90 Extension Note

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Mountain Pine Beetle and Salvage Harvesting: Small Stream and Riparian Zone Response in the Sub-Boreal Spruce Zone

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Introduction

The mountain pine beetle (MPB) infestation and its related salvage harvesting activities adjacent to streams have the potential to influence small stream (< 2 m bankfull width) and riparian zone function by altering and removing riparian vegetation and causing other disturbances. These alterations are a significant management issue because small streams are the most predominant channel type on the landscape, comprising upwards of 80% of a watershed's total channel length (Shreve 1969). Accordingly, understanding the influence of these changes on small streams and their riparian zones is important to forest management.

The MPB infestation of riparian pine stands and/or subsequent riparian harvesting can alter riparian structure by changing microclimate conditions, decreasing litterfall to streams, and opening previously shaded streams to higher levels of direct solar radiation. To address the likelihood of this scenario occurring over the expansive Sub-Boreal Spruce (SBS) biogeoclimatic ecosystem classification (BEC) zone in the Northern Interior Forest Region, a series of investigations was initiated to identify riparian stand structure and the influence of MPB and salvage harvesting on riparian zones and small streams. The initial studies described here were implemented in the Vanderhoof Forest District because it has been heavily affected by MPB and has correspondingly seen increased levels of salvage harvesting to recover some economic value from the forest. These studies aim to provide short-term answers to questions about the influence of the MPB and salvage harvesting on small streams, namely:

- What is the riparian stand structure of small streams in MPB-affected areas of the SBS within the Vanderhoof Forest District?
- How do the MPB infestation (grey attack stage) and salvage harvesting affect riparian zones and small streams, including shade?

Study Descriptions and Findings

Riparian stand structure

To assess riparian stand structure, basal area studies were completed in unharvested riparian zones of 45 small streams, 15 in each of the SBSmc (2/3), SBSdw (2/3), and SBSdk biogeoclimatic units in 2006/07 (Figure 1). The vegetation resources inventory database identified the riparian forest cover of these streams as pine leading. For each stream, field-based basal area

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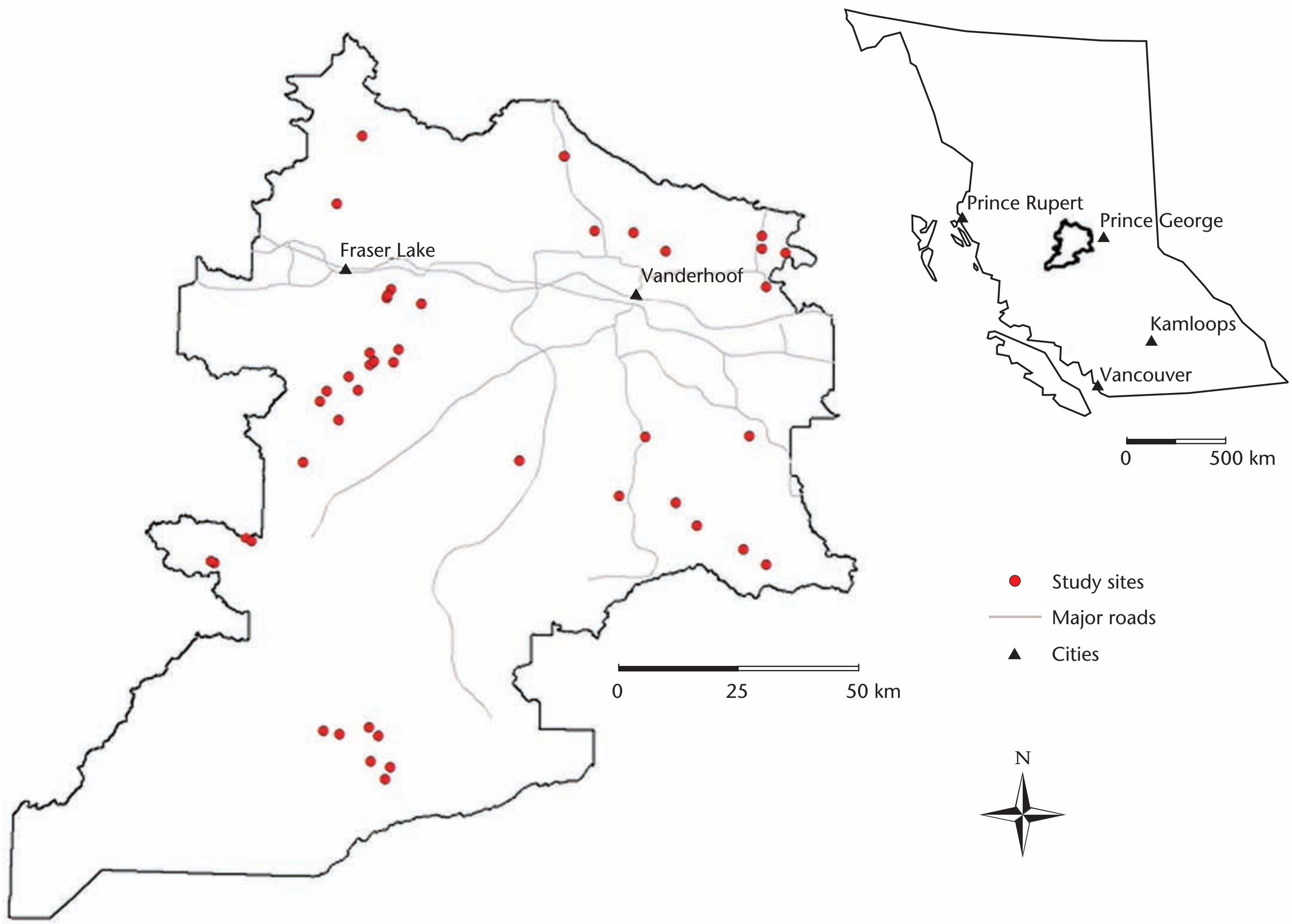

