STATUS OF MOUNTAIN PINE BEETLE ATTACK IN YOUNG LODGEPOLE PINE STANDS IN CENTRAL BRITISH COLUMBIA

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Executive Summary

Of the approximately 1.96 million ha of young, lodgepole pine leading stands between the ages of 20-55 years in B.C., 490,236 ha (25%) occur within the six districts where this study was conducted: Prince George, Quesnel, Vanderhoof, 100 Mile House, Central Cariboo and Nadina (Table 1). 9.7% of these young stands were aerially surveyed to quantify mountain pine beetle (MPB)-caused mortality.

The highest frequency and intensity of MPB attack was observed in polygons over the age of 40 (Tables 3, 9, Appendix 1), yet stands as young as 20 years sustained high levels of attack in areas of extreme beetle pressure outside what is considered the core, or older outbreak area. The mountain pine beetle did not discriminate between mature stands (≥60 years) and stands 40 to 60 years; therefore these stands should be first priority for future surveys and rehabilitation. 49.2% of young stands aerially assessed and 48.2% of those ground surveyed contained some level of MPB attack. Aerially observed mortality ranged from 0 to 95% red attack (2004 attack) with only trace amounts of older (grey) attack. 4.3% of the total number of polygons evaluated contained greater than 50% mortality (Fig. 2). 23% of polygons ground surveyed had greater than 50% MPB-caused mortality within the stand (Fig. 4).

The most severely impacted district was Quesnel with 72.8% of all polygons assessed by air having some level of MPB mortality. 60.5% of the total number of stands assessed in the 20-25 year age class had evidence of MPB attack ranging from 1% to 61% attack. Nearly 100% of stands surveyed in Quesnel over 31 years old had some level of MPB attack. In the Central Cariboo District, the percent of stands affected ranged from 45.1% to 93.3%, in 20-25 year old stands and 51-55 year old stands respectively. Approximately one third of all stands surveyed in Prince George between the ages of 20 to 40 years were attacked, with almost 100% of older stands sustaining some degree of attack. 100 Mile House and Nadina Districts had a lower frequency of attack in young stands, however, over one third of all stands aerially assessed in these two districts showed evidence of MPB-caused mortality. Green attack (2005 attack) levels in the 100 Mile House District ranged from no attack to 81%.

The risk to young stands is declining in the core or oldest parts of the outbreak, such as Quesnel, where the 2005 aerial overview survey showed a decline in hectares affected from 2004 (BCMOFR 2005). Attack will continue until the outbreak collapses, however, the highest future risk will be in peripheral Districts, where the outbreak has gained momentum in the past two years. We anticipate future losses in young pine to be highest in the Central Cariboo, 100 Mile House, and Nadina Districts. Young pine stands in more northern and southern districts are at risk, where MPB populations are building in adjacent mature stands and the mature host resource is limited. In the south (e.g. Kamloops, Okanagan Shuswap), there are localized areas of very high beetle attack where young pine is already under attack (personal observations). The impact may be even higher outside the core outbreak area as the beetle runs out of mature host material and more beetles disperse in from surrounding geographic areas.

It is imperative that forest managers, and those directing reforestation programs such as the Forests for Tomorrow program, have the necessary tools and information to maximize both the immediate harvest of mature stands posing a threat to young pine, as

well as placing high priority on stands impacted by the MPB. The entire 2 million ha of young pine cannot be assessed on the ground; therefore an alternate method of estimating potential risk must be elucidated. With data collected to date, targeted GIS analysis of cumulative MPB attack in adjacent mature stands, and fieldwork to test the results of this analysis may provide some guidance as to which areas of young pine at greatest risk. This combined GIS/field verified approach to estimating risk would provide necessary guidelines using reasonable stand-level measurements.

The results from this project will assist in prioritizing young pine stands with the highest risk to MPB attack. This will enable foresters to prioritize stands for surveys, treatments or rehabilitation thus mitigating or reducing impact. The risk to young stands will be based upon current and past levels of MPB attack and availability of mature hosts. Potential management options may include accelerated harvest of adjacent mature stands, fertilization and others treatments to minimize or mitigate further losses in young stands.

Introduction

Of the 14.9 million ha of pine in British Columbia, there are approximately 1.96 million ha of young pine (natural regeneration and managed plantations) between the ages of 20-55 years. More than 1.1 million ha are comprised of over 80% pine. Within this inventory of young pine, over 1 million ha are between ages 20-35 years (BCMOFR 2005). These stands represent future harvests, habitat and forest structure. Many of these young stands are currently being impacted by the mountain pine beetle (MPB), *Dendroctonus ponderosae*, and associated bark beetles such as *Ips pini*.

Approximately 8.5 million ha of mature pine were attacked by MPB in 2004, as represented in the 2005 Provincial Aerial Overview results (BCMOFR 2004, 2005) and it is estimated that number will increase 1.5-fold as a result of the 2005 beetle flight. In 2004, observations were made of MPB attacking young second growth pine stands. As a result of these observations, and field reconnaissance, a project was initiated to determine the extent, severity and implications of this new threat.

Young or small diameter pine has often been a "sink" for MPB during past outbreaks. A beetle "sink" can be defined as the phenomenon of MPB attacking trees in stands that are not thought of as susceptible due to age or size, and generally few, or no brood result from these attacks. The decline of the South Okanagan MPB outbreak (1984-1992) was in part due to the MPB being pushed into sub-optimal stands of very dense, small and often younger age pine (L. Maclauchlan, personal observations). Even if beetle production out of young stands is minimal, the local and landscape level conditions of this MPB outbreak are very different from past outbreak conditions. Beetle pressure, size and extent of the outbreak (>8.5 mill. ha) (Fig. 1), and the mixing and dispersal of beetles over the landscape is unprecedented.

As little as 25% mortality (e.g. less than 700 sph live) (M. Madill, personal communication) could cause a stand to be classified as NSR (not satisfactorily restocked) and therefore may require rehabilitation measures. Given the MPB pressure and levels of attack observed in 2004 and 2005, many of our young stands could become NSR in the next few years. As with mature stand risk (Safranyik et al. 2004; Shore and Safranyik 1992; Safranyik and Linton 1985; Safranyik and Jahren 1970), risk to young stands is highly dependent upon the level of MPB activity in adjacent stands or proximity to an ongoing outbreak. Normally, lodgepole pine less than 60 years of age would not be considered at risk to MPB due to their age, diameter and other physical attributes (Shore and Safranyik 1992). However, many young stands in these putatively low susceptible age- and size-classes are currently under attack.

Recent drought conditions may have increased the vulnerability of young trees, however many trees in managed stands reach diameters that are acceptable to MPB and other beetles at an earlier age than trees in naturally regenerated, unmanaged, and more densely grown stands. Existing plantations are likely very different than naturally regenerated stands, which result from insect and fire mortality. Therefore, current attack in young stands may be a result of changing parameters of susceptibility and the tremendous pressure from the beetle thus creating these beetle "sinks".

