attacked by engravers in 2008 with a high degree of brood success. These broods had not survived the winter. Four additional trees were infested by other secondary scavenger beetles like *Scolytus* and also contained woodborer larvae. Scavengers attack only dead trees and do not pose a future threat. The bark beetle populations pose a very low risk of ongoing infestation.

To view the data from Area 2, see Appendix 2.

Area 3: West Side of Marsh Lake (south)

This 17 ha area was more-or-less continuous with the northern portion, broken only by a narrow inlet off the Lake (Photo 8). We accessed the southern end via another deep inlet that took us to higher drier ground. The stand was dominated by white spruce with scattered pockets of pure trembling aspen. The trees were smaller and the stand more dense that the northern portion. A total of 80 living and dead trees were assessed for signs of beetle activity.

Table 5. Summary of Results from West Side of Marsh Lake north Area 3 (17 ha)

Type of Survey	# of Tree's Assessed and # of Tree's Attacked	Attack Frequency	Progeny Success	Probability of continued infestation
walk thru sampled a portion of area	80 trees (living and dead) were assessed 11 trees lightly attacked by spruce beetle with ips 3 by ips alone 12 trees by secondary beetles (Scolytus)	very low <3 attacks per tree	very low Brood survival of spruce beetle was very low Found secondary beetles (Scolytus) which pose no threat	nil- very low Risk

Survey Results

As in the northern portion attacks were seen only in the flood-killed trees. A total of 11 (13.75%) of the trees were lightly attacked by spruce beetle. All but one were attacked in the current year. The single 2008 attack was unsuccessful. All attack levels were very low and concentrated at the base of the trees. Brood production in these trees was also low. Low levels of engraver beetle attacks were seen in three (3.75%) additional trees. An additional 12 red trees contained secondary scavenger species such as *Scolytus sp*, and/or ambrosia beetles *Trypodendron sp.* As in the other areas, the low levels of spruce beetle attack and brood production pose little threat of ongoing infestation.

To view the raw data from Area 3, see Appendix 3.

Area 4: Km 2 Pennycook Lane

This small (1 ha) area of mortality, like all along Pennycook Lane, lay along the eastern side of a new subdivision road (Photo 9). The raised berm of the road had trapped the water and the few installed culverts had proved inadequate to properly drain the area during periods of high water such as occurred in 2008.

Because some beetle activity was seen during the initial reconnaissance, and the area of flood damage covered only one hectare, we decided to examine every tree. The pure white spruce stand was densely treed with 1600+ trees/ha and most trees were small reflecting the relative poor quality of the site.

Photo 9. Area 4 Pennycook Lane

Table 6. Summary of Results from Pennycook Lane Area 4 (1 ha)

Type of Survey	# of Tree's Assessed and # of Tree's Attacked	Attack Frequency	Progeny Success	Probability of continued infestation
100 % Survey All trees examined	1600 trees were assessed 11 trees successfully attacked by Spruce beetle	low 3-6 attacks per tree	very low -low Brood survival of spruce beetle was very low < 4-8 larvae or pupae per attack	nil- very low Risk

Survey Results

A total of 11 (approx .07%) of the largest trees had been successfully attacked by spruce beetles in 2009. Spruce beetle attacks were all initiated in June of the current year and were limited to the base of dominant trees. Two of the trees were successfully attacked at frequencies considered (by the parameters set for this survey only) moderate, with 11 or more per tree. Nine were attacked at low to very low levels. Another three had been attacked unsuccessfully (adult galleries but no larvae). Brood success in all cases was very low to low, and, even from the "moderately" attacked trees, the threat of ongoing infestation is low. Two smaller trees had been attacked by the Allegheny spruce beetle, *Dendroctonus punctatus*, a secondary beetle found increasingly in recent years in association with spruce beetle, but not one known to cause outbreaks on its own. Twelve additional trees were infested by the *Scolytus sp.* scavenger beetles. No engraver beetle attacks were seen. When the numbers for spruce beetle attack frequency and progeny success were applied conservatively within the risk matrix (Table 2), the probability of continued infestation remained very low.

