

The Bowron River Watershed Project:

*A Landscape-level Assessment of the Post-salvage
Change in Stream and Riparian Function*

2007

Introduction

British Columbia is currently experiencing a mountain pine beetle epidemic that threatens to kill 80% of the province's commercial lodgepole pine by 2013. To recover the greatest economic value from the dead trees before they burn or decay, the province has accelerated harvest in affected areas. Accelerated harvesting has the potential to influence other forest values such as stream and riparian function, especially when riparian timber is removed.

The Forest and Range Practices Act currently allows for harvesting in the riparian zone as an approved activity in a forest stewardship plan (FSP) or under the Forest Planning and Practices Regulation (FPPR) s.51(f) for the purposes of sanitation or s.51(g) to control damage by insects as long as it will not have a material adverse impact on the riparian zone.

The riparian zone is a sensitive ecotone that serves many functions, such as erosion and runoff control, protection of water quality, provision of shade and litterfall for aquatic biota, and habitat for wildlife. To gain some understanding of future conditions of riparian zones and streams in MPB salvage areas, the Bowron Watershed was used as a surrogate to identify the current condition of stream and riparian zones 20-30 years after large scale salvage harvesting.



Figure 1: North view toward the Bowron River from an unnamed hill in the Indian Point Creek watershed, November 1984. (Photo courtesy of Robert Hodgkinson, MFR Prince George.)

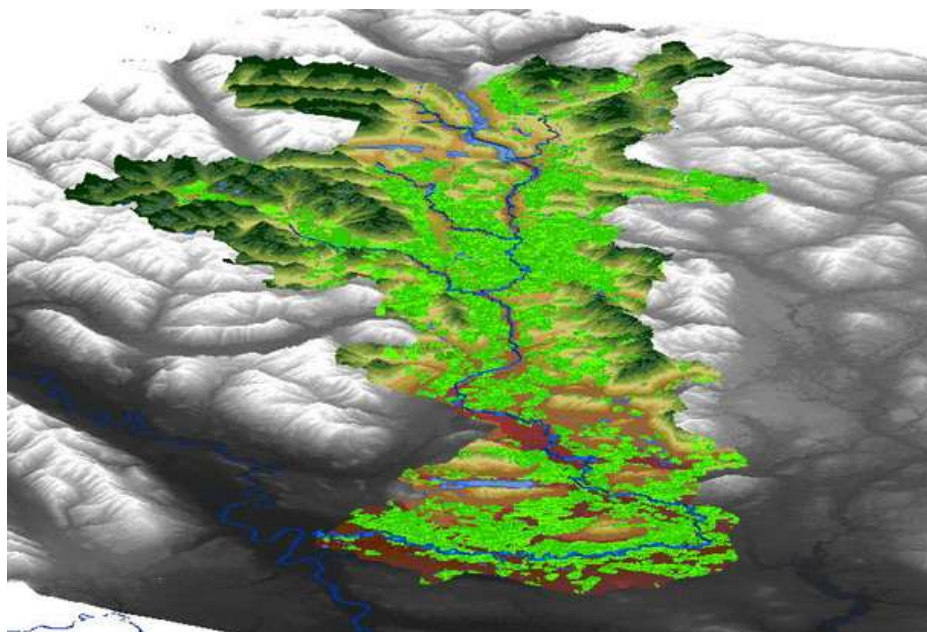


Figure 2: A GIS projection of the Bowron River watershed. The view is up the Bowron River in a southern direction toward the Bowron Lakes Park. High-elevation areas are coloured dark green and they transition with declining elevation to tan and then dark brown, the latter representing lowest elevations in the watershed. Salvage-harvested areas are identified by light green, mostly along the valley bottoms.

In 1975, a spruce bark beetle outbreak occurred in the Bowron River watershed. In response to the infestation, large scale salvage operations were initiated to control the spread of the beetle and recover economic value from infected timber before it burned or decayed. By the time harvesting slowed down in the mid-1980s, approximately 25% of the Bowron watershed was logged, equivalent to 90000 hectares.

Harvest activity was most extensive in the upper Bowron, removing 30% of the timber and producing a 50000-ha clearcut. Harvesting was also extensive in the middle and lower Bowron but occurred at a slower rate. During peak harvest, approximately 700 loads of logs were removed from the Bowron every day. Many riparian areas of small and mid-sized streams were completely harvested (Figures 1 and 2).

To identify the potential impact of today's mountain pine beetle infestation and large-scale salvage operations on streams and their riparian zones, present levels of ecologic function in the Bowron River watershed more than 25 years after harvesting was determined using the Routine Riparian Effectiveness Evaluation (RREE- FREP).

The RREE was used to assess the current condition of streams and riparian areas in 35 basins within the Bowron River watershed. Findings were then used to identify best management practices to protect stream and riparian functions in mountain pine beetle-infested areas.