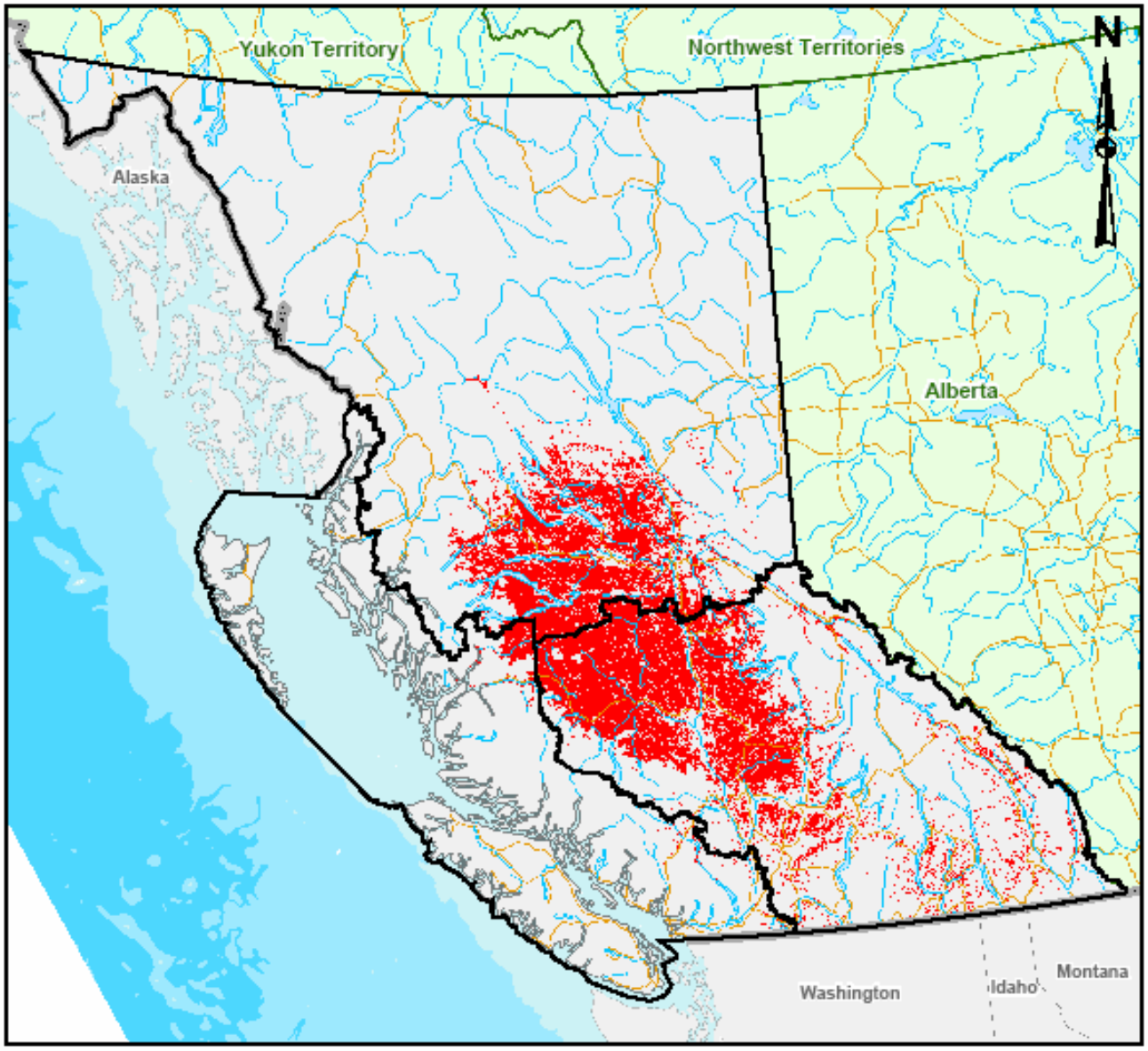


Figure 1. Map of B.C. with regional boundaries showing the extent of mountain pine beetle as mapped during the 2005 aerial overview survey.

The key objectives of this project are to:

1. determine the current level and severity of MPB attack in young pine;
2. determine the relative risk and damage to different age cohorts between 20 and 55 years;
3. determine the future risk to young pine in the various locations and stages within the current outbreak parameters; and,
4. determine if the MPB will propagate successfully within these younger pine.

The emphasis of this report will be on the extent and severity of mountain pine beetle damage throughout the core outbreak area in central British Columbia.

Methods

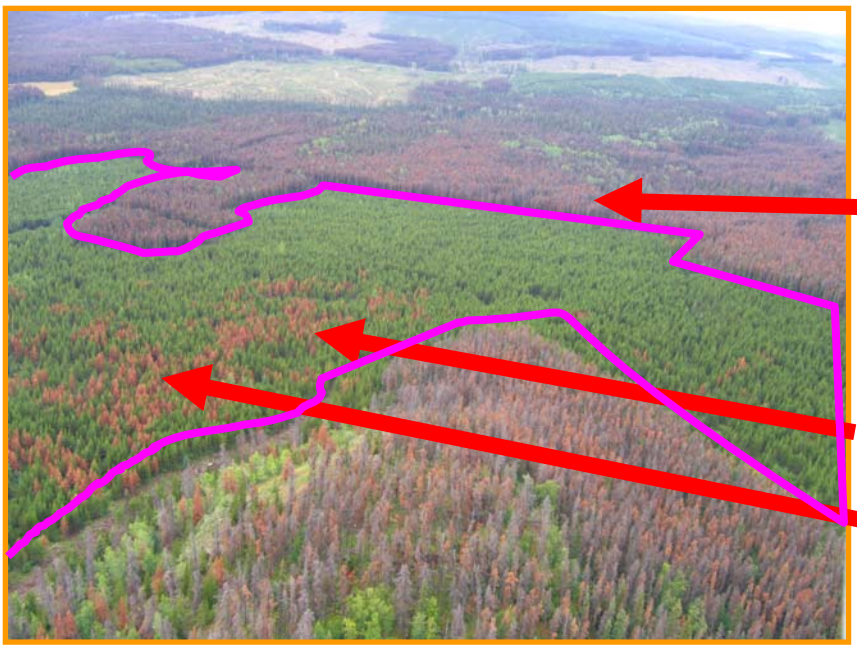
A 3-tiered approach was implemented to quantify and evaluate the incidence, impact and future risk to mountain pine beetle, *Ips pini* and other major forest health concerns in young lodgepole pine stands. The three levels of assessment included aerial surveys, ground surveys and 0.25 ha permanent sample plots to monitor long term impacts, brood production and success. Vegetation Resource Inventory (VRI) (BCMOFR 2005) provided the inventory data base for the Northern and Southern Interior Forest Regions of pine leading stands (20-55 years). For surveys conducted in 2005, the VRI data was stratified by 5-year age increments (20-25, 26-30, 31-35 and so on) (Table 1) for openings 5 hectares or greater with >80% lodgepole pine component.

Table 1. Total hectares of leading lodgepole pine (>80%) by 5-year age increments within nine forest districts comprising the study area.

	Ha of lodgepole pine by age category (years)					Grand Total
District	20-25	26-30	31-40	41-50	51-55	(ha)
100 Mile House	21,925	12,177	13,723	8,715	1,863	58,403
Central Cariboo	26,168	12,017	24,130	31,901	5,633	99,849
Chilcotin	8,321	5,000	41,123	73,655	15,759	143,858
Kamloops	6,301	3,677	2,189	3,962	2,330	18,458
Nadina	26,715	16,129	14,849	8,419	8,292	74,404
Okanagan Shuswap	36,603	14,862	10,763	4,496	2,290	69,014
Prince George	23,762	12,060	24,184	18,032	2,506	80,544
Quesnel	28,162	14,002	15,759	25,067	13,776	96,766
Vanderhoof	21,314	14,836	23,281	10,782	10,056	80,269
Grand Total	199,271	104,761	169,999	185,029	62,505	721,565

Aerial Surveys

The aerial survey enabled a far greater subset of potentially impacted stands to be assessed than ground surveys. The inherent limitation of aerial surveys was that it is only possible to record past attack levels. The data collected included: percent red and grey attack in polygons; the spatial pattern of attack (i.e. scattered, clumped, random); a "2006 risk" rating for the young stand based upon adjacent mature stands (i.e. low, moderate, high or negligible); and, an assessment of the outbreak in adjacent mature stand based on level of mortality and availability of mature host material (increasing, ongoing or declining). A photograph was taken of each polygon capturing the adjacent mature stand.



