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Yukon Forest Health Report

2007

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The annual survey of Yukon forests was conducted from July 2-30. The purpose of the survey was to provide an annual assessment of pest activity throughout the southern Yukon and to update the status of the ongoing spruce beetle infestation in the southwest. In addition to these core activities, two specific surveys were completed; one, a mid-July aerial survey to map forest pest activity within the Teslin Tlingit Traditional Territory (TTTT) and the other in the late fall to determine the cause of white spruce mortality adjacent to the Yukon River south of Dawson City.

The weather during the growing season was similar to last year being somewhat cooler and wetter than in recent years prior to 2006. According to pheromone trap data spruce beetles flew throughout the month of June, with peak flight near the middle of the month. There was 33.4 mm of precipitation recorded in July 2007 and 21.6 in 2006 compared with 0.4 mm in 2004 and 0.3mm in 2003. The winter of 2006/2007 was colder with periods of intense cold in November and again in January. Neither event, however, was prolonged and was unlikely to have adversely affected the survival of spruce beetle larvae overwintering in the boles of white spruce trees.

Among pests encountered during the 2007 were: spruce beetle, *Dendroctonus rufipennis*, spruce engraver beetle, *Ips perturbatus*, western balsam bark beetle, *Dryocoetes confusus,* fir-spruce budworm, *Choristoneura orae*, aspen serpentine leafminer, *Phyllocnistis populiella* and a willow leaf blotch miner, *Micrurapteryx salicifoliella*. Eastern spruce budworm, *Choristoneura fumiferana*, populations remained low in the southeast. In the southeast the harvest of immature lodgepole pine cones by squirrels killed numerous branch tips. Drought along the Yukon River between Minto Landing and Dawson City resulted in scattered small patches of white spruce mortality, some of which were attacked by secondary bark beetles.

Spruce Beetle

White spruce mortality resulting from 2006 attacks by spruce beetles and mapped from the air in late July 2007, declined significantly, with only 10 286 hectares (ha) (Map1), compared with 41 170 ha in 2006 and 82 620 in 2005. This was the lowest recorded area of mortality since the infestation was first mapped in 1994 (Figure 1). The reduction in area was complemented by a reduction in attack intensity; 99.5% of the area mapped was light (<10% of stand trees affected in a single year) and 0.5% was moderate (10-30%). No severe (>30%) mortality was mapped.

Summary of attacks

Beginning in the northeast, one of the few instances of increased beetle activity was seen in the lower Aishihik River valley above Seven Mile Creek, where six polygons totaled approximately 200 ha, including two of the only patches that were of moderate intensity. On the opposite side of the valley attacks continued, with light attacks totaling about 300 ha along the north side of

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Map 1. Spruce beetle and Ips-caused white spruce mortality mapped in 2007