FIGURE 1 *Map of the Vanderhoof Forest District identifying small stream study sites where basal area values were measured.*

estimates were gathered along four transects perpendicular to the stream channel spaced at 50-m intervals along a representative reach 200 m in length. Sample plots were located along each transect 0, 10, and 20 m from the channel bank as well as an upslope location outside the riparian zone. At each plot, tree species were identified and basal area was measured with a BAF-7 prism.

Field information shows that the riparian zone within 10 m of the channel bank is predominantly composed of spruce regardless of BEC unit (Table 1). An analysis of variance (ANOVA) of arc-sin transformed basal area data was completed assuming a randomized block design with distance acting as blocks and tree type as the main plot factor. This analysis identified:

- a significant interaction between distance and tree type ($F_{9, 351}$ = 19.1, $p < 0.05$), indicating that the riparian zone within 10 m of the channel bank was typically spruce dominant while the 20-m and upslope locations were typically pine dominant (Figure 2).
- a significant difference in basal area with distance from the channel ($F_{3, 117}$ = 9.3, $p < 0.05$). Basal area values were generally lowest near the channel and increased in an upslope direction for all study sites.
- significant differences between basal area values for each tree type ($F_{3, 117}$ = 40.5, $p < 0.05$). Specifically, pine and spruce comprise the largest proportion of total basal area at all study sites, while deciduous trees and balsam fir comprise a smaller proportion.
- a significant interaction between BEC unit, distance, and tree type ($F_{36, 351}$ = 1.6, $p < 0.05$), indicating that while there is typically a transition from spruce dominance closer to the stream and pine dominance farther from the stream, the proportions are variable between BEC units.

Small stream and riparian zone function

Small stream and riparian zone function was assessed in 2008 for 18 of the

TABLE 1 *Total basal area values for study sites in 2006/07 by BEC unit and tree type 0, 10, and 20 m from the channel bank, and at an upslope location (values reported are percent of total)*

BEC unit	Tree type	0 m	10 m	20 m	Upslope	*n*
SBSdw2	Spruce	62	52	30	29	3
	Pine	17	46	55	63	
	Balsam	0	0	15	8	
	Deciduous	21	2	0	0	
SBSdw3	Spruce	37	36	25	18	12
	Pine	6	35	58	76	
	Balsam	1	0	1	0	
	Deciduous	56	29	16	6	
SBSmc2	Spruce	56	36	22	15	8
	Pine	26	55	63	77	
	Balsam	9	0	2	0	
	Deciduous	9	9	13	8	
SBSmc3	Spruce	75	64	30	17	7
	Pine	24	33	60	79	
	Balsam	0	0	5	3	
	Deciduous	1	3	5	1	
SBSdk	Spruce	74	57	48	39	15
	Pine	9	31	39	55	
	Balsam	0	0	0	0	
	Deciduous	17	12	13	6	