Photograph of young stands as viewed during aerial survey showing how attack levels are estimated and surrounding risk assessed.

Ground Surveys

Twenty three to thirty stands were surveyed in each District within the core area of the outbreak. Variable radius plots (5 or 10 based upon polygon size) were established in each stand and the following information was collected: dbh; height; number and species of stems (>10 cm unless attacked by *Ips* or MPB); presence of other major pests; and MPB attack information (year of attack, attack density, brood success).

Permanent Sample Plots

Fifteen 0.25 ha permanent sample plots were established throughout the study area. Plots were located to obtain a cross-section of tree age and size, level of attack, stand origin and management (harvested, fire regenerated, spaced, pruned), and adjacent beetle pressure and future risk.

In addition to the above surveys, brood success, production and the influence of climate is being studied. Young lodgepole pine attacked in 2005 will be reared in controlled temperature environmental chambers and *in* situ with a climate station monitoring environmental conditions.

Results and Discussion

The majority of aerial and ground surveys were conducted in the core, or older and more severe, parts of the MPB outbreak area including Prince George, Quesnel, Vanderhoof, Central Cariboo, 100 Mile House and Nadina Forest Districts. Small areas within the Chilcotin, Kamloops and Okanagan Shuswap areas were surveyed; however, attack in young pine in these three districts was still very sporadic. Therefore, the results discussed refer primarily to the former six districts. Of approximately 1.96 million ha of young pine between the ages of 20-55 years in B.C., 490,236 ha (25%) occur within these

six districts (Table 1). Other districts in the south and to the north of the core outbreak area also have very large areas of young pine that could also be at risk in the coming years.

Aerial Survey Results

The total area of young pine aerially surveyed in each of the six districts ranged from 4% to 14%, averaging 9.7% coverage overall (Table 2). The total rotary wing flying time was 41 hours. A total of 1,164 polygons were surveyed and 49.2% had some level of 2004 MPB attack (red attack). Observed attack levels ranged from 0 to 95% red attack (Fig. 2) with over 50 polygons (4.3% of total) having greater than 50% red attack (Fig. 2). Once a representative number of polygons from each age class was surveyed on each mapsheet, the surveyors would move on to the next map unless there was extreme variation within an age. This gave a uniform coverage both by geographic area and age (Table 2).

Table 2. Percent of total area of young pine surveyed by air in six forest districts broken down by age category. Kamloops, Okanagan Shuswap and Chilcotin Districts were excluded because of the small area flown.

	Percent of total area, by age, aerially surveyed					
	20-25	26-30	31-40	41-50	51-55	Total
100 Mile House	9.6%	20.0%	21.0%	8.6%	4.4%	14.1%
Central Cariboo	6.7%	17.3%	8.6%	1.7%	16.8%	7.4%
Nadina	10.4%	8.9%	4.7%	0.7%	7.5%	7.5%
Prince George	3.5%	4.7%	5.1%	3.0%	10.0%	4.2%
Quesnel	6.8%	19.4%	21.3%	5.2%	4.7%	10.3%
Vanderhoof	11.0%	17.1%	13.4%	19.4%	7.8%	13.6%
Grand Total	8.0%	16.1%	11.9%	5.3%	7.9%	9.7%

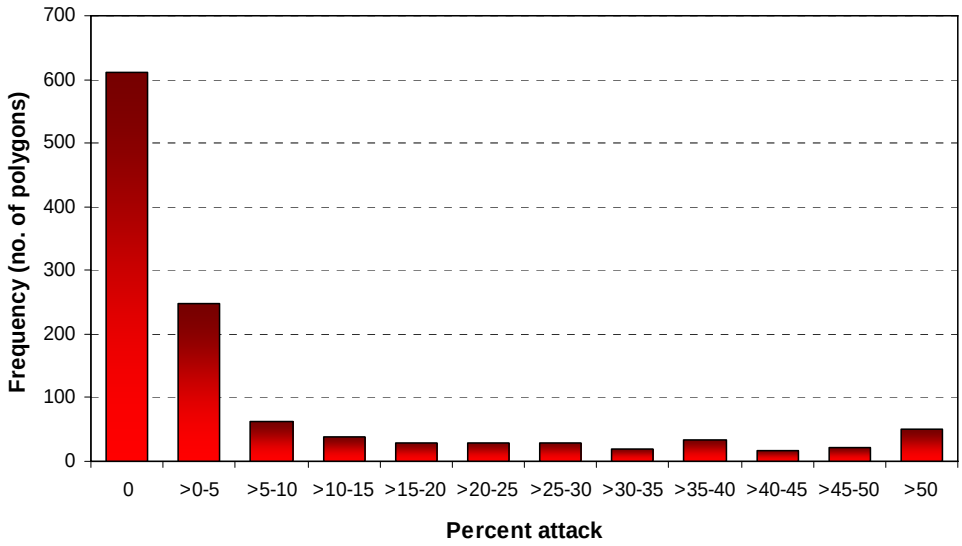


Figure 2. Summary of the frequency of polygons having different levels of MPB attack (red and grey attack combined).

Summarizing all Districts flown, the highest frequency of MPB attack was observed in polygons over the age of 40 (Table 3). Polygons containing 31-40 year old lodgepole pine also had a high frequency of MPB attack, with 62.5% of polygons surveyed having some level of attack (Table 3). In the heavier and older areas of the MPB outbreak the beetles are not distinguishing these intermediate age classes from mature stands and that the majority of the40-year plus stands will have moderate to severe attack levels. Relatively little MPB attack occurred in young stands until 2004 (Figure 3) . However, stands over 40 years which presumably contained larger stems were the first to be attacked and to a much higher degree than younger ages (Fig. 3). On average, over 20% red attack and over 5% grey attack was observed in stands over 40 years which would represent greater than 25% mortality thus making the stands NSR (M. Madill, personal communication).

Table 3. Summary for all districts of the percent polygons, by age category, surveyed by air having MPB attack.

Age	No. of polygons surveyed	% polygons with MPB attack
20-25	320	28.4%
26-30	343	33.5%
31-40	285	62.5%
41-50	125	83.2%
51-55	90	93.3%
unknown	1	100.0%
	1164	49.2%

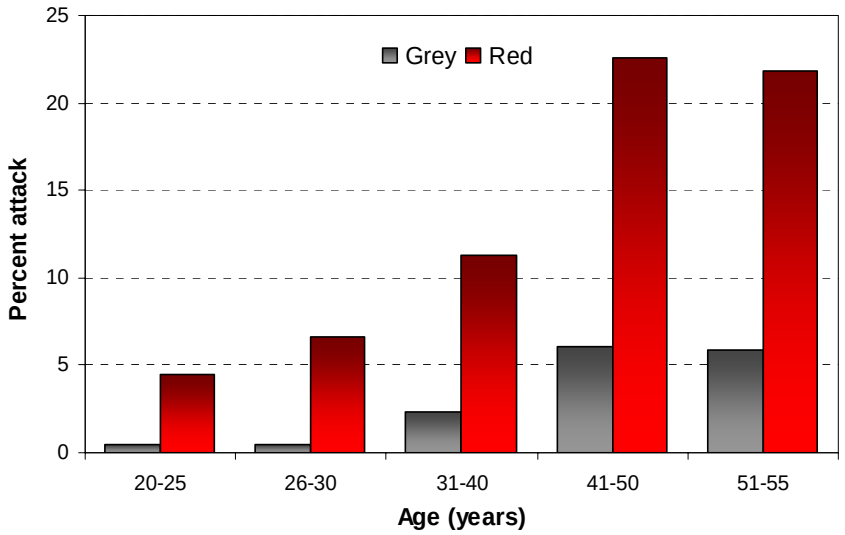


Figure 3. Summary of aerial surveys for all districts showing the average percent grey attack (prior to 2004) and red attack (2004 attack) within young lodgepole pine polygons surveyed in 2005.