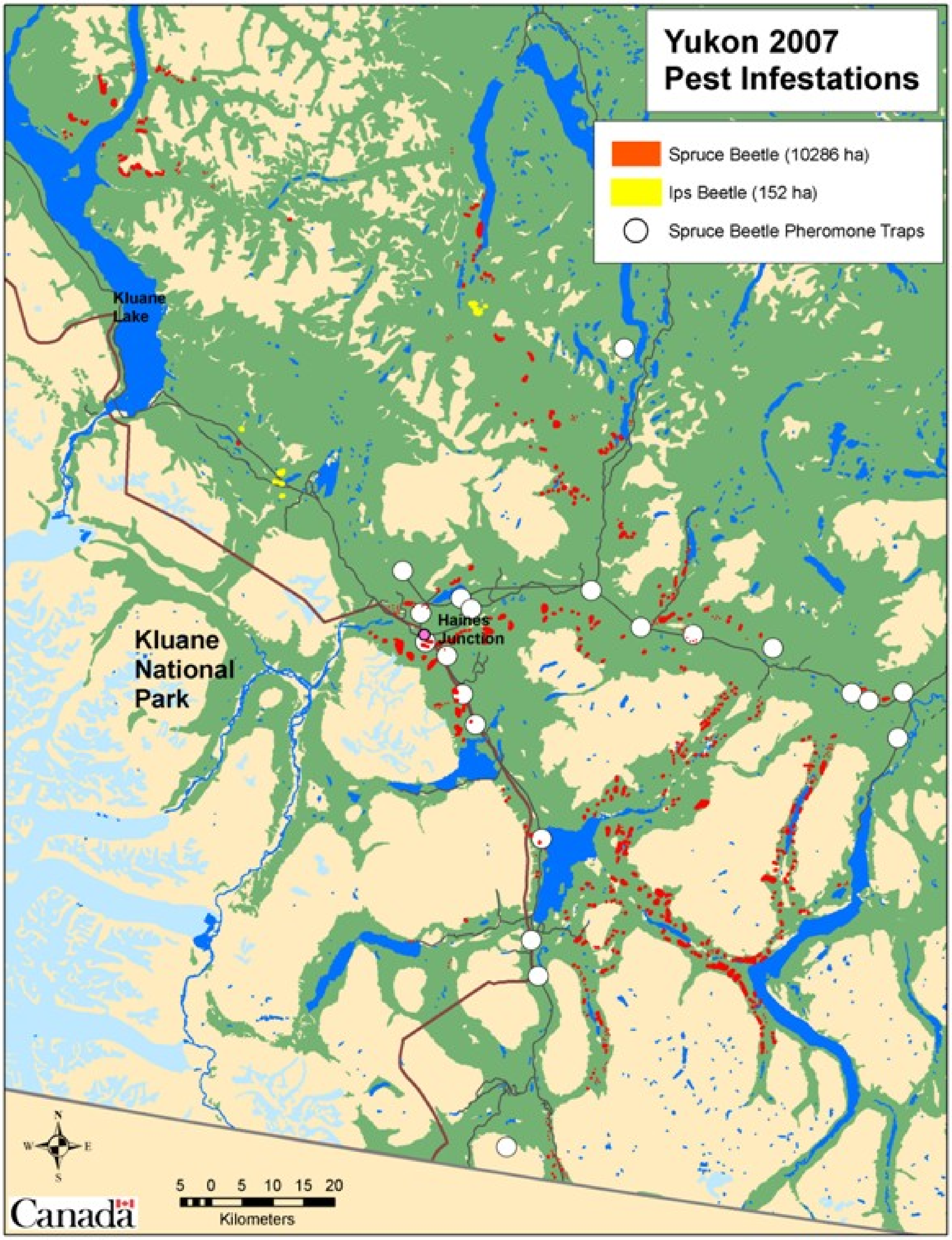

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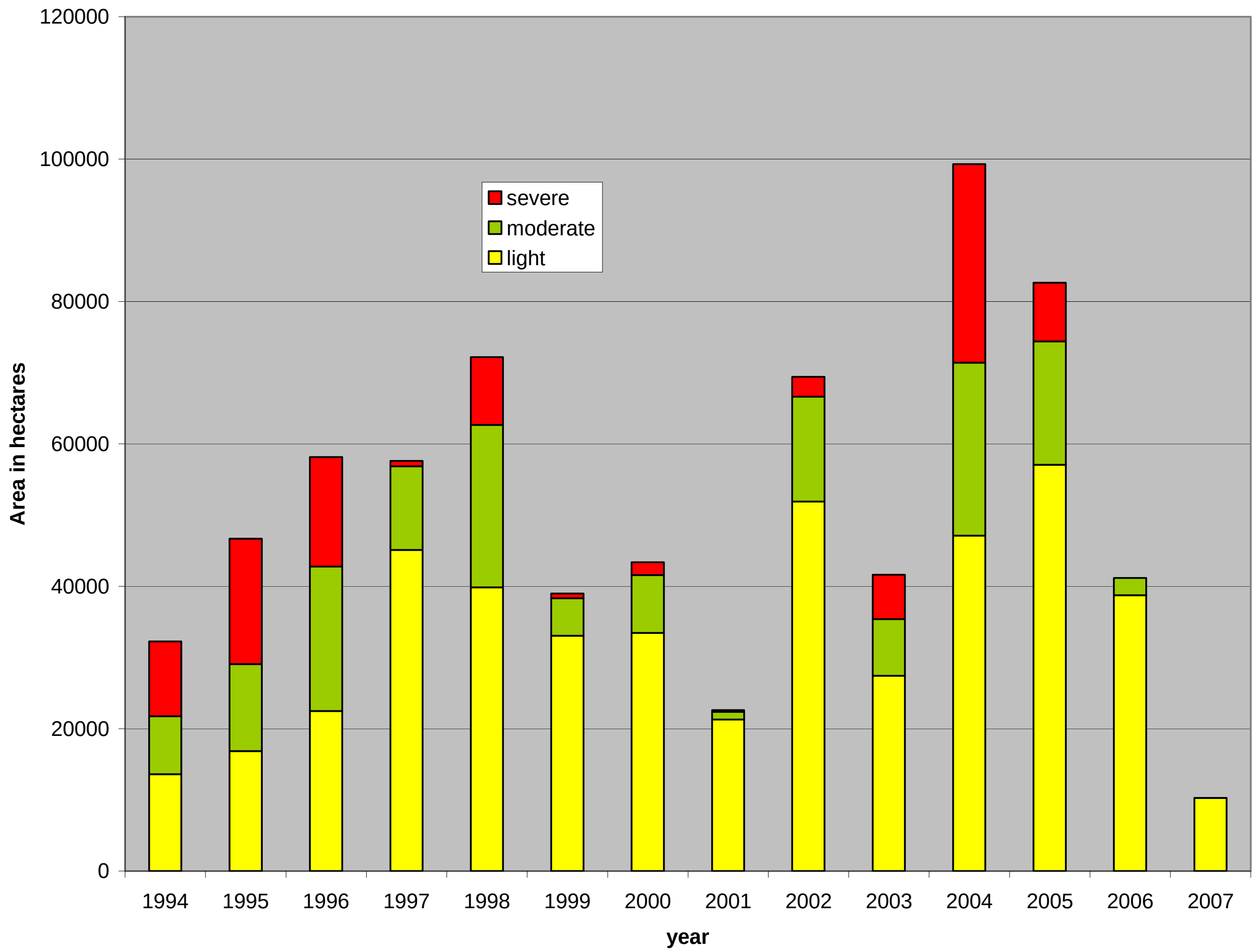
Figure 1. Area of spruce beetle-caused white spruce mortality by severity and year