45 small stream study areas identified during the basal area study. At each of these 18 small stream watersheds, the level of ecosystem function was determined using the Routine Riparian Effectiveness Evaluation (RREE) protocol (Tripp et al. 2007). Properly functioning condition is the ability of a stream, wetland, or lake and its riparian area to: (1) withstand normal peak flood events without experiencing accelerated soil loss, channel movement, or bank movement; (2) filter runoff; (3) store and safely release water; (4) maintain the connectivity to and among fish habitats in streams and riparian areas so that these habitats are not lost or isolated as a result of management activity; (5) maintain an adequate riparian root network or large woody debris (LWD) supply; and (6) provide shade and reduce bank microclimate change. Seventeen of the study areas had experienced some salvage harvesting and so were subdivided into treatment and control reaches and subjected to the RREE and shade estimation. Three of these watersheds had two treatment stream reaches because two separate streams were within harvested areas, bringing the total treatment stream sample size to 20. One of these three watersheds had two control streams. The remaining study area did not experience harvesting but was kept for observation as an extra control stream, bringing the total control reach sample size to 19.

The RREE is a monitoring strategy developed for and employed by the Forest and Range Evaluation Program (FREP) to identify if harvesting practices meet the sustainable management goals set forth in the *British Columbia Forest and Range Practices Act* (FRPA). The RREE protocol requires the measurement of 15 principal indicators by answering either "yes" (pass) or "no" (fail) questions that guide the user toward a recommendation on the relative health and functionality of a stream and its riparian area. These main indicators include:

- channel bed disturbance
- channel bank disturbance
- in-stream large woody debris (LWD)
- channel morphology
- aquatic connectivity
- fish cover diversity
- moss abundance and condition
- fine sediments
- aquatic invertebrate diversity
- windthrow frequency
- riparian soil disturbance
- LWD supply
- shade and bank microclimate
- disturbance-increaser and invasive plants
- riparian vegetation vigour, form, and structure.

To answer the indicator questions, a total of 53 observations or measurements must be made. These continuous and point measurements were taken along a 150- to 200-m homogeneous channel section referred to as the sample reach. The attribute measurements were compared to specific threshold values that led to a "yes" or "no" answer (i.e., pass/fail) for the indicator question. The thresholds represented values expected for undisturbed conditions (Tripp et al. 2007).