The Bowron Watershed study was initiated to identify the forest management activities that place streams and their riparian areas at risk, as well as identify how they recover following extensive salvage harvesting. The project identifies potential stream and riparian effects due to accelerated harvesting practices that include riparian zones and identifies best management options to maintain stream and riparian function.

The principal objectives of this study were:

1. To use the Routine Riparian Management Effectiveness Evaluation (RREE) to evaluate the current condition of streams and riparian areas in the most intensively harvested sub-basins of the Bowron River watershed that were identified during a 1994-1996 interior watershed assessment process (IWAP)
2. To use both evaluations to assess stream and riparian recovery over time in the Bowron River watershed
3. To propose best management practices to protect stream and riparian functions in mountain pine beetle-infested areas

Study Site Description

The Bowron River watershed is located 50 km east of Prince George, B.C. (Figure 3). The watershed is approximately 3590 km² in area with an elevation range of 602-2447 m, and is located within the Prince George and Quesnel Forest Districts. The Bowron River emerges from Bowron Lakes Provincial Park, where it flows north to the Fraser River.

The watershed comprises 43 sub-basins that range in area from 11.26 km² to 593.21 km². The annual hydrograph is snowmelt-dominated (Figure 4) but peak flows can occasionally occur during fall months as a result of high-intensity rainstorms or rain-on-snow events. The average annual peak flow (1977-2005) is 319 m³s⁻¹ and the highest recorded discharge on record (580 m³s⁻¹) occurred in the spring of 1990.

The watershed is on the Interior Plateau, specifically the Nechako Lowland, the Quesnel Highland, and the West Cariboo Mountain physiographic regions. It is composed of sedimentary and volcanic (igneous) rocks, with minor constituents of metamorphic and intrusive rocks. Surficial geology consists of colluvial, fluvial, glacial-fluvial, and till deposits. Significant ice presence during the Pleistocene has resulted in the deposition of thick deposits of till, glacial-fluvial sands/gravels, and glacial lacustrine silts and clays, which are currently being incised. Brunisols, Podzols, and Luvisols are the most common soil orders within the watershed.

The watershed's biogeoclimatic zone coverage is primarily of the Sub-Boreal Spruce (SBS) type, which occurs along most valley bottoms, although there are some Interior Cedar-Hemlock valley bottoms in the lower and middle sections of the watershed. Higher-elevation areas include the Engelmann Spruce-Subalpine Fir (ESSF) zone as well as small areas of the Boreal Altai Fescue Alpine (BAFA) and Interior Mountain-Heather Alpine (IMA) zones.