Emery Creek. Increases were also seen on the north side of the diversion canal at the south end of Aishihik Lake. There was no northward movement beyond this point within the Aishihik drainage.

To the north and west, following significant declines of attack recorded last year in the West Aishihik River valley, there were further reductions this year. This was most evident at the east end of Killermun Pass and on the east side of Sekulmun Lake where no recent mortality was mapped. A reduced number of scattered small patches of light mortality remained in the lower West Aishihik valley and at the southwest end of Sekulmun Lake, but unlike last year, no red trees were seen at the northwest end of the Lake. These contractions have significantly reduced the possibility that beetle populations could move north into the Nisling River drainage.

Moving westward, only a few red trees were seen adjacent to Isaac Creek compared to the numerous small patches mapped in 2006. In the Gladstone River valley there were fewer attacks up-stream but, like last year, numerous polygons of light intensity totaling about 300 ha were mapped on the north side of the valley. On the east side of the Talbot Arm of Kluane Lake between the Gladstone River and Raft Creek, only a few small areas of light attack were mapped, and at Raft Creek the area of recent attacks was reduced to about 100 ha. The most

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active populations in the area were on the west side of Talbot Arm in the hills above Striation Point and Doghead Point totalling about 300 ha of light attack.

No recent attacks were seen either above Thorsen Bay, in the Cultus Creek drainage, or in the Shakwak Trench between Kluane Lake and Bear Creek. Just north of Haines Junction scattered attacks were seen just west of the Haines Junction Airport, along Pine Creek and along the lower southeast facing slopes of Paint Mountain. Just south of Haines Junction, scattered medium-sized patches of light mortality once again occurred on the lower north-facing slope of the Auriol Range over an area totaling about 500 ha. Farther south, light activity persisted along Quill Creek west of the highway, and five small and medium-sized polygons totaling about 400 ha were mapped between here and Kathleen Lakes. Continuing on the west side thirteen small patches of light attack totaling about 100 ha were mapped from Kathleen Lakes to just south of the campground on Dezadeash Lake.

East of Haines Junction between Pine Lake and Cracker Creek, no red trees were seen north of the Dezadeash River. In the Cracker Creek drainage itself, numerous polygons of light mortality were mapped once again on the west side of the Creek, though the polygons were smaller and lower in elevation than last year. Scattered small patches of light attack were also seen along south-facing slopes of the hills just east of Cracker Creek.

South of the Dezadeash River numerous small and medium-sized polygons were mapped but the area and intensity diminished markedly east of Moose Creek, and only a few small patches occurred on the north slope of Mount Bratnober. Turning south in the Dezadeash Valley concentrations of attack increased, especially in the tributary Sanddune Creek as they encountered populations within the Dezadeash River valley moving northward from Dezadeash Lake. Farther south, numerous small infestations occurred on both the east and west sides of the Valley with the greatest concentrations north and south of Six Mile Lake. In all of these areas, the extent and intensity of attacks were much less than in prior years.