To view the raw data from the survey, see Appendix 4

Area 5: Km 4 Pennycook Lane

Though none of the assessed trees were infested, the area of reconnaissance covered only a small fraction of the approximately nine hectares of mortality (Photo 10). A large part of this area remained flooded at the time of the survey, so ground access was limited. Within much of the area, particularly at the south end, trees were small and crowded reflecting the poor quality of the site. The risk of attack from spruce beetle was negligible in that area. Any local populations would have been drawn into the larger trees close to the road, many of which were checked during the reconnaissance. However, in this area in particular, drainage was poor or non-existent, and there is an ongoing risk of flood mortality and subsequent infestation by bark beetles. This will be monitored closely.

Photo 10. Area 5 Km 4 Pennycook Lane

Table 7. Summary of Results from Pennycook Lane Area 5 (9 ha)

Type of Survey	# of Tree's Assessed and # of Tree's Attacked	Attack Frequency	Progeny Success	Probability of continued infestation
Walk about	Limited amount of trees assessed Due to high water	nil	nil	ongoing monitoring

Areas 6: Km 1.5 Pennycook Lane

The reconnaissance survey of Area 6, (at 0.6 ha, the smallest area of mortality) at Km 1.5 Pennycook Lane found no instances of attack and no further surveys were required.

Table 8. Summary of Results from Pennycook Lane Area 6 (0.6 ha)

Type of Survey	# of Tree's Assessed and # of Tree's Attacked	Attack Frequency	Progeny Success	Probability of continued infestation
Walk about	no trees attacked	n /a	n /a	no risk

Areas 7 and 8 East side of Marsh Lake

Areas 7and 8 were not surveyed this year. Time constraints led us to prioritize our surveys within areas considered to be of greatest risk for ongoing infestation. These two areas were determined to be at lowest risk. However, all areas will be subject to re-examination in 2010 and decisions regarding ongoing mitigation will be made then.

3. Response

Mitigation of spruce beetle populations is planned for Areas 1 and 4 during the winter of 2009/2010, prior to the early June spruce beetle flight period. This will ensure the destruction of overwintering broods before they emerge to attack fresh host. Even though the threat of ongoing infestation has been determined from the surveys to be very low, the decision to undertake active control in these areas was made for two reasons:

1. To exercise due diligence in an area where socio-economic values are high and the risk of ongoing infestation, though very low, does exist.
2. To gain experience and knowledge of mitigation methods and procedures

Table 9. Summary of Response Options by Area

Area	Response options
Area 1 Campground	Active control- 31 trees that were identified with current attack from bark beetles will be cut and burned or cut and peeled by spring 2010
Area 2 West side (North)	Monitor summer 2010
Area 3 West side (South)	Monitor summer 2010
Area 4 Pennycook Lane	Active control- 13 trees that were identified with current attack from bark beetles will be cut and burned or cut and peeled by spring 2010 Address drainage issue
Area 5 Pennycook Lane	Address drainage issue
Area 6 Pennycook Lane	Monitor summer 2010 Address drainage issue
Area 7 & 8 east side of Marsh lake	Monitor summer 2010

All infested trees in Areas 1 and 4 (31 trees in Area 1; 13 in Area 4) will be felled. Bark will be removed by chainsaw from the base of the felled trees and the stumps. The extent of bark removal will be determined by how far up the tree the beetle broods had been established. Because the warm summer favoured rapid brood development, up to 30% of the spruce beetle broods from 2009 attacks are expected to complete their cycle in a single year. This means that mature pre-flight adults from these trees, as well as those attacked in 2008 (on a two-year cycle), will overwinter a the base of the stumps and in the upper roots. Care will be taken to remove the bark in these areas. Axes and/or hatchets will be used where the base of the tree contacts the ground. The remaining 70% of two-year cycle broods from 2009 attacks will remain in their larval galleries as mature larvae and pupae. None, however, are expected to be above two meters as no attacks were seen at this level. Removal of bark up to the two meter mark (above ground when the tree was standing), therefore, will destroy all maturing broods.

Though this operation will ensure the control of known populations we can expect ongoing mortality as a longer term effect of the stress placed upon trees from the flooding. This will occur particularly at the margins of all of the areas of red trees and particularly in Area 6 where the water table remained high. These trees will continue to attract local populations of both spruce beetle and engraver beetles. For this reason close attention both by aerial and ground surveys will be paid to the Tagish area in 2010.