Table 4 summarizes, by district and age, the number of polygons with no MPB attack, with MPB attack, average percent attack within polygons and the overall percent polygons with MPB attack. As predicted, the districts with the highest occurrence of MPB attack in young stands, such as Quesnel, Prince George and Vanderhoof, were those in the more established areas of the outbreak (Table 4). The high frequency of attack seen in the Central Cariboo, 100 Mile House and Nadina (Table 4) are testament to the exponential increases in beetle populations over the past two years and rapidly diminishing mature host resource. In particular, 100 Mile House and Nadina Districts, having 38.4% and 31.4% of polygons surveyed showing presence of MPB attack respectively, are newer outbreak areas yet very high levels of young pine are under attack. This may be in part due to the long range movement and mixing of beetle populations out of the core area of the outbreak.

While conducting the aerial surveys, assessment of adjacent and future risk to the young stands were made. Adjacent risk was a prediction of the probability of the stand being attacked by MPB in 2006 and beyond, based upon adjacent stand parameters such as the level of harvest surrounding the stand, proximity to active MPB and availability of mature host (Table 5). Adjacent risk was not intended to predict the current level of green attack in the stand. The other assessment, future risk, although similar, was largely based upon the outbreak parameters of the geographic area and was defined as decreasing, increasing or static (Table 6). These assessments were conducted to assist in prioritizing stands most likely to be impacted by MPB for future surveys or rehabilitation.

The trends seen in Table 5 seem to verify our assumptions in that Prince George and Quesnel have the highest number of polygons with nil to low risk of attack in 2006. Only 22.5% and 14.1% in Quesnel and Prince George respectively are at high risk of attack in 2006. As figure 1 shows, the majority of mature pine has been infested in these two districts and the beetle has moved away from many of the locations where these young stands are located, thus reducing the future risk of attack. Therefore, within 2 years there should be less attack seen in young stands in the core of the outbreak, unless beetles move back into these areas. 100 Mile House and Nadina Districts show the opposite trend, with 37.9% and 55% of stands, respectively, at high risk to attack in 2006 and beyond (Table 5). In Quesnel, Prince George and Vanderhoof the majority of stands, 76.9%, 69.2% and 68.7% respectively, have decreasing future risk (Table 6). The Central Cariboo also shows a decreasing trend, with 60.4% of polygons assessed with decreasing risk. This could be largely due to rapid and severe infestation levels observed in the area over the past two years (BCMOF 2004, 2005).

Cross section of young pine, 24 years old, attacked by MPB in the Central Cariboo, July 2005.

Table 4. Summary by district and age of polygons aerially surveyed, showing the number of polygons with no MPB attack, with MPB attack, the average percent attack within polygons and the overall percent polygons with MPB attack.

	No. of polygons		Average attack (%)		% polygons with
Age (years)	No attack	Attacked	Red	Grey	MPB attack
100 Mile House					
20-25	51	9	6.6	1.2	15.0%
26-30	62	8	1.8	0.0	11.4%
31-40	18	40	5.6	0.7	69.0%
41-50	1	23	12.0	4.1	95.8%
51-55	1	3	17.7	10.0	75.0%
	133	83	7.5	2.0	38.4%
Quesnel					
20-25	17	26	3.3	1.6	60.5%
26-30	27	34	9.6	0.3	55.7%
31-40	7	45	13.2	5.7	86.5%
41-50	0	17	20.1	19.8	100.0%
51-55	1	16	23.1	15.9	94.1%
unknown	0	1	12.5	0.0	100.0%
	52	139	12.6	6.5	72.8%
Prince George					
20-25	12	7	8.8	0.0	36.8%
26-30	17	9	7.7	0.0	34.6%
31-40	24	14	8.2	0.4	36.8%
41-50	3	21	44.2	2.0	87.5%
51-55	0	14	28.1	0.9	100.0%
	56	65	24.1	0.9	53.7%
Central Cariboo/Chilcotin					
20-25	28	23	5.2	0.1	45.1%
26-30	16	37	16.9	2.7	69.8%
31-40	12	33	21.5	8.6	73.3%
41-50	7	12	30.0	13.9	63.2%
51-55	1	14	31.9	10.6	93.3%
	64	119	19.0	5.9	65.0%
Vanderhoof					
20-25	52	15	3.3	0.0	22.4%
26-30	60	13	3.7	0.0	17.8%
31-40	33	38	11.4	0.7	53.5%
41-50	8	30	21.4	2.3	78.9%
51-55	2	19	18.0	3.8	90.5%
	155	115	13.2	1.4	42.6%
Nadina					
20-25	65	9	3.0	0.0	12.2%
26-30	16	8	6.0	0.0	33.3%
31-40	12	8	19.0	0.0	40.0%
41-50	2	1	30.0	0.0	33.3%
51-55	1	18	34.3	0.0	94.7%
	96	44	19.9	0.0	31.4%

Table 5. Summary of adjacent risk for all ages of polygon combined, by district, noting the percent of total surveyed in each district. Adjacent risk is the subjective probability of that polygon getting attacked in 2006 based on level of MPB in adjacent mature stands, harvesting activity and other parameters.

		Adjacent risk		
		Nil	Low	High
100 Mile	% polygons	3.8%	58.3%	37.9%
Quesnel	% polygons	13.3%	64.2%	22.5%
Prince George	% polygons	64.1%	21.8%	14.1%
Central Cariboo / Chilcotin	% polygons	8.0%	49.4%	42.6%
Vanderhoof	% polygons	28.7%	28.7%	42.6%
Nadina	% polygons	0.7%	44.3%	55.0%

Table 6.Summary of future risk for all ages of polygon combined, by district, noting the percent of total surveyed in each district. Future risk is based on observed and known outbreak parameters in the location of the young stand. Future risk is defined: Decreasing – most mature pine in area is grey or red (older outbreak); Increasing – building MPB with mature host remaining (newer outbreak); and, Static – moderate MPB with some mature host remaining (mid- to full-outbreak).

		Future risk assessment			
		Decreasing	Increasing	Static	Total
100 Mile	% polygons	37.4%	32.5%	30.0%	
Quesnel	% polygons	76.9%	9.4%	13.7%	
Prince George	% polygons	69.2%	12.8%	17.9%	
Central Cariboo / Chilcotin	% polygons	60.4%	21.6%	18.0%	
Vanderhoof	% polygons	68.7%	16.9%	14.5%	
Nadina	% polygons	39.0%	14.7%	46.3%	

Ground Surveys Results

164 polygons comprising 1,185 circular plots were ground surveyed in 2005 (Table 7). Attack levels in stands ground surveyed ranged from no attack to 98% of the stems attacked. This level of attack renders the stand NSR and therefore must be scheduled for reforestation. 48.2% of polygons had some level of MPB attack (Fig. 4) and over 23% had attack levels greater than 50% within the stands (Fig. 4). Approximately half of the

stands surveyed had been spaced (Table 7) but there was no significant difference in level of MPB attack in spaced or unspaced stands (Table 8). The level of attack increased dramatically in 2005 as illustrated in Figure 5. The average percent of red attack (2004 attack) compared to green attack (2005 attack) increased from 1.2-fold in the Central Cariboo to over 21-fold in Vanderhoof. Quesnel experienced over a 7-fold increase in average attack levels in from 2004 to 2005 (Fig. 5).

Table 7. Summary attributes from the 2005 ground surveys in young pine stands, by district.