East of Dezadeash Lake in the Kluhini River drainage, and eastward beyond Frederick Lake into the Kusawa Lake drainage recent attacks represented about the only example of a sustained and advancing population within the waning infestation, and this year accounted for nearly one-half of the overall area infested. At Kusawa Lake the population split, moving north and southward along the western Lake shore. To the south damage was almost identical to last year, extending well up Devilhole Creek but no farther. To the north most of the population was diverted into the Jo Jo Lake drainage with only a few small spots along Kusawa Lake beyond this point. In the JoJo Lake area attack polygons were larger and more numerous than previously and for the first time mortality was mapped in adjacent Pond Creek. The leading edge of this same population had crossed the Mendenhall River in 2006 and was detected by local pheromone traps. The resulting nearly 200 ha of light mortality recorded around the Mendenhall Subdivision this year represented the most eastward population yet recorded. Unlike any other area in this waning infestation this single population from the Kluhini River to beyond JoJo Lakes will likely remain dynamic for the next few years.

South of Dezadeash Lake the expected collapse was almost complete. The only remnant of significant population was seen in the Takhanne River Valley where numerous scattered small red tree patches persisted. Farther south in the upper Tatshenshini River valley, where over 80% of mature trees were killed between 2004 and 2006, only scattered single red trees were

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seen. The same was true in the Fraser Creek valley and the Mush Lake area where few living mature spruce remain.

Population assessments

Pheromone trap results

For the third consecutive year Lindgren® funnel traps baited with a pheromone specific to spruce beetle were deployed at 20 locations along the Alaska Highway from Mendenhall to Haines Junction, up the Aishihik Road and along the Haines Road between Haines Junction and Dezadeash Lake. Trapped beetles were collected weekly throughout the month of June. Trap catches from both 2006 and 2007 are summarized in Table 1. From early on in the infestation there has been a larger beetle flight in the odd year and this year was no exception with twice the number trapped this year compared to last year. Like last year most of the beetles were trapped adjacent to the Haines Road between Haines Junction and Dezadeash Lake. Significant numbers were also trapped at Km 22 of the Aishihik Road, and these numbers were supported by recent increases in tree mortality.

The doubling of the pheromone trap catch this year might be expected to result in doubled red tree counts next year but, as mentioned earlier, only a slight increase is expected. This is due to the established impetus of an already declining population which historically, has tended to accelerate toward collapse.

Tree-by-tree assessments

One thing that marked this year in contrast to prior years was the scarcity of red trees (trees attacked and killed in 2006) in accessible stands. Of the only two red trees found, neither contained living broods and the trees only died because of concurrent attacks by *I. perturbatus* and the lethal effect of the fungi carried by both beetles. This was also the theme of the tree-by-tree assessments (Table 2) made at approximately 10 km intervals east of Haines Junction. This assessment was instituted in 2004 to address concerns that the eastward migration of spruce beetles could ultimately threaten stands as far east as Whitehorse. This year, pitch-outs (attacks repelled by the trees) averaged 10.7% of examined stand trees and last year's current attacks that had been recorded mostly as light attacks by both spruce beetles and Ips engraver beetles, resulted in no red trees. Almost without exception the beetles had died during initial gallery establishment and no eggs were laid. Almost no current attacks were seen east of Haines Junction this year. As would be expected from the results of the pheromone trapping, numerous current attacks were found south of Haines Junction, most of which were in trees of 15 cm diameter or less (most of the larger trees having already been killed). This concentration however is contained within the old heart of the infestation and will do nothing to promote expansion. Additionally, and most importantly for the future of spruce beetle populations, there has been no return to the drought conditions that, given the history of this infestation, would be required for it to become re-invigorated. The decline therefore is expected to continue.

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Table 1. Numbers of beetles caught in pheromone traps placed at 20 locations during the month of June 2006 and 2007.