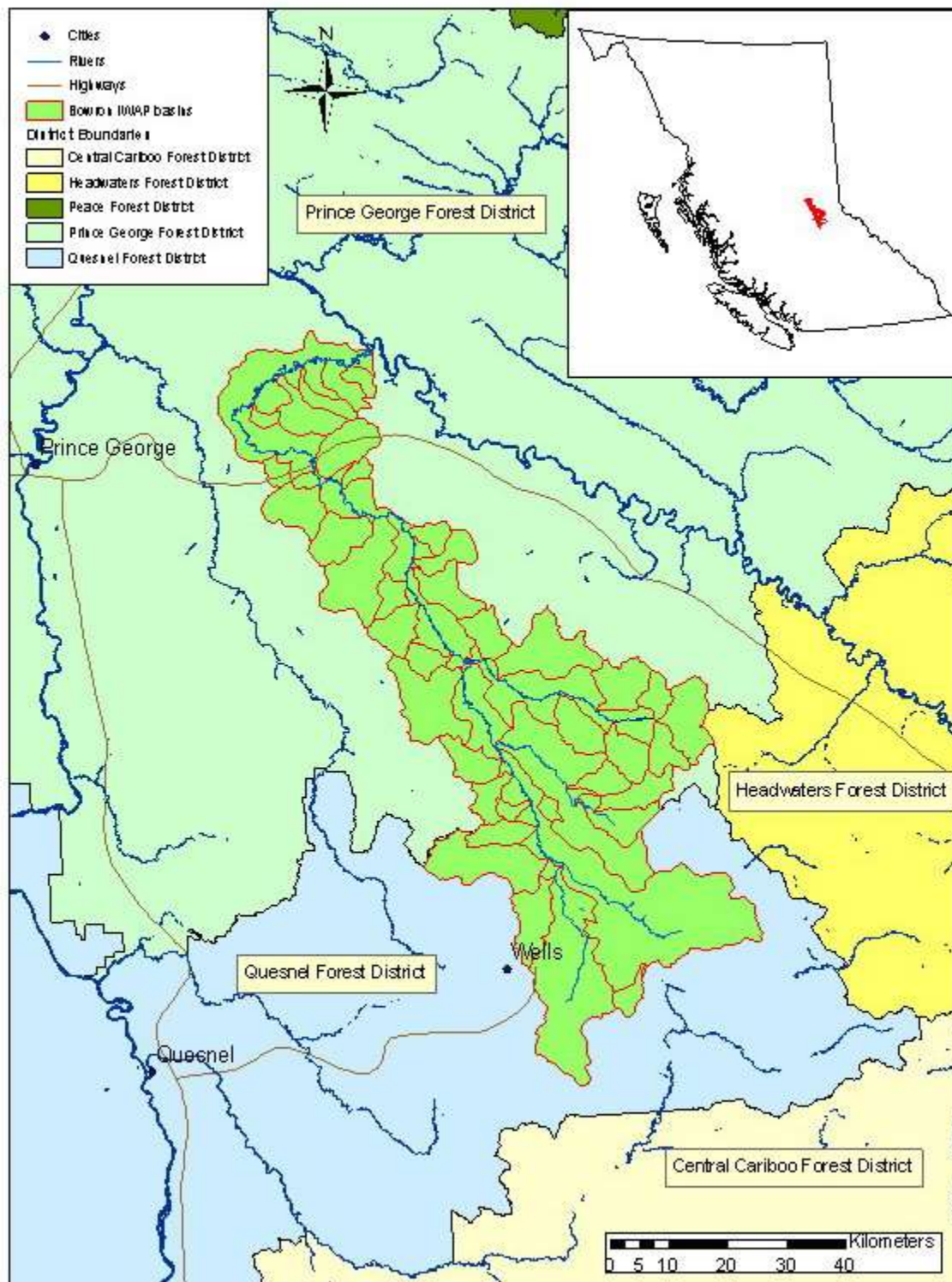


Figure 3: General location of the Bowron River watershed in relation to the Prince George, Headwaters, and Quesnel Forest Districts.

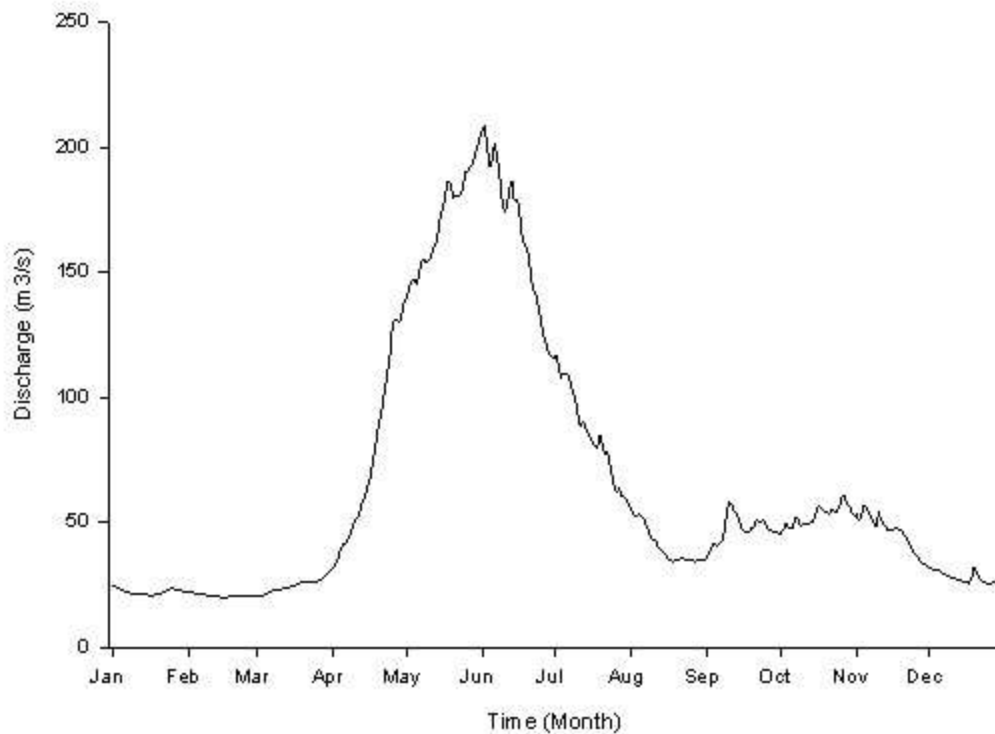


Figure 4: Average (1977-2005) daily discharge from the Water Survey of Canada station on the Bowron River at Box Canyon (O8KDOO7). Largest flow volumes occur during the spring melt between starts in late April and peaks in June.

Study Design

The Bowron River watershed was stratified using Level 1 Interior Watershed Assessment Procedure (IWAP) scores that were generated for each of the watershed's 43 sub-basins between 1994 and 1996 (Figure 5).