Attributes	Prince George	100 Mile House	Quesnel	Vanderhoof	Central Cariboo / Chilcotin	Nadina
No. polygons	28	30	25	29	23	29
No. plots	180	195	175	185	160	290
Ave. density (sph)	1,180	663	843	1,221	1,025	1,213
No. spaced polygons	13	11	13	14	8	17
Ave. Pl dbh (cm)	15.7	12.9	13.8	13.9	13.4	15.3
Ave. age (years)	28.2	27.4	27.9	27.1	30.4	29.9
Ave. height (m)	13.7	8.7	9.9	12.0	10.4	11.9
Ave. % green attack	23.2	14.2	32.6	23.4	13.3	10.0
Ave. green attack dbh (cm)	16.7	15.5	15.1	15.1	15.8	20.0
Ave. % red attack	4.9	3.3	4.3	1.1	11.4	0.7
Ave. red attack dbh (cm)	20.6	19.4	20.7	22.5	16.8	16.7
Ave. % unattacked	71.9	82.7	63.1	75.5	75.3	89.3
Ave. unattacked dbh (cm)	14.8	12.1	12.5	13.0	12.9	14.7

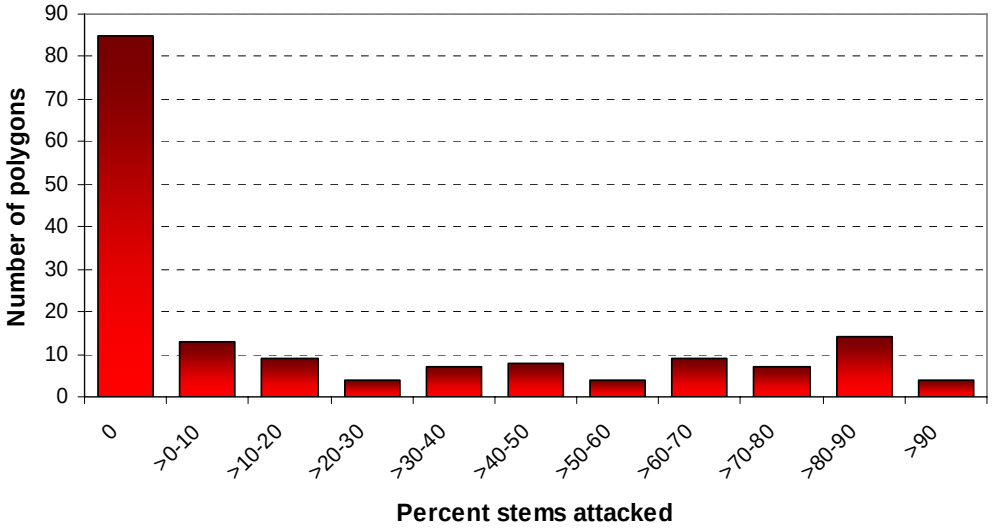


Figure 4. Frequency distribution showing the number of polygons surveyed falling into each attack category. Ground surveys from all districts are included.

Table 8. Comparison of the average percent pine stems remaining unattacked in all ground survey plots, by district and management (spaced *versus* unspaced).

	Prince George	100 Mile House	Quesnel	Vanderhoof	Central Cariboo[1]	Nadina[2]
Not spaced	78.5	84.5	62.7	70.7	70.7	86.6
Spaced	64.3	77.5	63.5	80.6	86.0	89.4

[1] Three additional stands were spaced and pruned and none were yet attacked by MPB.
[2] Five stands were not identified as spaced or natural and had 67.6% stems unattacked.

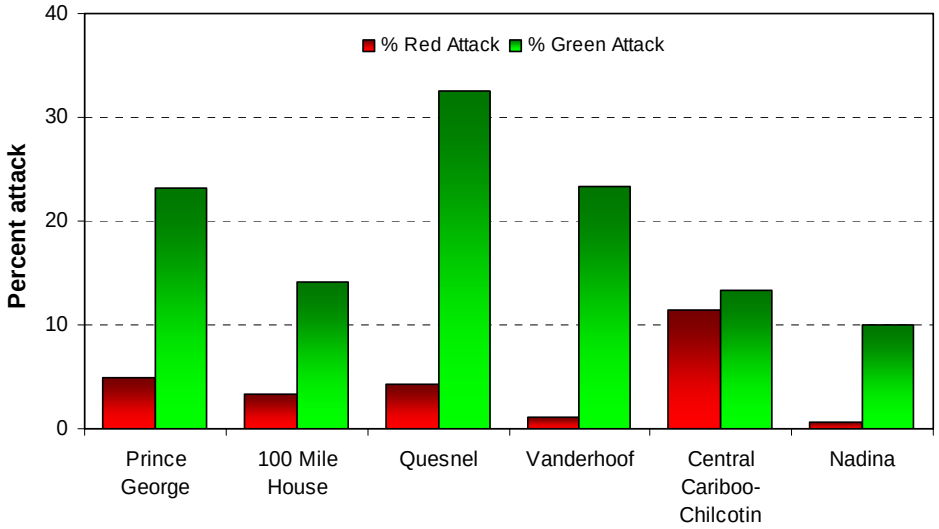


Figure 5. Average percent of red and green attack representing 2004 and 2005 MPB attack, respectively, recorded in ground surveys within six forest districts.

Another MPB attack trend that was evident is the classic "oldest and largest first" rule, although the largest trees were not always the oldest in young managed stands. Figure 6 clearly illustrates that the beetles chose the largest trees in the stands first. In many cases the trees remaining were 12 cm at dbh or less (Table 7, Fig. 6). These smaller diameter trees are also vulnerable to attack by *Ips pini*, which has been increasing, particularly in the Central Cariboo and 100 Mile House Districts (personal observations). The average tree size under attack in 2005 was 15 cm, however trees as small as 10 cm dbh were attacked in certain stands (Appendix 1).

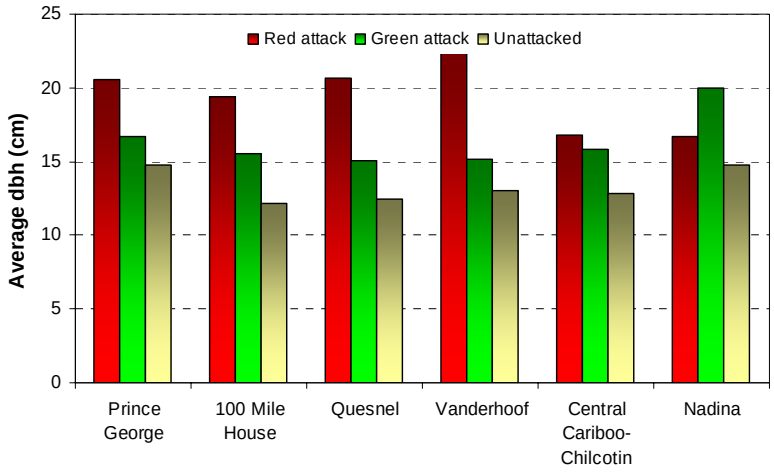


Figure 6. Average diameter (cm) of attacked and unattacked lodgepole pine in ground survey plots within the Prince George, 100 Mile House, Quesnel, Vanderhoof, Central Cariboo / Chilcotin and Nadina Forest Districts.

Aerial survey estimates of red attack were well correlated with ground survey estimates of red attack in all districts. Figure 7 compares the aerial and ground observations from six polygons in the Central Cariboo that were surveyed by both air and ground methods. The adjacent risk rating assigned to each polygon revealed that the polygons rated as very low have minimal in-stand attack and will most likely continue to have low levels of attack. Whereas the polygons rated as low will likely continue to sustain moderate levels of attack in 2006. Due to diminishing sources of beetles in surrounding stands and fewer and likely smaller live stems remaining in young stands (Fig. 7) already impacted by MPB, the risk will begin to decrease within the core outbreak area in2 years. The polygon rated as high adjacent risk has moderate in-stand attack, ample remaining host trees and a high level of active beetle in surrounding mature stands (Fig. 7) there remain at high risk for future attack by MPB.