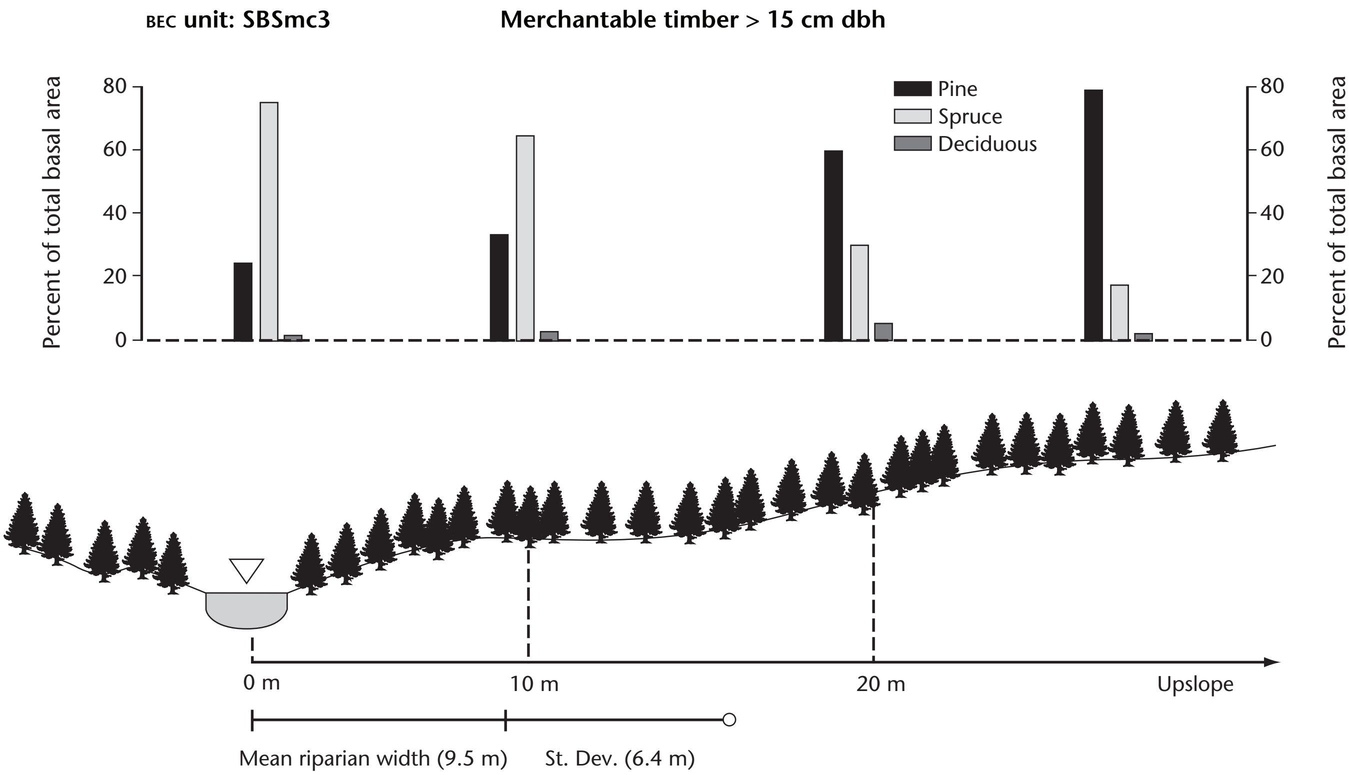

FIGURE 2 *Basal area percent composition by tree type in the SBSmc3 study sites 0, 10, and 20 m from the channel bank, and at an upslope location (n = 7). Mean riparian width and the standard deviation are also provided.*

Conversely, the LWD supply and riparian vigour/structure questions did not have measurements specific to them and indicator responses were based on field observations of the vegetation. The number of indicator "no" answers in the evaluation determined the overall level of functioning condition of the site according to the following guidelines:

- properly functioning condition (0–2 failed indicators)
- properly functioning but at low risk (3–4 failed indicators)
- properly functioning but at high risk (5–6 failed indicators)
- not properly functioning (> 6 failed indicators)

For comparison, using Pearson's chi-square test, RREE final scores for each site were ranked as 1–properly functioning, 2–low risk, 3–high risk, and 4–not properly functioning. This analysis indicated that there was a significant difference between control and treatment sites (chi-square = 11.1, d.f. = 3, $p < 0.05$). Generally, it was observed that control sites were properly functioning while harvested sites ranged between properly functioning and not properly functioning (Figure 3). Harvested sites that were properly functioning with a low level of risk generally had buffer widths greater than 10 m.

Riparian shade and buffer zones

Riparian shade measurements were collected along each treatment and control reach using the spherical angular canopy densiometer (ACD) (Teti and Pike 2005). Measurements were made while facing south with the ACD approximately 1 m above the stream surface at about 10 equally spaced locations along the sample reach (Figure 4). ACD measurements provide an estimate of canopy density between 10 a.m. and 2 p.m. solar time in August, when solar radiation is highest. These 10 measurements were averaged for the reach as a percentage between 0 and 1. Reach average ACD (arc-sin transformed) was compared between harvested and control sites as well as BEC units using ANOVA. Analysis indicates that ACD measurements were statistically different between control and harvested areas but were similar across BEC units (Figure 5). Control sites had higher ACD and hence shade values than harvested sites ($F_{1, 29} = 6.8$, $p < 0.05$).

Although harvested sites generally had lower ACD values, there was some variability based upon the width of retained buffer zones. The buffer zone width classes greater than 5 m wide reported similar ACD values, whereas buffers less than 5 m wide provided significantly lower ACD values (Figure 6).