To prevent similar damage from occurring in the future it is recommended that the ditch beside the Campground be deepened or its drainage be improved in such a way as to ensure adequate handling of future extreme runoff events. Along Pennycook Lane, where water was trapped behind the raised berm of the road, drainage could likely be improved by the installation of additional culverts.

Appendix

Appendix 1

Area 1: Tagish Campground **Type of Survey: 100% cruise**

Tree no.	dbh	[1]tree status	[2]attack freq.	Comments
1	13.5	ra	v. low	Spruce Bark Beetle (SBB) @ base: 09 attack
2	19.7	ra	low	SBB @ base , Ips perturbatus above: 09 attack
3	25.5	ra	v. low	SBB @ base current attack. Some woodborer larvae
4	25	ra	v. low	SBB and/or Allegheny spruce beetle, Dendroctonus punctatus
5	28.7	ra	v. low	SBB larvae @ base: 09 attack
6	26.8	ra	low	SBB larvae @ base: 09 attack
7	29.1	ra	v. low	SBB pupae @ base: likely on a 1-year cycle
8	23.9	ra	v. low	SBB larvae @ base: 09 attack
9	24.3	ra	v. low	SBB larvae @ base: 09 attack
10	28.9	ra	v. low	SBB larvae @ base: 09 attack
11	26.8	ra	v. low	SBB larvae @ base: 09 attack
12	27.5	ra	v. low	SBB larvae @ base: 09 attack
13	20	ra	v. low	SBB larvae @ base: 09 attack
14	23.8	ra	low	SBB larvae @ base: 09 attack
15	23.8	ra	v. low	SBB larvae @ base: 09 attack
16	24.2	ra	v. low	SBB larvae @ base: 09 attack
17	23.2	ra	v. low	SBB larvae @ base: 09 attack
18	21.1	ra	low	Ips pupae & SBB pupae @ base. SBB likely on a 1-year cycle
19	18.5	ra	low	SBB pupae @ base: likely on a 1-year cycle
20	25.8	ra	v. low	SBB pupae @ base: likely on a 1-year cycle
21	20.6	ra	low	no comment recorded
22	29.6	ra	low	no comment recorded
23	33.4	ra	v. low	Ips perturbatus + SBB @ base: 09 attack
24	36.6	ra	v. low	no comment recorded
25	25.7	ra	v. low	SBB larvae @ base
26	29.2	ra	v. low	SBB adults @ base: 08 attack
27	26.1	ra	v. low	SBB adults @ base: 08 attack
28	22.9	ra	v. low	SBB adults @ base: 08 attack
29	24	ga	v. low	SBB larvae @ base: 09 attack
30	39.1	ra	low	SBB adults @ base: 08 attack
31	25.3	ga	v. low	SBB larvae @ base: 09 attack

[1] tree status: "ra" indicates attacked red tree; "ga" indicates attacked green tree

[2] attack frequency: 0-5 =very low; 5-11 =low; 11-25 =moderate; 25+=severe (sev)

Appendix 2

Area 2: West side of Marsh Lake (north) **Type of Survey: Walkthrough**

Tree no.	dbh	Tree status[1]	Attack freq.[2]	Comments
1	not recorded	ra	low	Ips perterbatus
2	not recorded	ra	n/a	Scolitus sp.
3	not recorded	ra	n/a	Scolitus sp. , woodborers
4	not recorded	ra	very low	Ips perterbatus
5	not recorded	ra	n/a	Scolitus sp.
6	not recorded	ra	n/a	Scolitus sp.
7	not recorded	ra	very low	SBB @ base 2009 attack
8	not recorded	ra	very low	SBB @ base 2009 attack
9	not recorded	ra	n/a	Scolitus sp.
10	not recorded	ra	very low	SBB @ base 2009 attack
11	not recorded	ra	very low	SBB @ base 2009 attack
12	not recorded	ra	n/a	Scolitus sp.

tree status[1]: " ra" indicates attacked red red tree
attack freq.[2]: 0-5-=very low; 5-11=low; 11-25=moderate (mod); 25+severe (sev)

