Mountain Pine Beetle Impact Analysis Using CMI Data

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Executive Summary

Change Monitoring Inventory (CMI) plots have been established in several management units (TSAs and TFLs) across the province, including TFL 5, TFL 30, TFL 33, TFL 35, TFL 37, TFL 52, Fort. St. John TSA, Merritt IFPA, Quesnel TSA, Kamloops TSA, Okanagan TSA, 100 Mile House TSA, and Hope IFPA. Some of these CMI plots have been remeasured and change monitoring analyses done. The original objective of the management unit CMI was to check the projected growth or change in timber volume and other tree attributes (e.g., species composition and top height) at a management-unit level. To date, however, no analyses of CMI data have been done in the TSAs.

Meanwhile, the mountain pine beetle (MPB) has killed lodgepole pine trees in a large portion of the Interior of BC. The CMI plots provide an opportunity to assess the impact of MPB in terms of the number and quality of trees lost to MPB and post-MPB condition and recovery. This report illustrates the types of MPB impact analyses that can be conducted using remeasured CMI plots. Data from 58 CMI plots from three TSAs in the Interior (Okanagan, 100 Mile House and Kamloops) were used. These plots were stratified into MPB impacted plots (22) and non-MPB impacted plots (36).

The key MPB impact analyses results are as follows:

- The overall average change in whole stem volume (Dbh ≥ 4 cm) is negative (-13.7 m^3/ha/yr) with the mortality rate (-18.4 m^3/ha/yr) dominating the survivor growth (4.7 m^3/ha/yr). The mortality rate in the MPB impacted plots is approximately three times that in the non-MPB impacted plots (-33 m^3/ha/yr vs. -11 m^3/ha/yr), with considerable variability. For both MPB impacted and non-MPB impacted plots, there was a small decrease in log grade quality between 2006 and 2011, but the decrease was much greater in the MPB impacted plots (14%) than in the non-MPB impacted plots (4%).
- Approximately 1/3 of the 58 plots were affected by MPB. The average survivor volume growth in the MPB impacted plots was 2.8 m^3/ha/yr compared to 5.4 m^3/ha/yr) in non-MPB impacted plots. At the population level (the sum of the areas of the three TSAs), the standing dead volume on the MPB impacted area was 316 million m^3 in 2011 compared to 202 million m^3 in the non-MPB impacted area. The total live volume in 2011 was 946 million m^3.
- Approximately 1/3 of the mature (81+ years old) MPB impacted plots meet the secondary structure guidelines, ignoring the spacing criterion and assuming pine does not contribute to the secondary structure. If pine is considered an acceptable species, approximately one-half of the mature plots meet the secondary structure guidelines in 2011. The immature plots have more, smaller stems and more meet the 4m height standard than the 6m height standard. In addition, the immature plots are more sensitive to whether pine is included. In 2011, if pine is excluded, only 14% of the immature plots meet the 6m standard while 29% meet the 4m standard. If pine is acceptable, 43% of the immature plots meet the 6m standard and 71% meet the 4m standard.

The results from this report suggest that the CMI data, in addition for use for growth and yield monitoring, can also be used to evaluate the impact of MPB. The 22 plots that showed evidence of MPB are a very small sample from which to draw any substantive conclusions or management interpretations. As a result, this report should be used as an example of the types of analyses that can be conducted rather than a basis for decision-making.

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List of Abbreviations and Acronyms

BA	Basal Area (of trees)
BC	British Columbia
Dbh	Tree Diameter at Breast Height
MFLNRO	Ministry of Forests, Lands and Natural Resource Operations
MPB	Mountain Pine Beetle
TFL	Tree Farm License
TSA	Timber Supply Area
WSV	Whole Stem Volume

1. Introduction

Change Monitoring Inventory (CMI) plots have been established in several management units (TSAs and TFLs) across the province, since about 2000. These units include TFL 5, TFL 30, TFL 33, TFL 35, TFL 37, TFL 52, Fort. St. John TSA, Merritt IFPA, Quesnel TSA, Kamloops TSA, Okanagan TSA, 100 Mile House TSA, and Hope IFPA. Projects for the establishment of these CMI plots were implemented with funding largely from the past Forest Renewal BC/Forest Investment Account Landbase Program. The original objective of the management unit CMI was to monitor (or check) the projected growth or change in timber volume and other tree attributes (e.g., species composition and top height) at a management-unit level.[1] Some of these CMI plots, such as those in TFL 35, have been remeasured and change monitoring analysis done. To date, however, no analyses of CMI data have been done in the TSAs.

Meanwhile, the mountain pine beetle (MPB) has killed the lodgepole pine (PL) trees in a large portion of the Interior of BC. The CMI plots provide an opportunity to assess the impact of MPB loss (amount, condition and quality of trees lost to MPB) and renewal (post-MPB stand condition and recovery). This report illustrates the types MPB impact analyses that can be conducted using remeasured CMI plots, in terms of loss and renewal.

2. Objective

The objective of this report is to demonstrate how to use the CMI data to examine the impact of MPB, specifically, to address the following questions:

- Loss: What has been lost to MPB?
- Renewal: Do the post-MPB plots meet the guidelines for secondary structure? What are the growth rates of the green trees?

3. The Sample Data

Data from 58 CMI plots in three adjacent TSAs in the Interior of BC (100 Mile House, Okanagan and Kamloops) were used (Table 1). These were chosen because, at the time, they were the only TSAs with remeasured CMI plots.

Table 1. CMI plots summaries by TSA. The age means are followed in brackets by the range. The data are from the first measurement (2006). The summary is for trees with Dbh ≥ 7.5 cm. The area is the area of the target CMI population (a subset of the TSA).

TSA	Project ID	Number of plots (N)	Total Age (years)	Area (ha)	Weight (Area/N)
Kamloops	011M	19	127 (63 - 279)	1,838,689	96773
Okanagan	022M	20	112 (48 - 189)	1,302,270	65114
100 Mile House	DMHM	19	83 (37 - 126)	938,421	49391
Total		58	112 (37 - 279)	4,079,380	

Twenty-four plots had more than 30% lodgepole pine at the time of plot establishment (calculated as the live + dead lodgepole pine basal area (BA) as a percent of total live + dead BA for trees with Dbh ≥ 7.5 cm). Seven other plots had some PL, ranging from 1-13% of the total BA.