			Number of beetles in traps											
			Week 1		Week 2		Week 3		Week 4		Week 5		Totals	
Trap#	Location	Geog. co-ordinates	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
4	Km 7 Kusawa Lake Road	8 441709 6731004	0	no trap	0	no trap	7	no trap	0	no trap	0	no trap	7	no trap
28	Km 1498 Alaska Hwy.	8 433365 6737267	no trap	7	no trap	5	no trap	3	no trap	3	no trap	0	no trap	18
24	Km 1.3 Mendenhall Tower Rd	8 441628 6738414	0	2	0	0	12	0	0	1	0	0	12	3
23	Km 1495 Alaska Hwy,	8 436353 6736375	0	2	4	0	126	0	0	1	0	0	130	3
22	Km 1514 Alaska Hwy	8 419822 6742854	1	33	0	13	1	0	0	1	0	1	2	48
21	Km 1528 Alaska Hwy	8 406854 6743375	0	5	0	17	0	2	0	11	0	1	0	36
20	Km 1535.8 Alaska Hwy	8 398291 6743525	0	0	0	1	0	1	0	1	0	0	0	3
19	Km 22 Aishihik Lake Road	8 387334 6657427	0	77	0	35	4	4	0	18	0	13	4	147
18	Km 10 Aishihik Lake Road	8 389981 6787898	0	0	0	0	1	2	1	0	0	0	2	2
17	75m up Aishihik Rd	8 389565 6748439	0	2	0	11	3	3	1	4	0	2	4	22
16	Km 1557.4 Alaska Hwy	8 359004 6747720	0	1	1	1	7	3	5	0	1	2	14	7
15	Km 1567.3 Alaska Hwy	8 368887 6744544	0	1	0	2	3	1	2	1	4	0	9	5
14	Haines Junction Airport Road	8 362790 6741339	0	1	0	0	0	0	0	1	0	0	0	2
13	10 km E of HJ Muffin	8 370774 6743057	0	6	2	3	28	0	4	0	0	1	34	10
27	Km 243.4 Haines Road	8 364070 6736799	4	6	5	6	19	1	1	2	1	0	30	15
12	Km 240 Haines Road	8 367784 6735019	0	*2*	1	4	1	0	1	0	2	0	5	6
26	Km 234.5 Haines Road	8 371120 6729204	0	39	2	137	30	17	3	80	1	11	36	284
11	Km 228 Haines Road	8 373759 6724570	0	111	0	375	44	2	37	44	6	43	87	575
10	Km 206 Haines Road	8 386718 6707582	3	60	10	384	152	18	31	62	8	10	204	534
9	Km 189 Haines Road	8 387097 6691099	0	1	0	1	3	0	0	1	0	0	3	3
25	Km 182.2 Haines Rd: Quill Cr.	8 388906 6685513	1	33	25	268	454	3	16	123	3	84	499	511
											grand total		1082	2234

Table 2. Tree-by-tree assessments

		UTM[1]			% of trees					
Plot no.	Location	Zone	Easting	Northing	Healthy[2]	Current	Red	Grey	Partial	Pitch-out
1	10 km -E- Haines Junction	8	368051	6743782	28	3 (Ips)	0	43	3	22
2	20 km -E- Haines Junction	8	377688	6747210	81	0	0	12	0	8
3	25 km -E- Haines Junction	8	382626	6747921	29	1	0	41	4	25
4	36 km -E- Haines Junction	8	395120	6745544	26	1	0	56	15	1
5	40 km -E- Haines Junction	8	397395	6743828	70	0	0	17	5	8
6	50 km -E- Haines Junction	8	408497	6743171	95	0	0	4	1	0
				average	54.8	0.8	0	28.8	4.7	10.7

[1] Universal Trans-Mercator grid system

[2] Healthy - not attacked
Current - killed by spruce and/or Ips beetles in current year
Red - attacked the previous year
Grey - attacked two or more years previously
Partial - attacked but not killed
Pitch-out - attacks repelled by tree

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Spruce beetle at Jackson Lake

Spruce beetles attacked scattered, mostly very old, high elevation white spruce near the north end of Jackson Lake, just northwest of Whitehorse. A significant population of beetles had bred in trees that were blown over in 2005. Ordinarily a small patch of blowdown would not, in itself spawn an infestation. However, the forest at this location was comprised of largely decadent white spruce that, because of lowered resistance and an increased incidence injuries like branch breakage, supported a larger than average endemic beetle population. Thus there was a resident population poised to take advantage of the breeding opportunity offered by the blowdown. The beetle progeny had emerged from the blowdown in June of this year and was sufficiently large to successfully attack standing trees. When the site was visited in mid July at least seven trees had been attacked with well established adult galleries and many eggs. The site will be re-visited in 2008 to monitor the progress of this, as yet, small infestation.

Forest Assessment Plots

Between the years 2000 and 2003 a network of 27 Forest Assessment plots was established to measure the ongoing effect of this unprecedented infestation. Through the various protocols many aspects of stand structure and composition were measured and characterized including the identity and abundance of the various ground cover species. We also attempted to measure the wildfire hazard posed by each stand by quantifying the available coarse and fine fuels including a unique assessment of standing tree fuels. The first round of measurements will serve as a baseline against which future measurements will be compared, though the timing of the second round is, as yet, undetermined. The results are summarized in an establishment report, BC-X-406, entitled “Spruce Beetle and the Forests of the Southwest Yukon” http://dsp-psd.pwgsc.gc.ca/collection_2007/nrcan-rncan/Fo143-2-406E.pdf