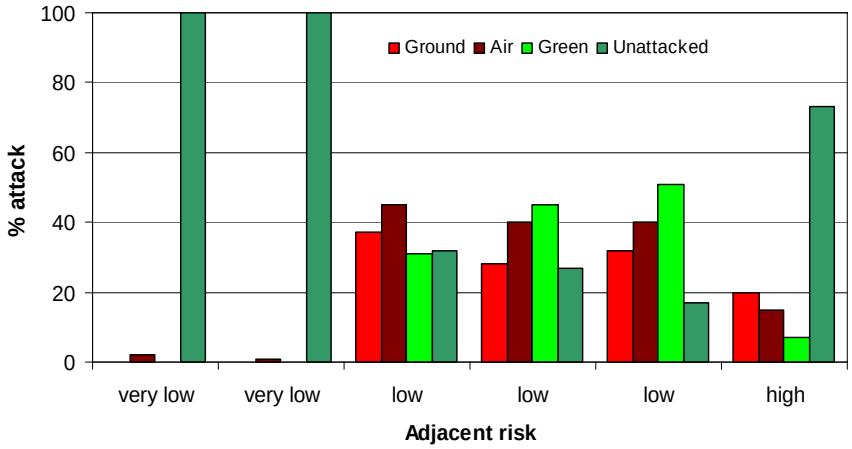


Figure 7. Comparison of aerial and ground observations from six polygons in the Central Cariboo that were surveyed by air and ground. Ground and air percent of red attack is shown along with percent of green attack and unattacked pine collected in ground surveys. The adjacent risk rating assigned to each polygon is shown on the x-axis.

Photograph of young stand in the Central Cariboo with moderate levels of attack within and surrounding the stand.

Table 9 shows the location and parameters of the 15 permanent plots established in 2005. Attack in these plots ranged from no attack to 81% (Table 9). Location rather than density seems to be more important in terms of whether or not the stand will be attacked.

Table 9. List of 15 permanent plots established in 2005 noting stand age, density (sph), management (spaced, planted, naturally regenerated) and percent stems attacked by MPB.

Location	Age	Stems per ha	Treatment	% stems attacked
100 Mile House	20-25	1,316	spaced	0
Prince George	20-25	1,568	spaced	57
Central Cariboo	20-25	1,416	planted	71
100 Mile House	26-30	1,160	spaced	0
150 Mile House	26-30	1,224	spaced	0
Central Cariboo	26-30	1,200	planted	0
Vanderhoof	26-30	1,280	spaced	1
Quesnel	26-30	804	spaced	30
Central Cariboo	26-30	1,244	spaced	42
Central Cariboo	26-30	1,636	unspaced	42
Prince George	31-40	1,440	spaced	1
Quesnel	31-40	880	spaced	63
100 Mile House	41-50	1,428	nat. regen.	81
100 Mile House	51-55	872	nat. regen.	42
Prince George	51-55	1,420	spaced	64

Work on determining if the mountain pine beetle will successfully develop and expand within young pine is still ongoing. However, preliminary data show that due to extremely high attack densities in young pine, ranging from 117 galleries/m^2 to >300 galleries/m^2, very little emergence has been observed. Raffa and Berryman (1983) determined that reproductive success of the MPB decreases at attack densities greater than 80 galleries/m^2. Larger diameter tree are yielding some brood success and this may increase as MPB dispersal into these stands decrease and attack densities approach normal levels.

This report summarizes the results from the first year in a multi-year project. It is imperative to continue assessing the impact of MPB in our young pine stands in order to rapidly respond and regenerate these areas. It is hoped that this will remain a priority with the government and industry so that more extensive and intensive coverage will be possible in 2006. We plan to expand the evaluation to include more southern and northern areas of the province. Numerous collaborative projects have been initiated to facilitate this work. There are also ongoing research trials that will determine the likelihood of brood success in young lodgepole pine and the effects of temperature on their success.

MPB gallery density in young pine is above the optimum for brood success so very little emergence has been observed from these young stands.

References

British Columbia Ministry of Forests and Range. 2005. 2005 Summary of Forest Health Conditions in British Columbia. BC Ministry of Forests, Forest Practices Branch, Victoria, BC. *in preparation.*

British Columbia Ministry of Forests. 2004. 2004 Summary of Forest Health Conditions in British Columbia. BC Ministry of Forests, Forest Practices Branch, Victoria, BC.

Ministry of Forests and Range. 2005. Vegetation Resource Inventory Data base.

Raffa, K.F. and A.A. Berryman. 1983. The role of host plant resistance in the colonization behavior of bark beetles (Coleoptera: Scolytidae). Ecol. Monogr. 53: 27-49.

Safranyik, L., T.L. Shore, A.L. Carroll and D.A. Linton. 2004. Bark beetle (Coleoptera: Scolytidae) diversity in spaced and unmanaged mature lodgepole pine (Pinaceae) in southeastern British Columbia. Forest Ecology and Management 200: 23-38.

Safranyik, L and D.A. Linton. 1985. The relationship between density of emerged Dendroctonus ponderosae (Coleoptera: Scolytidae) and density of exit holes in lodgepole pine. Can. Entomol. 117: 267-275.

Safranyik, L. and R. Jahren. 1970. Host characteristics, brood density and size of mountain pine beetles emerging from lodgepole pine. Dept. Fish. For. Can., Bimonthly Res. Notes 26:35-36.

Shore, T.L. and L. Safranyik. 1992. Susceptibility and risk rating systems for the mountain pine beetle in lodgepole pine stands. Forestry Canada, Pacific and Yukon Region, Pacific Forestry Centre, Information Report BC-X-336.

Appendix 1. Summary statistics from ground surveys conducted in seven forest districts in the summer of 2005.

Mapsheet	Opening	No. Plots	Average Density	Spaced Yes/No	dbh (Pl)	Average Age	Height (m)	% green attack	dbh	% red attack	dbh	% unattacked	dbh
Prince George													
93G 066	31	10	1,353	N	15.3	23	14.7	72	16.4	0		28	12.3
93H 081	64	10	798	N	18.1	24	14.4	79	18.4	10	21.7	11	12.5
93H 071	606	5	1,327	N	15.9	24	13.5	0		0		100	15.9
93H 071	718	5	1,007	N	11.8	?	9.4	0		0		100	11.8
93H 071	697	5	1,063	N	21.5	33	18.1	7	15.3	72	23.1	21	17.8
93G 084	1216	5	1,330	N	13.6	?	14.1	0		0		100	13.6
93G 084	2797	10	1,151	N	14.9	20	12.3	0		0		100	14.9
93G 086	140	10	538	N	14	21	9.3	82	14.3	0		18	12.8
93J 026	898	5	1,105	N	15.2	25	10.9	0		0		100	15.2
93G 085	1466	5	1,285	N	13.8	26	12.6	0		0		100	13.8
93G 039	62	10	1,168	N	18.2	32	15.7	0		0		100	18.2
93G 039	24	5	1,585	N	14.8	30	12.6	0		0		100	14.8
93J 057	660	5	438	N	24.7	55	24.3	0		0		100	24.7
93J 058	703	10	1,209	N	16	20	9.7	0		0		100	16
93J 068	390	5	1,325	N	12.5	25	11.9	0		0		100	12.5
93G 066	146	5	1,212	Y	18.1	30	15.0	33	19.2	0		67	17.5
93G 066	255	5	1,397	Y	16.6	22	13.9	2	22.0	0		98	16.5
93G 042	94	5	1,300	Y	15.1	41	17.0	20	13.6	54	16.9	26	12.5
93G 042	170	5	1,250	Y	13.1	22	10.7	84	13.4	0		16	12
93G 043	338	10	1,505	Y	13.2	26	12.1	89	13.4	0		11	11.1
93G 043	70	5	1,345	Y	12.1	24	11.9	98	12.2	0		2	10.3
93J 026	197	5	1,720	Y	14	25	12.6	0		0		100	14
93G 085	551	5	1,220	Y	14.3	22	12.7	0		0		100	14.3
93G 085	1543	5	1,525	Y	13.2	28	13.6	0		0		100	13.2
93G 094	2809	5	1,092	Y	18.4	37	16.3	0		0		100	18.4
93J 058	239	5	667	Y	24.5	49	22.7	84	25.4	0		16	19.9
93J 078	839	10	1,074	Y	13	26	11.6	0		0		100	13