Trees were tallied using the CMI methodology. Trees with 4.0 ≤ Dbh < 9 cm were tallied on a 0.01-ha plot and trees with Dbh ≥ 9 cm were tallied on a 0.04-ha plot. Four plots (Samples 011M-0067-MR1, 011M-0073-MR1, 022M-0093-MR1 and DMHM-0127-MR1) were harvested between 2006 and 2011 and were

[1] *Graphical & Statistical Analysis for Monitoring Estimates of Change at the Management-Unit Level (Version 2.0).* Contract report prepared by J.S. Thrower & Associates Ltd. for the Resources Inventory Branch, BC Ministry of Forests, Victoria, BC. Dated March 31, 2000.

removed from the analysis. One plot had a single large Douglas-fir (DMHM-0131) that was alive in 2006 and dead in 2011. This tree was not identified as a veteran but had a Dbh of 61.3 cm, a breast height age of 379 years and a measured height of 23.1 m. The next largest tree had a Dbh = 29.5 cm and the next oldest cored tree had a breast height age of 55 years. This illustrates the importance of identifying veterans in field data collection and the effect it can have on predictions. In this analysis, the large Douglas-fir was changed to a veteran and not included in the main canopy layer.

4. Methods

4.1 Stratification

The plots were grouped into two MPB status strata: MPB impacted and non-MPB impacted. A threshold of 60% or greater loss in plot volume was used to identify MPB impacted plots[2]. Twenty-five plots met this criterion, and formed the MPB affected stratum. The remaining plots formed the non-MPB impacted stratum. Three of the MPB affected plots had less than 30 m^3/ha of live plus dead volume and were not considered MPB affected. Thus, only 22 plots were considered MPB affected. Therefore, the number of plots in the MPB affected and non-MPB affected strata were 22 and 36, respectively. The MPB impacted plots were stratified further into immature and mature age classes for the renewal analysis, based on the mature age threshold of 81 years set by Churlish and Jahraus (2009).

4.2 Data compilation

Live and dead plot volume and number of stems were compiled at the 4.0 cm and 7.5 cm Dbh utilization levels by species and by 5cm Dbh class. The compiled volumes were: Whole stem volume (WSV: volume of the main stem including stump, top and defective and decayed wood) and merchantable volume (MV: WSV less stump, top, decay, waste and breakage). The 4.0 cm utilization better shows the MPB impact on regeneration and secondary structure. The 7.5 cm utilization better shows the MPB impact on wood supply.

4.3 Loss

Overall MPB losses were calculated in terms of weighted per-hectare mean volume and number of stems by MPB strata, species and 5 cm diameter classes, in 2006 and 2011. The weighting was based on the TSA weights from Table 1. The per-hectare mean estimates were expanded to the population level (combined three TSAs) using the weights in Table 1. Average volume mortality, ingrowth and survivor growth over the period 2006-2011 were also calculated by MPB strata. Standard errors were calculated for all these estimates.[3]

Finally, changes in log grade between 2006 and 2011 were examined. This was done using a two-way change matrix, where the columns represented the log grades in 2011 and the rows represented the log grades in 2006. The matrix cell entries were the number of logs.

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[2] This is based on "Provincial-level projection of the current mountain pine beetle outbreak: update of the infestation projections based on the provincial aerial overview surveys of forest health conducted from 1999 through 2011 and the BCMPB model (year 9)" by A. Walton who projected approximately 58% of the pine volume in the province will be killed by MPB.

[3] The standard error refers here to the square root of the estimated variance of the estimate divided by the sample size. Under a number of assumptions, including normality of errors, a $(1 – \alpha)\%$ confidence interval can be constructed by $(1 – \alpha)\%$ confidence interval = estimate $\pm\ t_{\alpha/2,n-1}$ x standard error, where t is from the student t distribution with a probability of α and n-1 degrees of freedom. The estimated standard errors for the population estimates assumed that the area affected by MPB is known (approximately 1.4 million ha).

4.4 Renewal

The MPB affected plots were further examined to determine whether they satisfied the secondary structure guidelines. The following is an excerpt from the "Explanation of the Forest Planning and Practices Regulation Amendments to Protect Secondary Structure"[4].

> Recent timber supply analysis indicates that it will not be possible to harvest all lodgepole pine leading stands that have been killed by MPB before the dead trees deteriorate beyond the point where they can be harvested economically. The intention of the Forest Planning and Practices Regulation (FPPR) amendments for secondary structure is to require licensees and BC Timber Sales to leave MPB killed stands with an "adequate stocking density" of "suitable secondary structure" un-harvested and to harvest pine leading stands that have little or no secondary structure instead. If a MPB killed pine stand with adequate stocking density of suitable secondary structure remains un-harvested, the secondary structure will likely develop into a merchantable forest. If a MPB killed stand without secondary structure is left un-harvested it may take many years before a new forest regenerates or the area may require costly reforestation at Crown expense. By making a concerted effort to avoid harvesting stands with an "adequate stocking density" of "suitable secondary structure", a higher percentage of the land base will be stocked and growing timber which should improve future timber supplies.

The pine leading polygons met the main criteria for "targeted pine-leading stands" in that they are pine-leading and within the MPB impacted area. Therefore, these plots were further examined to see whether they met the adequate stocking density and suitable secondary structure definitions from the amended schedule, namely,

"**Adequate Stocking density**" means a stand of trees comprised of:

(a) At least 700 tree per ha that are
  - a. At least 1.6 m apart from each other, and
  - b. 6 m or greater in height, or

(b) At least 900 trees per ha that are
  - a. At least 1.6 m apart from each other, and
  - b. 4 m or greater in height;

"S**uitable secondary structure**" means the saplings, poles, sub-canopy and canopy trees within a stand of trees that are:

(a) Likely to survive an attack from mountain pine beetle,

(b) A species of tree
  - a. Specified in a forest stewardship plan applicable to the area, or
  - b. If there is no forest stewardship plan applicable to the area, specified as a preferred or acceptable species in the publication of the Ministry of Forest and Range titled "Reference Guide for Forest Development Plan Stocking Standards", as amended from time to time,

  For the purposes of establishing a free growing stand on the site series, and

(c) Of sufficiently good form, health and vigor to provide merchantable trees for future harvesting;

Ideally the renewal analysis would use the secondary structure definitions to determine whether adequate stocking density has been achieved. Unfortunately, descriptions of the spatial arrangement of the trees in a plot were not available, so the spacing requirement could not be assessed. Churlish and Jahraus (2009) distinguished between polygons that would be considered for harvest (and therefore subject to secondary structure guidelines) and those not eligible. They defined polygon eligibility for harvest as those 81 years or older.