One of the main drivers of succession will be an increase in the amount of light reaching the forest floor as a result of thinning crowns in the grey trees. This increase began with the loss of needles in the year following attack. Because we thought, at that time, that needle loss would be sufficient to initiate succession, a second round of plot assessments was planned for between 2008 and 2010. It soon became apparent, however, that the dense network of fine branchlets that characterize the slow-growing relatively open white spruce stands in the southwestern Yukon, remained an effective barrier to light penetration following needle-drop. The question then became “how long will these branchlets be retained by the trees?” Photo1 is of a tree that was attacked by spruce beetles around 1996 and, 11 years later, though some shedding has occurred, there has been no appreciable thinning of the crown. In this dry northern environment the progress of decay is very slow and shedding of these branches will rely more on the forces of wind, rain and snow than on fungi. Meanwhile the plots will be protected and maintained for some as yet undetermined future time when the project can be completed. Unfortunately the recent agricultural subdivision development just east of Haines Junction cut though the centre of Plot 16, so the network has been reduced from 27 to 26 plots.

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Fir-spruce budworm, *Choristoneura orae*

In early July 2002 trace amounts of white spruce defoliation were seen in the Kaskawulsh River valley and later in the month budworm moths were observed flying in the same area. At the time it was assumed that the damage was caused by the two-year cycle spruce budworm, *Choristoneura biennis*. This was reinforced the following July when a markedly increased population was found feeding in white spruce from Beaver Creek south, almost to Haines Junction. The damage was confined to the branch tips and the larvae were very small so the population was clearly on a two-year life cycle. Branch samples containing larvae were collected from near Congdon Creek and sent to Entomologist and budworm specialist Dr.Vince Nealis at the Pacific Forestry Centre where they have been laboratory reared ever since. The following year (2004) we trapped budworm moths using plastic "Multipher" traps baited with two different pheromones; the first of which was known to attract the two-year cycle spruce budworm, *C. biennis* (as well as the eastern and western spruce budworms, *C. fumiferana and C. occidentalis* respectively), and the second to attract only *C. orae*, a species that was common in north-coastal B.C. forests centred in the Kitimat valley. The catches in traps baited with *C. orae* pheromone outnumbered the other bait 3:1, so Dr. Nealis concluded that the population was, indeed *C. orae*.

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Photo 1. Persistent fine branches on spruce beetle-killed white spruce

In 2007 we decided to trap again in a non-flight year. If the budworm was on a regular two year cycle few or no moths would be caught. The catches listed in Table 3 were surprisingly high and suggest either that the life cycle can shift from two years to one in warm years or that a certain portion of the population is pre-disposed to the one year cycle. The latter alternative is supported by results in artificial rearing at PFC where a small proportion of the population has cycled in one year while the majority reared under the same conditions cycled in two. Trapping will be repeated in 2008.

Table 3. Numbers of fir-spruce budworm, *Choristoneura orae* moths caught in pheromone traps in 2004 and 2007

		No. of moths	
Location	**Geo. Co-ordinates**	**2004**	**2007**
Congdon Creek	07 630730 6781348	157	38
Nines Creek	07 623906 6787919	71	70
Destruction Bay	07 613608 6797968	210	110
Duke River	07 599848 6805286	40	47
Quill Creek (north)	07 589256 6823641	107	65
Donjek River	07 559595 6844406	145	26
	average	105	59

Aspen serpentine leafminer, *Phyllocnistis populiella*

By now familiar to all residents of the Yukon, particularly those in the central portion between Carmacks and Dawson City, is the silvering of aspen leaves from the mining of the serpentine aspen leafminer. Larvae of this insect feed on the epidermal layer on the upper and lower surface of the leaves leaving only the silver leaf cuticle behind (Photo 2). Feeding begins almost as soon as the leaves have flushed, normally in early May. This year, once again, moderate and severe leaf mining was seen wherever aspen occurred and when defoliation was severe balsam poplars and cottonwoods were also infested. In the area between Stewart Crossing and Mayo where severe mining has occurred every year for 15 or more years, the trees have become stunted and lacking in vigour but as yet little or no mortality attributed to the leafminer has been observed or reported.

Willow blotch miner, *Micrurapteryx salicfoliella*

Outbreaks of this insect caused the reddening of foliage of various willow species in many areas in the central Yukon, most noticeably adjacent to the Stewart River at Stewart Crossing (Photo 3). This being the first year of severe infestation, little long-term damage can be expected.

Squirrel damage

This damage which is characterized by the reddening of lodgepole pine branch tips occurred in scattered young stands across the southeast from Watson Lake as far as Teslin. It results from the stripping of immature cones from the branches by squirrels, and is

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thought to occur in late winter after they have depleted their winter seed store. The stripping effectively girdles and kills the branches distal to the site of cone production (Photos 4 and 5). Usually only a few branches are killed but up to10 red tips were seen on some trees. This is the most severe incidence of this type of damage that I have seen since the late 1990s.