Appendix 3

Area 3: West side of Marsh Lake (south) **Type of Survey: Walkthrough**

Tree no.	dbh	Tree status	Attack freq.	Comments
15	not recorded	ra	not recorded	small Ips not perterbatus; SBB unsuccessful
17	not recorded	ra	not recorded	light Scolitus attack
22	not recorded	ra	v. low	Ips spp ; Scolytus sp.
23	not recorded	ra	v. low	Ips spp ; Scolytus sp.
29	not recorded	ra	v. low	Ips spp ; Scolytus sp.
30	not recorded	ra	v. low	Ips spp ; Scolytus sp.
31	not recorded	ra	v. low	SBB @ base; Scolytus sp. above
35	not recorded	ra	v. low	SBB @ base; Scolytus sp. above
39	not recorded	ra	v. low	Ips perterbatus ; SBB at base
41	not recorded	ra	v. low	SBB @ base
42	not recorded	ra	v. low	SBB @ base
43	not recorded	ra	v. low	SBB @ base
44	not recorded	ra	v. low	SBB @ base
45	not recorded	ra	not recorded	SBB attack unsuccessful; Ambrosia beetle
48	not recorded	ra	v. low	SBB @ base
49	not recorded	ra	not recorded	Scolitus sp.
51	not recorded	ra	not recorded	Scolitus sp.
52	not recorded	ra	v. low	Ips perterbatus
53	not recorded	ra	not recorded	Scolitus sp.
54	not recorded	ra	not recorded	Scolitus sp.
55	not recorded	ra	not recorded	Scolitus sp.
56	not recorded	ra	not recorded	Scolitus sp.
60	not recorded	ra	not recorded	Scolitus sp.
61	not recorded	ra	not recorded	Scolitus sp.
67	not recorded	ra	v. low	SBB @ base
68	not recorded	ra	not recorded	Scolitus sp. ; Ambrosia beetle
73	not recorded	ra	not recorded	Scolitus sp.

tree status[1]: "ra" indicates attacked red red tree
attack freq.[2]: 0-5-=very low; 5-11=low; 11-25=moderate (mod); 25+severe (sev)

Appendix 4

Area 4: Km 2 Pennycook Lane **Type of Survey: 100% cruise**

Tree no.	dbh	Tree status	Attack freq.	Comments
1	23.4	ra	not recorded	SBB attack unsuccessful
2	29	ra	v. low	SBB @ base
3	17	ra	not recorded	Scolitus sp.
4	25.2	ra	v. low	SBB @ base: larvae 09 attack
5	25.3	ra	not recorded	SBB attack unsuccessful
6	25.3	ra	v. low	SBB @ base 09 attack + Scolytus sp.
7	20.8	ra	low	SBB @ base 09 attack + Scolytus sp.
8	37.9	ra	v. low	SBB @ base: larvae, pupae; 1 and 2yr cycling
9	not recorded	ra	not recorded	Scolitus sp.
10	13.1	ga	v. low	Dendroctonus punctatus 09 attack
11	37.2	ra	low	SBB @ base 09 attack
12	not recorded	ga	not recorded	SBB attack unsuccessful
13	16	ra	v. low	SBB @ base: late '09 attack
14	not recorded	ra	not recorded	Scolitus sp.
15	not recorded	ra	not recorded	Scolitus sp.
16	not recorded	ra	not recorded	Scolitus sp.
17	not recorded	ra	not recorded	Scolitus sp.
18	not recorded	ra	not recorded	Scolitus sp.
19	not recorded	ra	not recorded	Scolitus sp.
20	14.5	ga	low	Dendroctonus punctatus 09 attack
21	not recorded	ra	not recorded	Scolitus sp.
22	not recorded	ra	not recorded	Scolitus sp.
23	not recorded	ga	not recorded	Scolitus sp.
24	37.4	ra	mod	SBB @ base: larvae, pupae; 1 and 2yr cycling
25	30.6	ra	mod	SBB @ base: larvae, pupae; 1 and 2yr cycling
26	21.4	ra	v. low	SBB @ base: larvae, pupae; 1 and 2yr cycling
27	not recorded	ra	not recorded	Scolitus sp.
28	35.4	ga	low	SBB @ base: larvae, pupae; 1 and 2yr cycling

tree status[1]: "ra" indicates attacked red red tree; "ga" indicates attacked green tree
attack freq.[2]: 0-5-=very low; 5-11=low; 11-25=moderate (mod); 25+severe (sev)

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