As for the suitable secondary structure definition, all conifers were assumed to be suitable species. Trees with broken or dead tops were rejected but trees with forks were allowed to contribute to the stocking density. The potential for lodgepole pine to contribute to the future forest in the presence of MPB was

[4] http://www.for.gov.bc.ca/hfp/silviculture/secondary_structure/secondary_structure_reg.pdf

uncertain, so two assessments were undertaken – the first did not consider lodgepole pine a suitable species, and the second included lodgepole pine as a suitable species. The percentages of the plots that met the adequate stocking density criteria were calculated for the two assessments.

The MPB impacted and non-MPB impacted plots were examined for opportunities for recovery. The average annual changes in volume mortality, ingrowth and survivor components were calculated by MPB strata. Average height in 2006 and 2011 and changes between 2006 and 2011 were calculated by strata. The average heights examined were top height, Lorey height and site height. Changes in leading species between 2006 and 2011 were also examined using the methods similar to those for log grade change analysis (Section4.3).

5. Results

5.1 Loss

The impact of MPB is considerable. Already in 2006, the MPB impacted plots had twice the standing dead volume of non-MPB impacted stands (109 ± 20 vs. 42 ± 12 m^3/ha) (Figure 1, Table 2). By 2011, for whole stem volume at the 4.0 cm utilization, the MPB impacted plots had 226 ± 29 m^3/ha dead volume while the non-MPB impacted plots had 75 ± 17 m^3/ha. When the results from these plots are applied to the population of approximately 4 million hectares (Table 1), the dead volume on MPB impacted stands (representing approximately 1/3 of the total area) has more than doubled from approximately 153 ± 28 million m^3 in 2006 to 316 ± 40 million m^3 in 2011. Dead volume increased in the non-MPB impacted portion of the landbase (from approximately 112 ± 31 million m^3 in 2006 to 202 ± 46 million m^3 in 2011), but the increase was much lower than in the MPB impacted area. The live volume in 2011 was 946 million m^3. Thus, in 2011 the dead volume in MPB impacted area was approximately 33% of the total live volume. There is little difference between the 7.5 cm compiled volume (Figure 1) and the 4.0 cm compiled volume (Figure 2), indicating that there is little volume in trees within the 4 cm - 7.5 cm Dbh range.

The mortality in the MPB impacted stratum was mainly lodgepole pine and tended to affect larger trees (Figures 3 and 4). In the MPB impacted stratum, the average Dbh of the trees that died was greater than that of the survivors, and greater than the average tree that died in the non-MPB stratum (Figure 5); the survivors were mostly non-pine species (Figures 6 and 7).

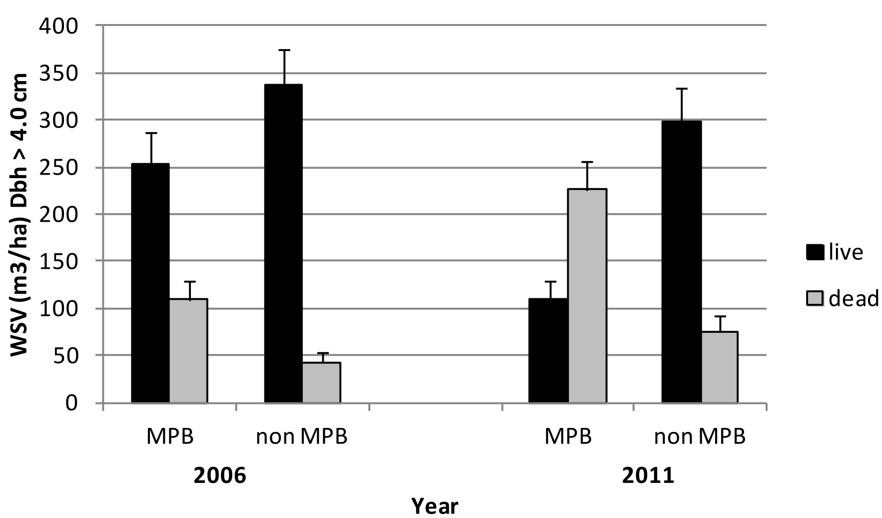

Figure 1. Weighted average live and dead whole stem volume (Dbh ≥ 4.0 cm) for the MPB impacted (pine-leading) and non-MPB impacted (non-pine-leading) plots. Standard error bars are given.

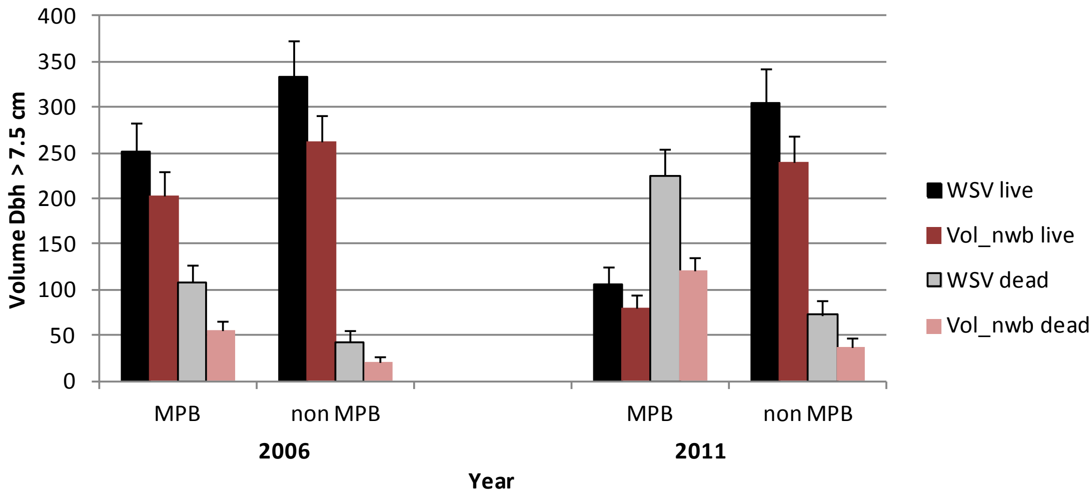

Figure 2. Weighted average live and dead volume (Dbh ≥ 7.5 cm) for MPB impacted (pine-leading) and non-MPB impacted (non-pine-leading) plots. WSV is whole stem volume, and Vol_nwb is whole stem volume net of decay, waste and breakage. Standard error bars are given.