Photo 2. The track of an Aspen serpentine leafminer. Note leaf fold at pupation site.

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Special survey of Teslin Tlingit Traditional Territory (TTTT)

On July 17th a four-hour helicopter survey of the forests of the western half of the TTTT was undertaken to provide an overview of forest health conditions. The survey was done to provide baseline information in support of the Strategic Plan for Forest Resources. It was the first time such a survey had been completed in the area. The only pest damage mapped from the air was light mortality of alpine fir, *Abies lasiocarpa*, caused by the western balsam bark beetle, *Dryocoetes confusus.*

Higher elevation forest stands in the hills adjacent to Teslin Lake are within the narrow belt across the extreme southern Yukon characterized by the presence of alpine fir in addition to white spruce and lodgepole pine. Unfortunately the western balsam bark beetle, has recently invaded these stands from the south and is slowly killing the mature trees.

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Photo 3. Willow leafminer larvae in cocoons

Balsam bark beetle infestations were first seen from the South Klondike Highway in the early 1990s, in stands along both sides of Windy Arm (Tagish Lake). Near the same time they were mapped by aerial survey in the La Biche River drainage in the extreme southeast. It is likely that they have been resident in the TTTT as well since that time, but have not been visible from the highway. During this year's survey alpine fir mortality was mapped over an area of approximately 16 000 ha. The intensity of annual attacks within these stands is difficult to estimate from the air because dead trees retain red foliage for up to four years, but historically mortality has remained low with only about 1% of stand trees being killed annually. The balsam bark beetle normally requires three years to complete its life cycle and because of this and the relatively marginal high elevation environments in which they live, populations are not prone to the rapid increase which characterizes outbreaks of other beetles such as spruce or mountain pine beetle. Instead, balsam bark beetle populations are maintained at relatively low but fairly stable levels and annual tree mortality more-or-less constant.

The recorded history of significant defoliating insect activity within the TTTT is limited to periodic outbreaks of the large aspen tortrix, *Choristoneura conflictana*, and the aspen serpentine leafminer, *Phyllocnistis populiella*, in trembling aspen. Observations of pest

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activity have historically been limited to stands visible from the Alaska Highway and the south Canol Road. The first records of large aspen tortrix damage date from the early 1980s when infestations caused severe defoliation at various (unidentified) locations around Teslin Lake. Populations persisted throughout the remainder of the decade but defoliation remained light. In 1993 severely infested patches totalling 1300 ha were seen on hillsides above Teslin Lake from Johnson's Crossing southeast to Nisutlin Bay. The most severe defoliation was at the northwest end of the Lake near Deadman Creek. Since that time no tortrix defoliation has been observed within the TTTT, possibly because of the rise in serpentine leafminer populations that have caused from light to severe damage to the leaves of aspen throughout the host range from the mid 1990s until the present day.

The majority of insect and disease pests hosted by the coniferous forests are relatively minor in terms of overall damage, and chronic because the pests are persistent and damage levels change little from year to year. Within the white spruce the most serious of these, the spruce broom rust, *Chrysomyxa arctostaphyli* infects up to 10% of mature trees. In the nature of effective parasites, *C. arctostaphyli* rarely kills its host, but can significantly compromise growth and vigour. Over time the presence of the disease is manifested by the formation of densely matted small branches or brooms on the branches of its host. An infected tree typically supports one or two brooms but severely infected trees may have as many as ten. In early summer the brooms produce millions of bright yellow-orange spores and become far more visible against the green background. Another rust disease, the western gall rust *Endocronartium harknessii* produces globose galls on the branches and stems of lodgepole pine. Though not as common in the TTTT as farther south they can still be easily found, especially in young stands. Young trees are more susceptible both to infection and damage as galls are capable of girdling and killing branches and small diameter trees. The lodgepole terminal weevil, *Pissodes terminalis*, kills the terminal shoots of young pine. It was first recorded in the Yukon north of Watson Lake in 1990 and was another example of the moderating climate allowing the establishment of a forest pest in areas in which they were traditionally denied. In the next two years it was found across the southern forests as far west as Whitehorse. In the TTTT the incidence of damage caused by this pest increased quickly, peaked in 1992, and then declined, though it is now established and will likely persist.