Mapsheet	Opening	No. Plots	Average Density	Spaced Yes/No	dbh (Pl)	Average Age	Height (m)	% green attack	dbh	% red attack	dbh	% unattacked	dbh
93J 078	770	5	1,060	Y	13.9	23	10.9	0		0		100	13.9
100 Mile House													
92P 061	380	10	706	N	12.8	29	7.5	0.0		0.0		100.0	12.8
92P 061	569	5	795	N	15.2	42	11.3	2.5	13.3	32.5	24.0	65.0	11.2
92P 027	746	5	580	Y	13.9	27	7.6	2.0	27.0	0.0		98.0	13.6
92P 027	830	5	637	N	12.2	25	8.1	0.0		0.0		100.0	12.2
92P 027	838	5	510	N	10.3	24	6.7	0.0		0.0		100.0	10.3
92P 036	320	5	360	Y	10.4	24	6.4	0.0		0.0		100.0	10.4
92P 036	396	5	863	Y	13.0	31	8.9	0.0		0.0		100.0	13.0
92P 036	28	5	573	Y	13.5	27	7.5	0.0		0.0		100.0	13.5
92P 054	811	10	768	Y	12.5	25	7.8	0.0		5.0	14.0	95.0	12.3
92P 054	782	10	877	N	14.2	27	11.2	0.0		8.0	18.3	92.0	13.8
92P 054	87	10	707	N	13.4	35	10.3	10.0	15.3	0.0		90.0	13.2
92P 054	1127	5	590	N	10.5	25	9.4	0.0		0.0		100.0	10.5
92P 054	492	5	660	N	11.5	24	9.4	20.0	12.9	0.0		80.0	11.1
92P 054	870	5	1007	N	14.7	28	10.7	0.0		0.0		100.0	14.7
92P 063	679	5	670	Y	18.9	27	11.8	81.0	20.3	0.0		19.0	12.9
92P 063	105	5	600	N	17.3	41	12.8	4.5	12.5	41.0	23.0	54.5	13.8
92P 063	97	5	535	N	14.7	23	9.7	0.0		0.0		100.0	14.7
92P 031	1808	5	327	N	11.5	23	6.3	0.0		0.0		100.0	11.5
92P 031	984	10	1228	N	14.1	41	11.3	77.0	14.6	7.0	17.1	16.0	11.0
92P 031	1435	10	529	Y	11.1	25	6.6	0.0		0.0		100.0	11.1
92P 063	857	5	619	N	13.6	29	9.4	65.0	14.2	2.5	26.5	32.5	11.3
92P 063	840	5	865	Y	13.4	28	10.2	66.5	14.3	0.0		36.5	12.3
92P 062	953	5	690	N	11.6	25	7.4	0.0		0.0		100.0	11.6
92P 062	866	5	340	N	10.2	17	5.8	0.0		0.0		100.0	10.2
92P 062	1021	5	933	N	12.8	?	7.9	25.0	13.8	0.0		75.0	12.4
92P 062	875	10	606	Y	11.7	23	7.5	0.0		0.0		100.0	11.7
92P 062	598	10	813	Y	12.1	30	8.8	71.5	12.6	2.5	12.7	26.0	10.8
92P 053	473	5	543	?	12.9	27	7.9	0.0		0.0		100.0	12.9

Mapsheet	Opening	No. Plots	Average Density	Spaced Yes/No	dbh (Pl)	Average Age	Height (m)	% green attack	dbh	% red attack	dbh	% unattacked	dbh
92P 053	460	10	565	N	12.2	20	7.9	0.0		0.0		100.0	12.2
92P 054	713	5	383	N	10.7	22	6.2	0.0		0.0		100.0	10.7
Quesnel													
93B 096	56	10	872	Y	12.9	29	10.8	41.0	14.2	2.5	16.5	56.5	11.8
93B 095	363	5	773	Y	12.7	23	10.1	42.5	13.7	0.0		57.5	11.9
93G 005	2514	5	513	Y	16.5	21	9.3	68.0	17.8	0.0		32.0	13.4
93G 005	2061	10	830	Y	15.2	25	10.4	38.0	17.7	0.0		62.0	13.7
93G 005	2067	10	880	N	14.6	22	9.2	0.0		0.0		100.0	14.6
93B 095	2006	10	896	Y	12.7	25	9.0	0.0		0.0		100.0	12.7
93B 069	562	10	987	N	15.6	33	14.1	44.0	16.4	24.0	19.8	32.0	11.4
93B 069	661	5	1025	N	15.9	?	15.0	29.0	14.8	44.0	17.9	27.0	13.7
93B 085	565	5	680	N	14.1	27	10.7	62.5	15.8	0.0		37.5	11.2
93B 085	436	5	812	Y	14.4	21	10.7	98.0	14.5	0.0		2.0	10.2
93B 094	2041	10	840	Y	14.2	21	8.9	17.5	15.8	0.0		82.5	13.8
93B 093	862	5	1173	N	12.7	48	11.1	46.5	14.0	0.0		53.5	11.6
93B 067	707	10	667	Y	14.5	25	8.8	0.0		0.0		100.0	14.5
93B 067	320	5	1450	N	12.7	24	8.4	0.0		0.0		100.0	12.7
93B 065	189	10	583	Y	15.2	23	8.6	40.5	16.5	0.0		59.5	14.4
93B 065	797	5	867	Y	13.7	29	8.2	10.0	15.9	0.0		90.0	13.5
93B 075	676	10	477	Y	16.1	25	10.0	86.5	16.5	0.0		13.5	13.6
93B 066	486	10	859	Y	12.5	24	7.4	14.5	13.9	0.0		85.5	12.3
93B 066	89	5	560	N	10.7	24	7.3	0.0		0.0		100.0	10.7
93B 076	702	5	1065	Y	12.5	24	7.8	15.0	15.1	0.0		85.0	12.0
93B 056	284	5	1355	N	13.6	45	11.5	73.0	13.7	9.0	17.1	18.0	11.4
93B 057	556	5	747	N	14.3	45	12.0	40.0	14.1	7.5	31.3	52.5	11.9
93B 057	402	5	507	N	14.1	39	10.9	41.5	12.7	19.5	21.4	39.0	11.8
93B 047	1043	5	647	N	11.4	23	7.6	0.0		0.0		100.0	11.4
93B 047	898	5	1012	N	12.3	24	8.6	7.0	13.8	0.0		93.0	12.2
Vanderhoof													
93G 072	155	5	1485	Y	13.8	25	13.4	0.0		0.0		100.0	13.8