Table 2. Average live and dead whole stem volume (Dbh ≥ 4.0 cm), and annual change by growth component in 2006 and 2011. The standard errors are given.

Strata	Year	Whole stem volume (m^3/ha)		Component	Annual change (m^3/ha/yr)
		Live	Dead		
MPB impacted	2006	254.1 ± 32.2	109.4 ± 19.9	Mortality	-32.4 ± 23.4
	2011	110.1 ± 18.4	226.0 ± 29.2	Ingrowth	0.2 ± 0.3
				Survivor	2.8 ± 2.8
Non-MPB impacted	2006	337.1 ± 38.6	42.2 ± 11.6	Mortality	-11.1 ± 20.6
	2011	297.9 ± 35.8	75.6 ±17.3	Ingrowth	0.1 ± 0.3
				Survivor	5.4 ± 3.2
All	2006	308.5 ± 36.4	65.3 ± 14.4	Mortality	-18.4 ± 16.3
	2011	234.8 ± 30.0	126.0 ± 21.3	Ingrowth	0.2 ± 0.2
				Survivor	4.5 ± 2.4

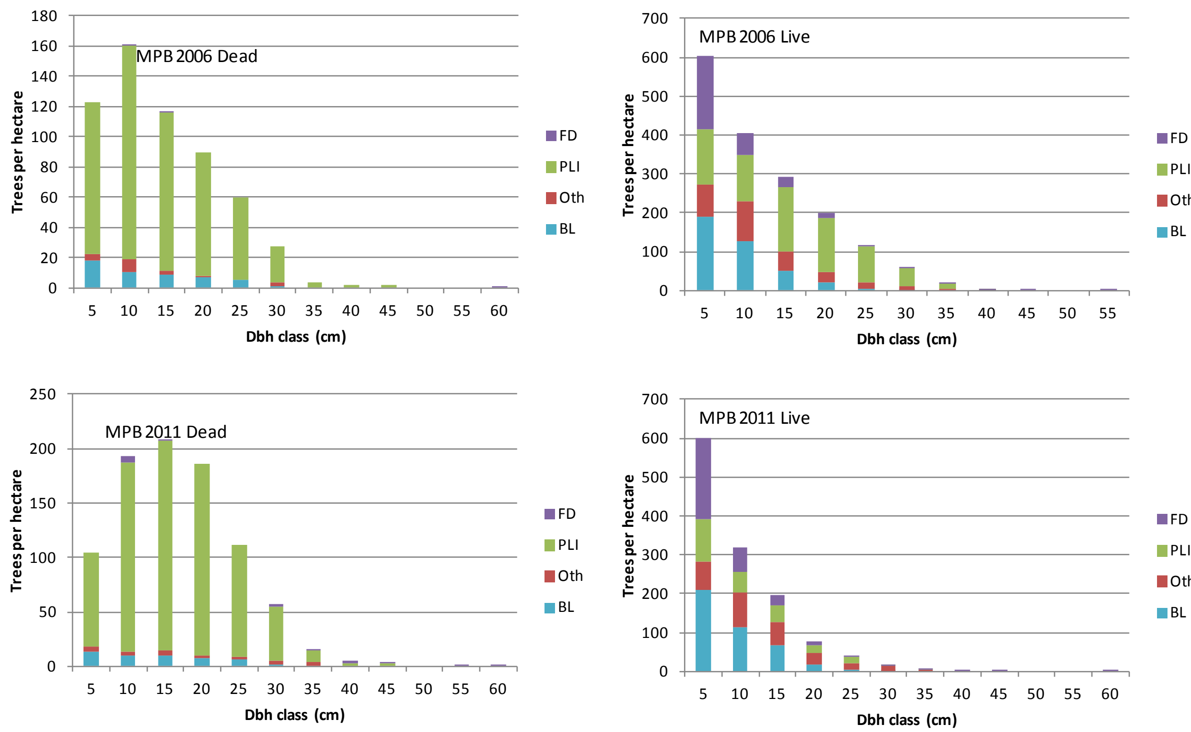

Figure 3. Average number of live and dead stems/ha by 5-cm Dbh class and year in the MPB impacted plots.