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Photo 4. Scar on lodgepole pine branch from squirrel stripping immature cones

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Photo 5. Red lodgepole pine branch tip resulting from squirrels stripping immature cones

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Summary of a Brief Survey of Tree Mortality along the Yukon River South of Dawson City

On October 16, 2007, I flew by helicopter up the Yukon River from Dawson City with Rob Legare, Yukon Forest Management Branch, Whitehorse, and Chad Dyce of Client Services and Inspections, Dawson City. The purpose of the trip was the investigation of beetle-infested white spruce trees that Chad had seen from the air and investigated on the ground in July and August. Some trees at the mouth of the Indian River appeared at that time to be infested by spruce beetle**,** *Dendroctonus rufipennis* and the spruce engraver beetle, *Ips perturbatus*. The tree needles had turned red by the time they were identified but it was unclear as to whether the trees had died in 2006 or early 2007. This was to some degree clarified by bark samples sent to me by Chad in late August. In some samples adult and larval galleries characteristic of one year-old spruce beetle attacks were engraved into the bark. This was reinforced by advanced woodborer (*Cerambicidae* and *Buprestidae*) gallery production that would only be seen in trees that had been dead for one or more years. Considering the absence of spruce beetle larvae, however, it is likely that the progeny were killed by the intense cold of early last winter, but not before the tree had been killed by a combination of beetles boring within the cambium and the proliferation of sap-stain fungi introduced by the beetle.

The day of our flight was cool with a light dusting of new snow and hoar frost clinging to the trees. We also encountered a cloud ceiling of less than 100 meters. The low ceiling limited our search to the river level and tree crown coatings of snow and frost made it difficult to pick out the recently-killed trees. The limitations of visibility were further increased by the graying of the once red tree crowns. However our air search did reveal numerous small groups of grey trees at the first stop near the mouth of the Indian River, but the ground search failed to locate any killed by spruce beetles. Most of the recently killed trees at this site had been attacked in the current year by *Ips perturbatus* and other secondary beetles, but in many the attacks were insufficiently dense to have caused tree death. These insects had completed their brief life cycle and this year's production of young adults had left the trees to over-winter in the surrounding duff. It was evident at this point that the condition we were witnessing was more complex than simply small bark beetle infestations. This was reinforced by a second site on the bank of the Yukon River, just south of the mouth of the Indian River, and a stop much farther south at Ballerat Creek. More engraver beetle attacks were found at both sites, but more importantly, fully half of the dead trees were found to contain no signs of beetle attack. There was no external boring dust and no beetle galleries under the bark.

Chad had mentioned earlier that he thought the trees were stressed by drought and predisposed to attacks by beetles. It was evident at the first site that drought was the most likely stressor, even of trees on the river bank as they were meters above high water and thus unable to reach the river's water table. Though it is not yet known why river-side trees would be under more stress than those farther back in the stand, it could be that the coarse gravels that underlay these stands drained available water away more quickly than the soils farther upriver. It appears now that drought was the single cause of death for most of the trees.

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At the same time as he saw the riverside mortality Chad had seen and photographed clusters of fading trees at Barker Creek, in the hills between the Yukon and Stewart rivers, on a much larger scale that those small patches seen adjacent to the Yukon River. The density of the stands precluded landing a helicopter so ground examinations have not yet been done. Chad is intending before next July to create some helicopter landing pads in the vicinity of these higher elevation stands.

What appears to be happening in the central Yukon is a consequence of the high moisture codes that have been recorded in the last four growing seasons. In 2007 the cumulative effects of moisture stress became so severe that trees began to die. Because the trees were so dry, reddening and subsequent shedding of the needles occurred very rapidly following death. It is unclear whether the drought has been due to one or both of reduced rainfall or simply increased temperatures forcing the trees to transpire at a higher rate. In the Shakwak Trench, especially in the high elevation stands, senescent old growth trees maintained a high endemic population of spruce and other secondary beetles, so when severe drought stress weakened the trees in the late 1980s the infestation proliferated very quickly. In contrast, extensive harvesting to fuel the riverboats coupled with a much higher incidence of wildfire has resulted in a greatly reduced incidence of old-growth along the upper Yukon River corridor, with the result that endemic beetle populations are much lower. This would explain why so many of the dying trees remained unattacked. The engraver beetle attacks unlike the spruce beetle appeared to be largely successful so we can anticipate a larger population next year. If drought conditions persist, damage caused by secondary beetles will be moot, at least in the initial stages, because they will be attacking trees already dead. The danger from pests will increase when their populations increase beyond the numbers that can be absorbed by the dead and dying trees and they begin attacking healthy trees.

More detailed aerial and ground surveys will be completed in July, 2008. We hope then to further determine the nature and scope of the condition, as well as the role of forest pests in its development.

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