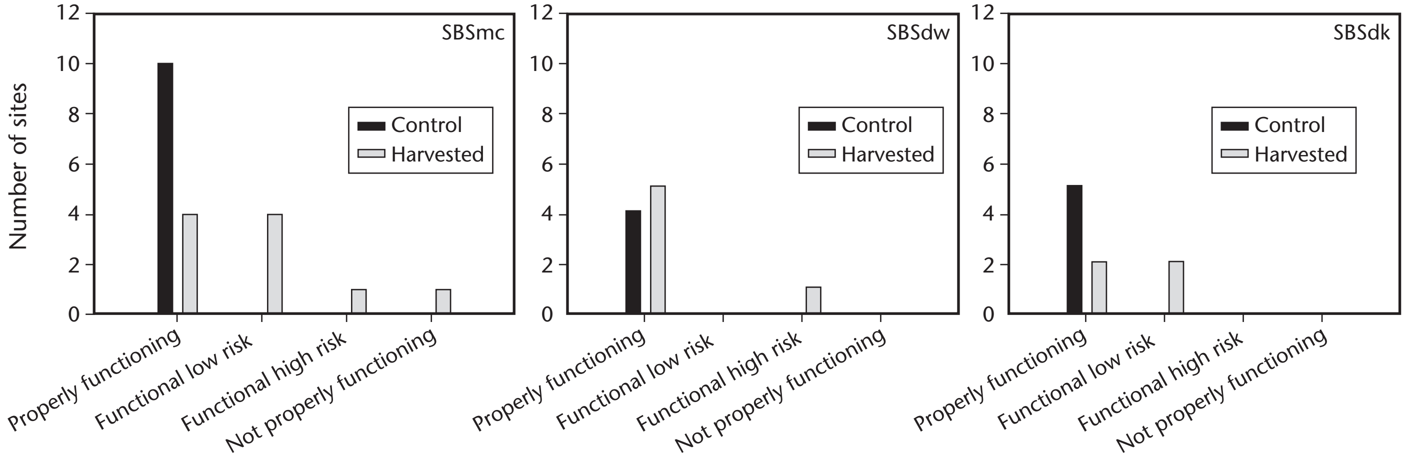

FIGURE 3 *RREE scores for control and harvested sites in the SBSdw, SBSmc, and SBSdk, summer 2008.*

FIGURE 4 *Angular canopy density data collection at a point along the control reach of a small stream, August 2008.*

Discussion and Management Considerations

These preliminary findings from the Vanderhoof Forest District should be supplemented with further investigation in other forest districts affected by the MPB. This study indicates that salvage harvesting activities reduce shade and stream functioning beyond that of the MPB infestation. Specifically, they have identified that:

- small stream riparian zones in pine-dominated watersheds were spruce dominant;
- riparian zones of grey attack stands were properly functioning according to the RREE, whereas harvested areas were properly functioning but with some risk (impairment); and
- riparian zones of grey attack stands had higher ACD, and hence shade values, than harvested sites.

In accordance with these observations, it is recommended that retention levels around small streams be increased within the 10-m zone closest to the stream. The data presented here indicate that retention within the 0- to 5-m zone was ineffective at keeping functional condition and shade levels similar to those of control areas. Given the extent of the infestation throughout the SBS and the opportunity to increase harvesting areas through salvage, consideration should be given to increasing retention of non-pine species, especially around small streams, and protecting these areas where windthrow risk may be a concern. These findings support retention guidance issued by the Chief Forester in 2007 regarding potential hydrologic impacts (Snetsinger 2007) and landscape- and stand-level structural retention (Snetsinger 2005).

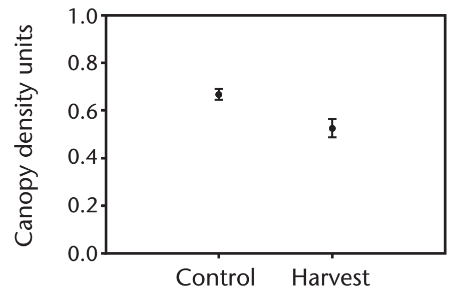

FIGURE 5 *Mean angular canopy density for control and harvested areas in the Vanderhoof Forest District. Error bars represent one standard error of the mean (n = 19 and 20, respectively).*

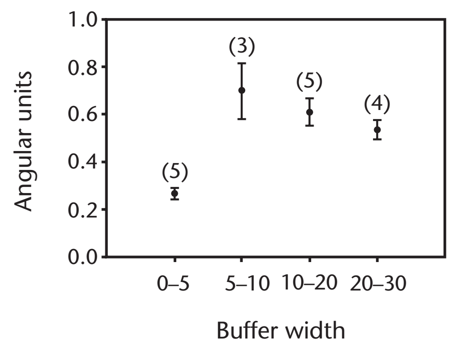

FIGURE 6 *Mean angular canopy density by retention width at harvested sites in the Vanderhoof Forest District. Error bars are one standard error of the mean. Seventeen sites were included with the sample size for each buffer class provided in brackets. The two excluded buffer width classes (30–40 and > 50 m) had low sample numbers, 1 and 2, respectively.*

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