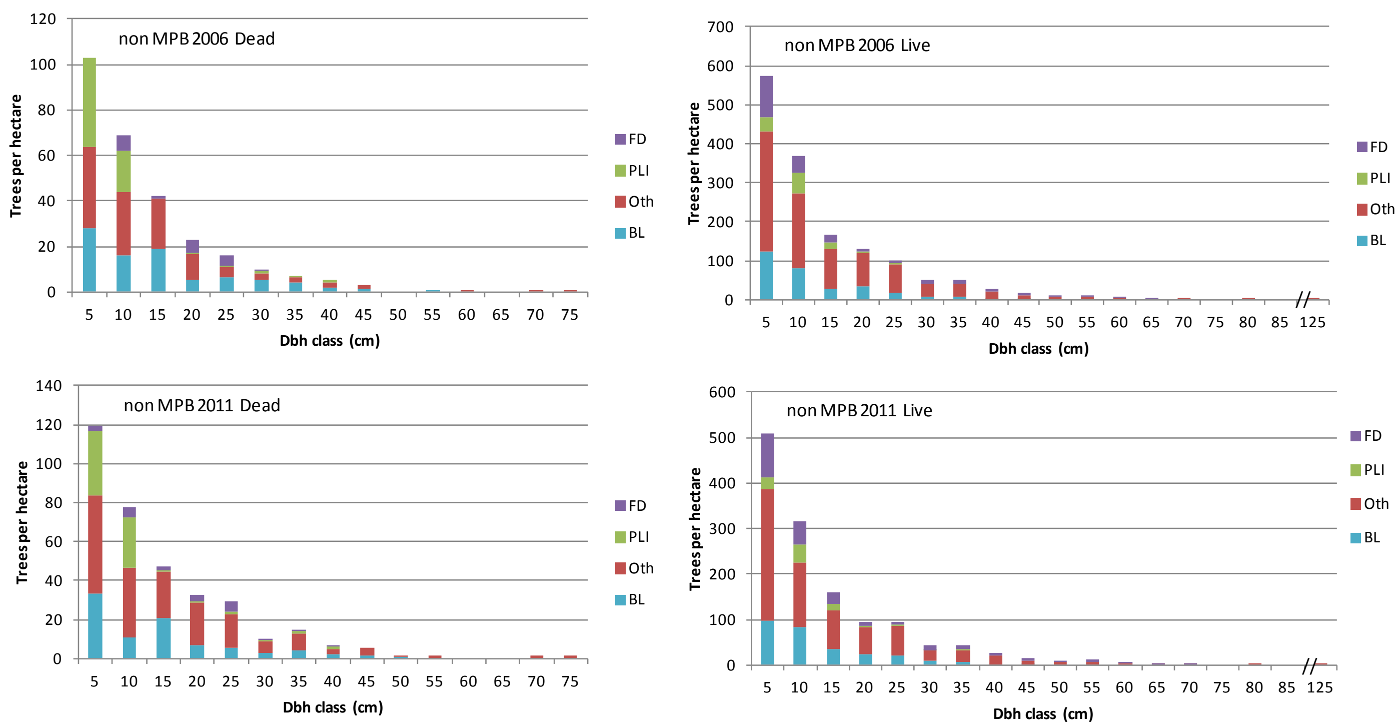

Figure 4. The average number of live and dead stems/ha by 5-cm Dbh class and year in the non-MPB impacted plots. Note that for the live stems, there is a break in the x-axis; there is only one tree in the 125 cm Dbh class.

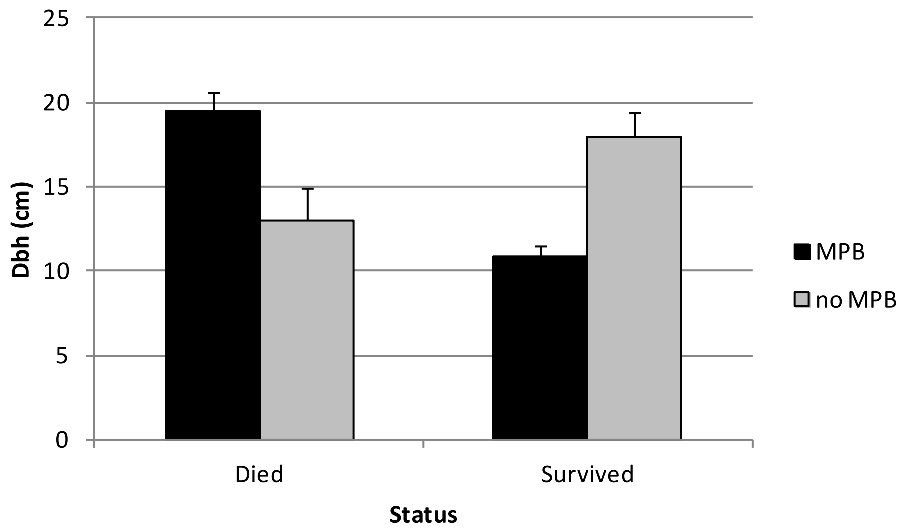

Figure 5. Average Dbh in 2006 of trees that died, and those that survived between 2006 and 2011, by MPB impact strata. Standard error bars are given.

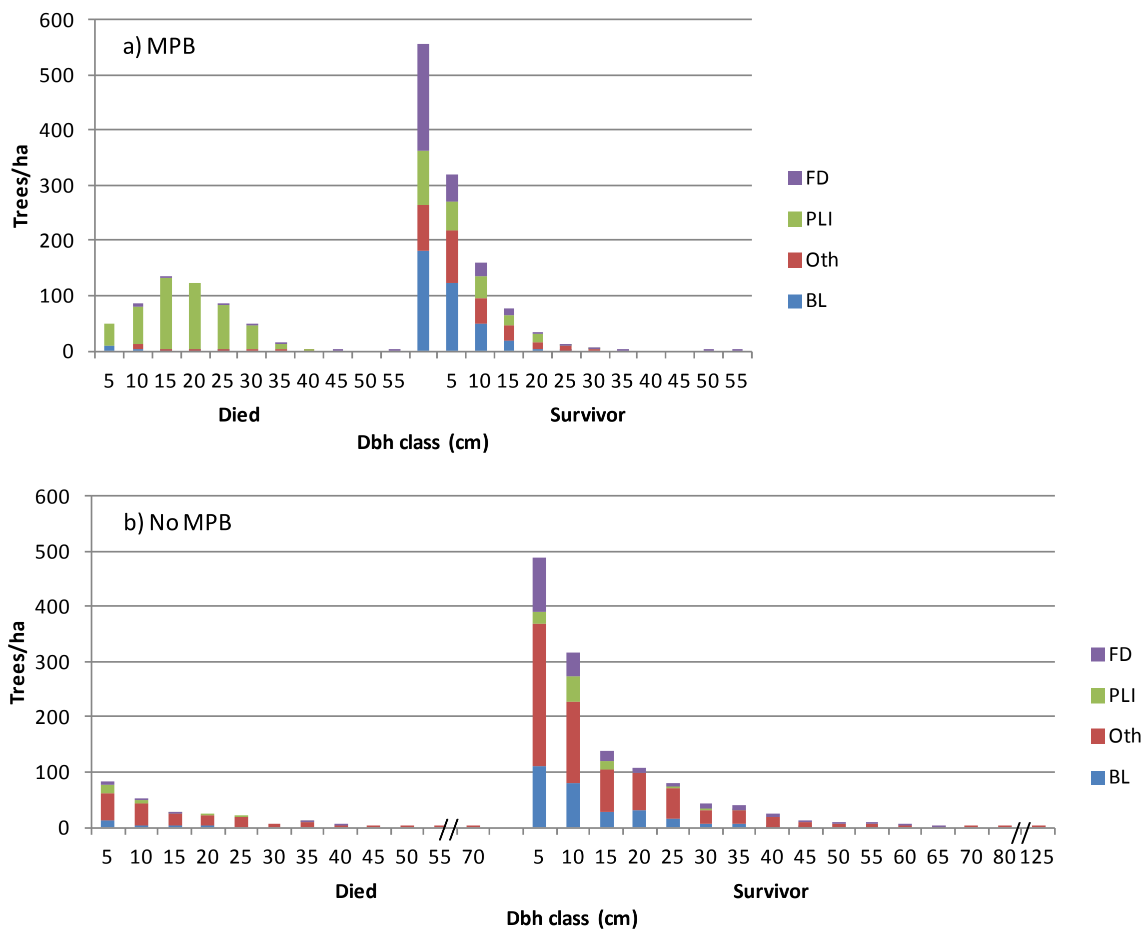

Figure 6. Number of trees that died, and those that survived between 2006 and 2011, by species, Dbh class and MPB impact strata.