Mapsheet	Opening	No. Plots	Average Density	Spaced Yes/No	dbh (Pl)	Average Age	Height (m)	% green attack	dbh	% red attack	dbh	% unattacked	dbh
93G 072	105	5	1595	N	15.5	37	17.1	60.0	16.6	7.0	21.8	33.0	12.4
93G 072	351	5	1030	Y	16.7	24	13.0	93.0	17.1	0.0		7.0	11.7
93G 072	41	10	1323	Y	13.0	22	11.4	0.0		0.0		100.0	13.0
93G 063	5	5	1600	Y	14.9	21	12.9	44.0	15.4	0.0		56.0	14.5
93G 063	246	10	1181	Y	14.6	27	15.1	12.0	15.4	0.0		88.0	14.5
93G 062	196	5	1273	N	15.0	25	12.2	14.0	14.7	0.0		86.0	15.1
93K 029	343	5	773	N	12.9	?	9.0	2.0	17.2	0.0		98.0	12.9
93K 029	131	5	1055	N	8.8	54(?)	8.0	0.0		0.0		100.0	8.8
93K 028	549	10	990	N	19.6	26	12.9	0.0		0.0		100.0	19.6
93G 083	1573	5	1545	Y	14.0	28	11.9	0.0		0.0		100.0	14.0
93G 083	477	10	1381	Y	13.0	27	12.6	0.0		0.0		100.0	13.0
93G 092	520	10	1046	N	14.4	26	11.8	89.0	14.6	0.0		11.0	12.1
93G 092	697	5	760	N	13.1	27	13.3	2.0	16.0	0.0		98.0	13.0
93G 092	717	5	1387	N	12.7	39	14.6	65.0	13.4	0.0		35.0	11.3
93F 090	238	5	750	N	15.5	25	11.6	0.0		0.0		100.0	15.5
93F 090	243	5	987	N	14.9	31	14.8	96.0	15.0	0.0		4.0	10.3
93F 089	757	10	700	Y	13.8	24	9.5	6.0	16.5	0.0		94.0	13.7
93F 090	305	5	1220	Y	12.9	24	10.0	77.0	13.6	0.0		23.0	10.8
93F 090	757	5	2120	N	15.3	31	14.8	82.0	15.9	0.0		18.0	12.2
93F 029	1504	5	687	Y	10.1	15	5.5	0.0		0.0		100.0	10.1
93F 015	91	10	922	N	13.0	13	8.0	0.0		0.0		100.0	13.0
93F 058	1510	5	1080	Y	12.3	21	9.7	0.0		0.0		100.0	12.3
93F 058	391	5	1340	N	13.9	20	9.8	0.0		0.0		100.0	13.9
93F 058	191	10	1700	N	11.4	36	12.8	0.0		0.0		100.0	11.4
93F 058	555	5	1240	Y	12.6	22	10.0	2.0	10.1	0.0		98.0	12.7
93F 058	543	5	1820	N	12.0	48	13.9	10.0	13.0	12.0	15.1	78.0	11.4
93G 093	640	5	1060	Y	15.1	27	12.1	0.0		0.0		100.0	15.1
93G 093	449	5	1353	Y	18.1	42	17.4	24.0	17.6	13.0	30.6	63.0	15.7
Central Cariboo / Chilcotin													
93B 049	233	10	769		12.3	24	7.4	0		0		100	12.3

Mapsheet	Opening	No. Plots	Average Density	Spaced Yes/No	dbh (Pl)	Average Age	Height (m)	% green attack	dbh	% red attack	dbh	% unattacked	dbh
93B 040	2700	10	1050	N	13.8	27	11.2	51	13.2	32	15.6	17	12.5
93B 040	2749	5	479	Y	11.7		8.5	0		0		100	11.7
93B 040	2893	10	1200		13.4	23	10.7	45	14.0	28	13.7	27	12.0
93A 046	522	5	1620	Y	15.2	43	16.3	0		0		100	15.2
92O 037	99	10	1448		15.4	48	11.3	1	22.1	0		99	15.4
93A 073	875	5	1285	N	17.4	29	16.7	60	18.9	0		40	15.4
93A 073	448	5	1125		14.8	19	11.0	0		0		100	14.8
92O 078	169	10	1693		12.6	45	12.6	36	10.7	52	14.2	12	11.1
93B 030	2982	10	1118	Y	14.4	33	14.1	31	14.7	37	15.2	32	13.1
93B 040	2811	5	1057	N	12.4	18	10.1	6	13.2	25	13.9	69	11.8
93B 030	3242	5	1230	N	12.5	23	10.7	33	14.1	26	12.1	41	11.9
92O 066	318	10	922	N	14.0	54	10.4	0		11	21.4	89	13.1
92O 066	1600	5	715	Y	11.5	29	6.4	0		0		100	11.5
92O 066	505	5	917	N	12.2	26	8.4	0		0		100	12.2
93A 012	328	5	437	N	18.1	28	11.1	7	19.4	20	26.1	73	17.3
93B 006	160	5	1463	N	11.0	29	9.0	0		0		100	11.0
93B 006	1509	5	447	Y	11.2	26	6.8	0		0		100	11.2
93B 006	82	5	1200	N	12.4	33	9.7	2	16.1	15	17.7	83	11.3
93B 016	84	10	922	N	11.4	31	9.0	1	13.8	5	15.0	95	11.3
93B 016	756	5	988	Y	13.7	21	8.1	0		0		100	13.7
93B 050	429	5	547	Y	11.2	20	6.2	0		0		100	11.2
93A 046	500	10	946	Y	16.7	40	13.0	33	19.2	11	19.9	56	14.7
Nadina													
93K033	930	10	1643	Y	12.8	21	8.9	0		0		100	12.8
93K033	618	10	1200	N	12.4	23	9.7	0		0		100	12.4
93K 032	790	10	914	Y (Pr)	16.5	28	12	0		0		100	16.5
93K 032	604	10	1188	Y	14.2	22	9.3	0		0		100	14.2
93K 014	252	10	1680	N	16.2	58	19.7	53.7	19.2	0		46.3	12.8
93K 023	794	10	543	Y	23.8	39	17.6	84.1	24.8	0		15.9	18.6
93K 012	647	10	1318	N	17.4	44	16.8	59.2	19.4	0		40.8	14.6

Mapsheet	Opening	No. Plots	Average Density	Spaced Yes/No	dbh (Pl)	Average Age	Height (m)	% green attack	dbh	% red attack	dbh	% unattacked	dbh
93K 012	703	10	865	Y (Pr)	15.6	27	12.6	0		0		100	15.6
93F 062	500	10	914	Y	14.4	23	10.1	0		0		100	14.4
93F 062	378	10	1223	Y	14.5	22	9.4	0		0		100	14.5
93F 072	223	10	2010	N	13.5	47	17.4	16.5	13.5	19.3	16.7	64.2	12.6
93F 063	602	10	849	Y	13.2	23	9.8	0		0		100	13.2
93E 100	1081	10	877	Y	18.6	43	13.1	27.6	20.7	0		72.4	17.5
93E 099	476	10	1290	Y (Pr)	16.2	27	12.1	0		0		100	16.2
93E 099	446	10	1073	Y	15.4	26	9.9	0		0		100	15.4
93K 031	1416	10	1125	Y	14.2	24	10.9	0		0		100	14.2
93L 039	352	10	1311	N	14.1	24	9.1	0		0		100	14.1
93L 040	355	10	1413	N	15.4	27	12.8	0		0		100	15.4
93L 049	324	10	702	Y	14.4	21	9.4	0		0		100	14.4
93L 050	150	10	1750	N	14.6	56	16.1	12	20.8	0		88	13.7
93E 098	492	10	1362	N	13.6	18	8.2	0		0		100	13.6
93E 088	64	10	1003	N	16.5	26	10.5	0		0		100	16.5
93E 088	301	10	690	N	20	26	11.8	0		0		100	20
93E 087	357	10	1078	N	17.3	27	11.5	0		0		100	17.3
93F 092	881	10	1481	Y	18.3	45	17.4	37.4	21.7	0		62.6	16.3
93F 083	57	10	730	Y	11.6	21	8.4	0		0		100	11.6
93L 008	345	10	1070	Y	12.1	19	9.9	0		0		100	12.1
93L 029	206	10	2520	Y	14.3	36	12.1	0		0		100	14.3
93L 018	198	10	1346	N	12.8	24	9.7	0		0		100	12.8