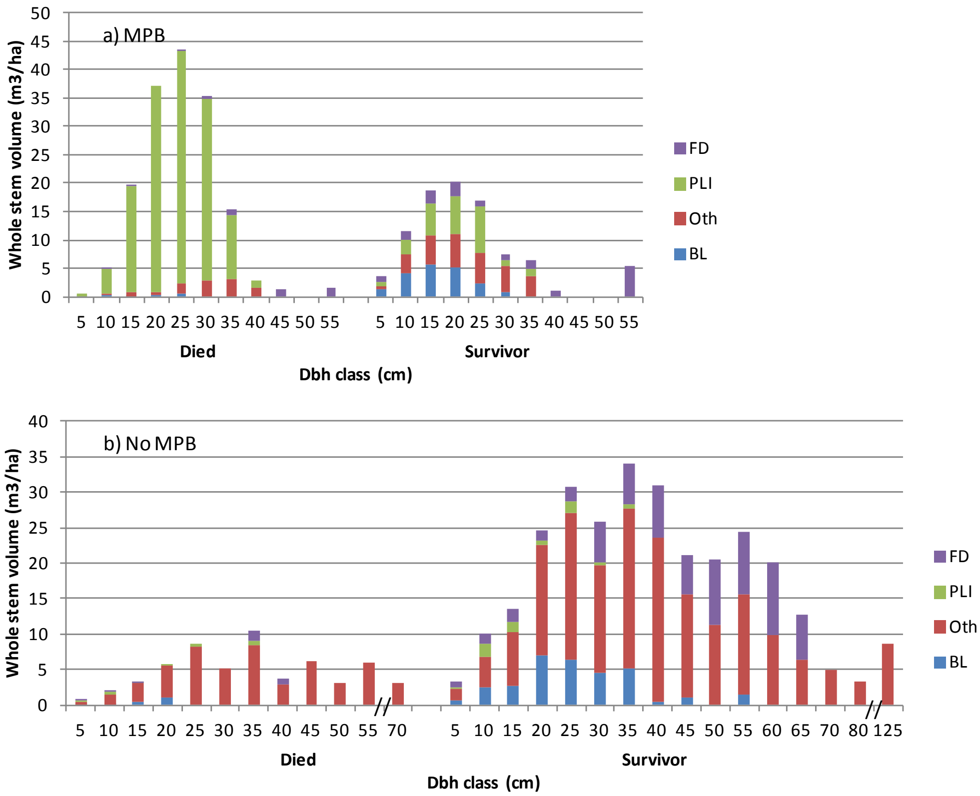

Figure 7. Volume of trees that died, and those that survived between 2006 and 2011, by species, Dbh class and MPB impact strata.

Associated with the MPB incidence was a decline in log quality (Table 3). Generally a decline in log grade is associated with a decline in value. Note, however, that as trees grow, logs may remain the same grade but increase in value.

Table 3. Changes in log grade in the MPB impacted plots between 2006 and 2011. The diagonal cells did not change log grade. The green cells indicate an improvement in log grade and the red cells indicate a decline in quality. "New" indicates trees tallied in 2011 but not in 2006.

log grade	log grade in 2011										
in 2006	C	H	I	J	N	P	Q	R	U	X	Y
New					48	40	7	1	1	3	3
C											
H		1									
I			2								
J				90					1	23	38
N					180						1
P				2		248	8	10	7	1	
Q						7	144	7	3		1
R							1	66			
U				5	4	1		1	289	25	73
X					2				1	36	10
Y					7						151

Of the 1,446 logs, 239 (about 17 %) changed log grade: 210 (about 15%) of the logs declined in quality while 29 (about 2%) improved in quality. Most of the improvements were a change from grades associated with very small logs (P, Q and R) to grades associated with larger logs (U, X and Y). Following Congalton (1991), the log grade changes between 2006 and 2011 were compared using the Kappa statistic. There was an overall agreement of 85% with a Kappa value of 0.81, indicating fairly good agreement. This implies that changes in log grades between 2006 and 2011 were minor and not statistically significant.

In the non-MPB impacted plots, of the 2,148 logs, 101 (5%) changed log grade – 1% improved while 4% declined in quality (Table 4). The overall agreement was 95%, with a Kappa value of 0.94 indicating good agreement. This implies that changes in log grades between 2006 and 2011 were minor and not statistically significant.

Table 4. Changes in log grade associated with the non-MPB impacted plots between 2006 and 2011. The diagonal cells did not change log grade. The green cells indicate an improvement in log grade and the red cells indicate a decline in quality. "New" indicates trees tallied in 2011 but not in 2006.

log grade	log grade in 2011										
in 2006	C	H	I	J	N	P	Q	R	U	X	Y
New				2	56	46	11	7	6		4
C	6										
H		18									
I			20								
J				240					1	4	16
N					165						2
P						371	4	3	5		
Q						2	271	9	2		1
R								146			
U				9	2				448	6	27
X				1					1	75	3
Y					3						286

5.2 Renewal

Summaries of the results of the examination of the MPB impacted plots that met the adequate stocking density standards are given in Table 5. Two sets of summaries are provided – the first, which considered lodgepole pine likely to survive and contribute to stocking, and the second, which assumed the lodgepole pine would not contribute to the future crop.

Table 5. Percentages of MPB impacted plots that met the adequate stocking density criteria of a) at least 700 stems/ha and at least 6 m tall and b) at least 900 stems/ha and at least 4 m tall. There were 7 immature plots (< 81 years old) and 15 mature plots.

Maturity	Year	Stocking density criterion a)		Stocking density criterion b)	
		Excluding pine	Including Pine	Excluding pine	Including Pine
Immature	2006	14%	71%	43%	86%
(<81)	2011	14%	43%	29%	71%
Mature	2006	40%	73%	40%	73%
(81+ years)	2011	33%	47%	40%	47%

If lodgepole pine is excluded from the adequate stocking definition, there is little change in the number of plots meeting the stocking criteria from 2006 to 2011, regardless of maturity, for both stocking density criteria and a) and b) (Table 5). If pine is included, the number of plots meeting the stocking criteria drops by about 1/3 between 2006 and 2011, particularly in the mature stratum, for both stocking density criteria a) and b). It appears that some pine survive but not all. If pine is included in the stocking calculations it might be good to apply some sort of reduction factor to the pine (e.g., 2-3 pine stems are equivalent to 1 stem in the stocking criteria).

If pine is not considered acceptable species, less than one-half of the pine-leading plots have adequate stocking with the immature stratum having a lower proportion of stocked plots. Note, however, that some of the trees on these plots are quite large and some plots may have acceptable primary structure. For example, in 2011, Okanagan plot 94 has 290 m^3/ha of live volume but only 600 stems/ha taller than 6m (it does meet the 4m criterion).

The average annual changes in volume mortality, ingrowth and survivors are given in Table 2 and Figure 8.

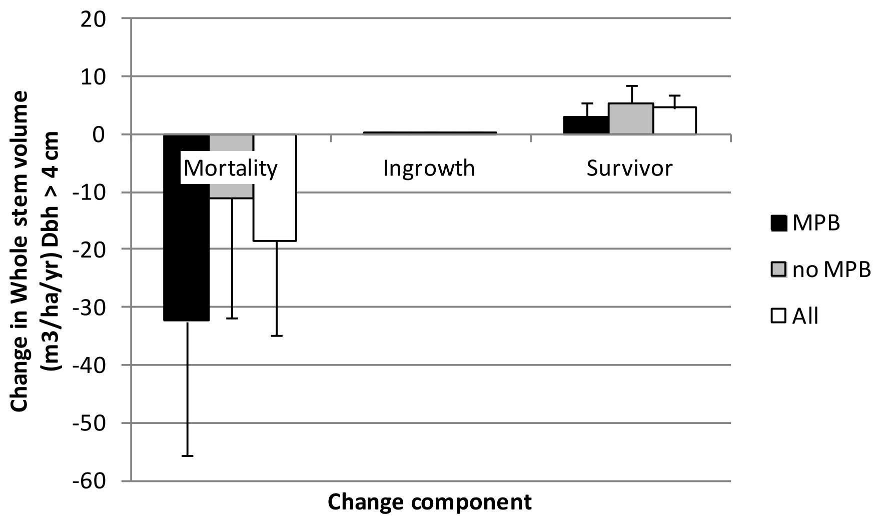

Figure 8. Average annual change in whole stem volume for trees with Dbh > 4 cm (m^3/ha/yr) by MPB impact strata and change component. Standard error bars are given.

As expected, the annual mortality rate is higher in the MPB impacted plots. Ingrowth is slightly higher in the MPB impacted plots than in the non-MPB impacted plots (0.2 m^3/ha/yr vs. 0.1 m^3/ha/yrs) (Table 2). This is encouraging and, perhaps, an indication of potential recovery. Survivor growth is higher in the non MPB impacted plots mainly because there are more trees alive and growing. At the tree level, the MPB impacted plots are growing slightly faster than the non-MPB impacted plots (the MPB impacted trees grew an average of 0.87 cm in Dbh in 5 years vs. 0.74 cm for the non-MPB impacted trees) (Figure 9).

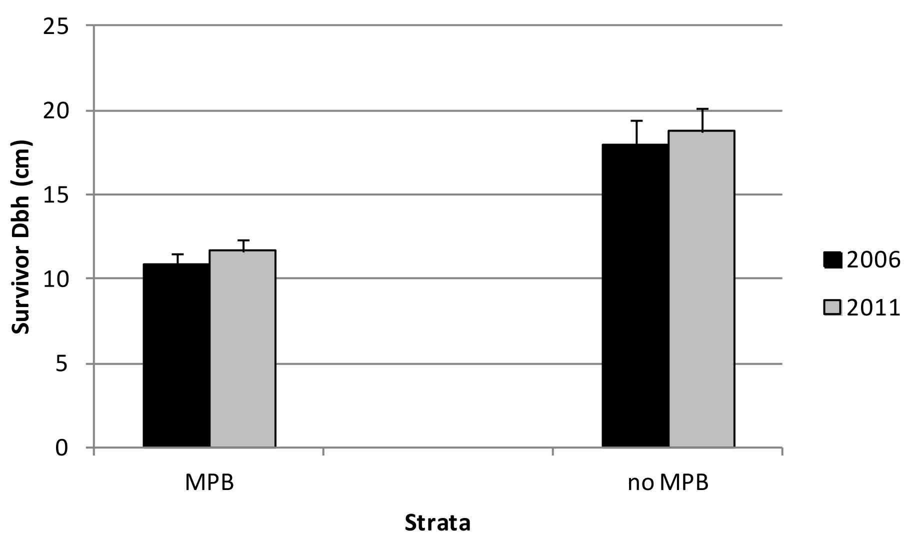

Figure 9. Average Dbh of the surviving trees by MPB impact strata and year. Standard error bars are given.

The changes in top-height and site-height trees average age and height for the non- MPB impacted plots between 2006 and 2011 were relatively minor (Figure 10 and Figure 11). For the MPB impacted plots, the average height declined by about 2 m and the age of the site trees decreased by 2 years and that of the top height trees decreased by almost 15 years, between 2006 and 2011 (Table 6).

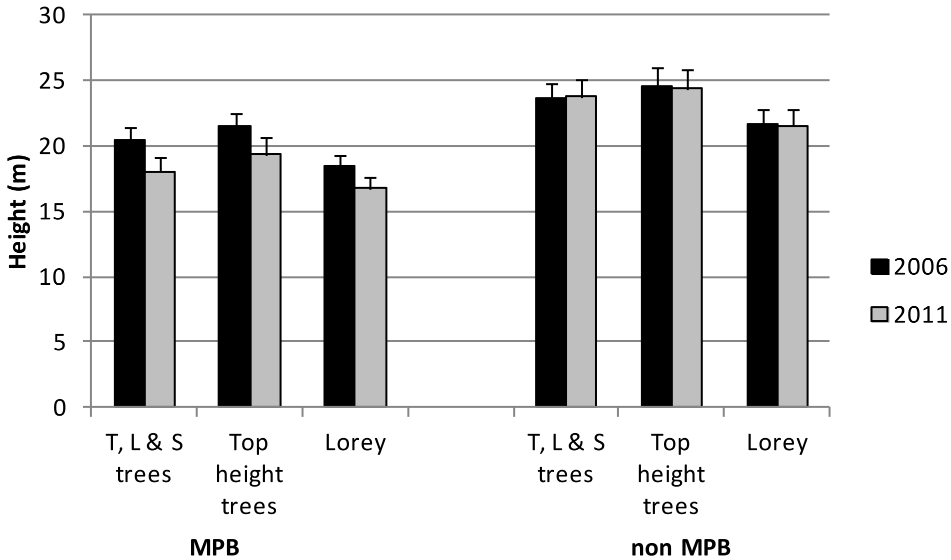

Figure 10. Average site height, top height and the Lorey height by year and MPB impact strata. Standard error bars are given.

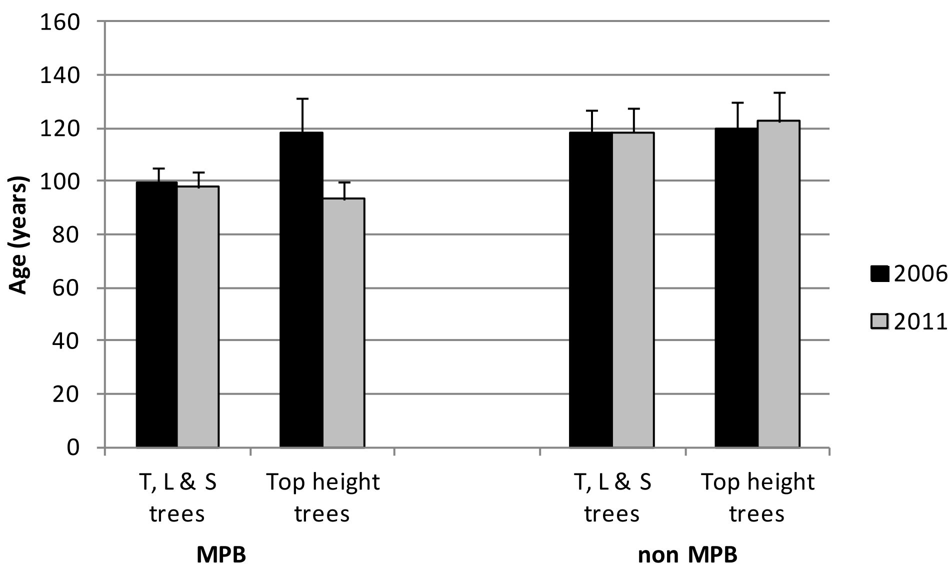

Figure 11. Average age of the site trees and of the top height trees by year and MPB impact strata. Standard error bars are given.

Table 6. Weighted average annual change in height and age between 2006 and 2011, as well as the standard error (s.e.) and sample sizes (N).

Attribute	MPB impacted plots		Non-MPB impacted plots	
	N	Average ± s.e.	N	Average ± s.e.
Site height (m)	21	-0.479 ± 0.120	36	0.033 ± 0.084
Top height (m)	19	-0.448 ± 0.239	33	-0.025 ± 0.090
Lorey height (m)	21	-0.350 ± 0.093	36	-0.018 ± 0.067
Age of site trees (yrs)	21	-0.379 ± 0.507	36	0.127 ± 0.433
Age of top height trees (yrs)	19	-5.064 ± 3.588	33	0.041 ± 0.591

The changes in species composition in the non-MPB impacted stratum were minor (Table 7). Of the 36 non-MPB impacted plots, three changed leading species – one from cedar to hemlock, one from spruce to balsam and one from spruce to Douglas-fir. OF the 22 MPB impacted plots, half changed leading species. One Douglas-fir plot had no trees in 2011. Of the 16 pine plots, 10 changed leading species, 4 to balsam, two to Douglas-fir and 4 to spruce.

Table 7. Changes in leading species between 2006 and 2011 by MBP strata.

Strata	Leading species 2006	Leading species 2011								
		None	BL	CW	FDI	HW	LW	PLI	PY	S
MPB impacted	FDI	1			3					
	HW					1				
	PLI		4		2			6	4	
	S									1
Non-MPB impacted	BL		3							
	CW			5		1				
	FDI				7					
	HW					2				
	LW						1			
	PLI							1		
	PY								2	
	S		1		1					12

6. Discussion

The sample size is relatively small (58) especially when the data are further subdivided into strata. The results should be used with caution.

The overall average change in whole stem volume (Dbh ≥ 4 cm) is negative (-13.7 m^3/ha/yr) with the mortality rate (-18.4 m^3/ha/yr) dominating the survivor growth (4.7 m^3/ha/yr). The mortality rate in the MPB impacted plots is approximately three times that in the non-MPB impacted plots (-33 m^3/ha/yr vs. -11 m^3/ha/yr), with considerable variability. For both MPB impacted and non-MPB impacted plots, there was a small decrease in log grade quality between 2006 and 2011, but the decrease was much greater in the MPB impacted plots (14%) than in the non-MPB impacted plots (4%).

Approximately 1/3 of the 58 plots were affected by MPB. The average survivor volume growth in the MPB impacted plots was 2.8 m^3/ha/yr compared to 5.4 m^3/ha/yr) in non-MPB impacted plots. At the population level (the sum of the areas of the three TSAs), the standing dead volume on the MPB impacted area was 316 million m^3 in 2011 compared to 202 million m^3 in the non-MPB impacted area. The total live volume in 2011 was 946 million m^3.

Approximately 1/3 of the mature (81+ years old) MPB impacted plots meet the secondary structure guidelines, ignoring the spacing criterion and assuming pine does not contribute to the secondary structure. If pine is considered an acceptable species, approximately one-half of the mature plots meet the secondary structure guidelines in 2011. The immature plots have more, smaller stems and more meet the 4m height standard than the 6m height standard. In addition, the immature plots are more sensitive to whether pine is included.

7. Conclusion

This report has demonstrated analyses methods to examine the impact of MPB, specifically, loss (amount, condition and quality of trees lost to MPB) and renewal (post-MPB stand condition and recovery), using data from CMI plots. These methods should be applied to other TSA CMI projects when remeasured plot data become available. The results of the analyses should, however, be interpreted with caution since the sample sizes used were very small.

8. Literature Cited

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