The RREE was used to assess current stream and riparian condition at two sites in all of the high- and moderate-risk sub-basins, as well as 11 low-risk sites (not largely associated with roads or harvesting) (Figure 5).

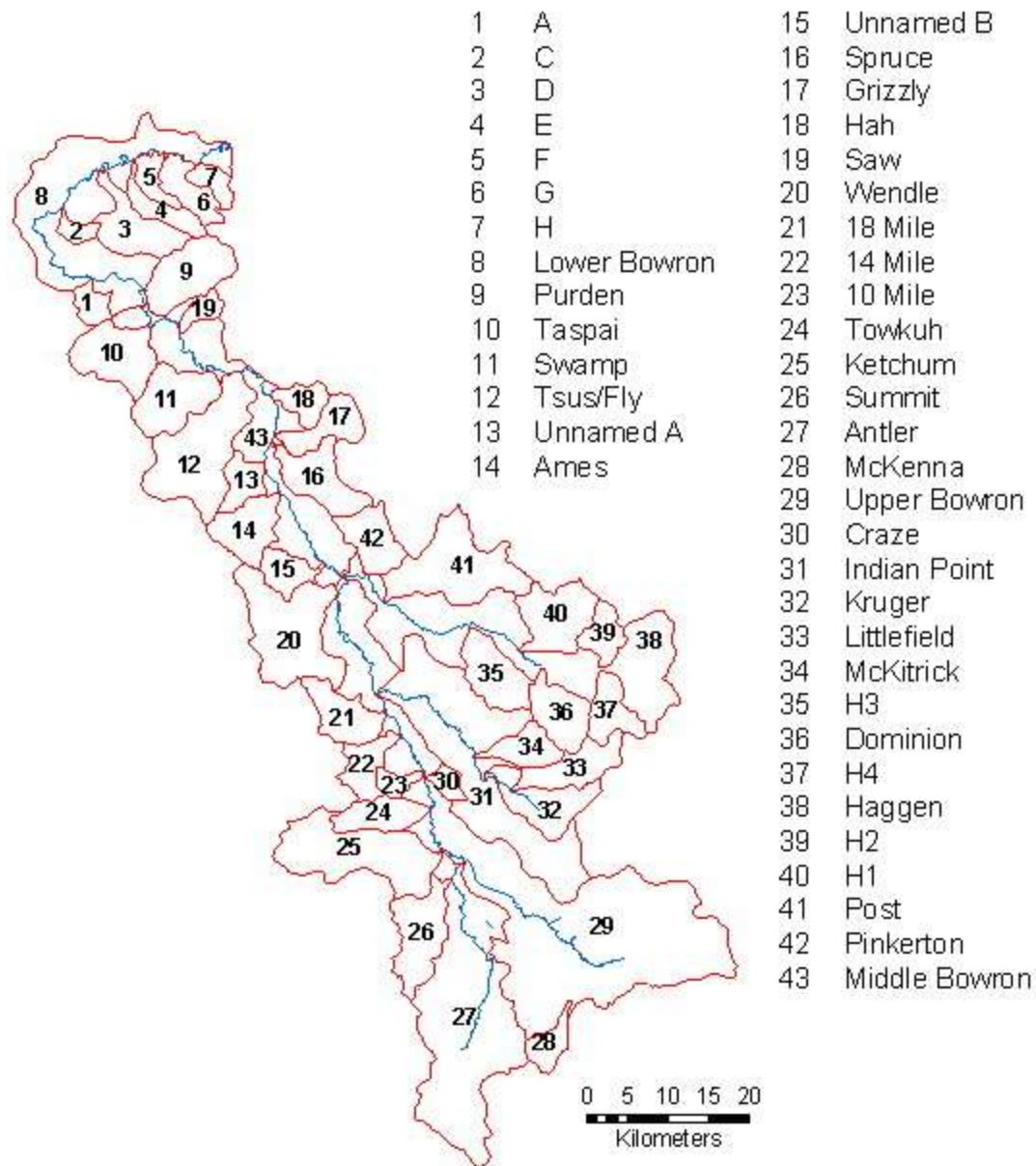


Figure 5: Location of the 43 sub-basins within the Bowron River watershed (excluding residual areas that were identified in IWAP).

Field evaluations were conducted for an upper and lower stream reach in each selected sub-basin. The lower site was selected to represent the cumulative effects of salvage harvesting on the entire sub-basin and was generally a larger stream that may or may not have been harvested at the sample reach. In contrast, the upper site was a smaller stream that was selected to identify localized harvesting effects and was typically harvested to the stream edge. A total of 70 stream reaches were assessed between May and October of 2007, including 59 treatment reaches and 11 control reaches (Figure 6).

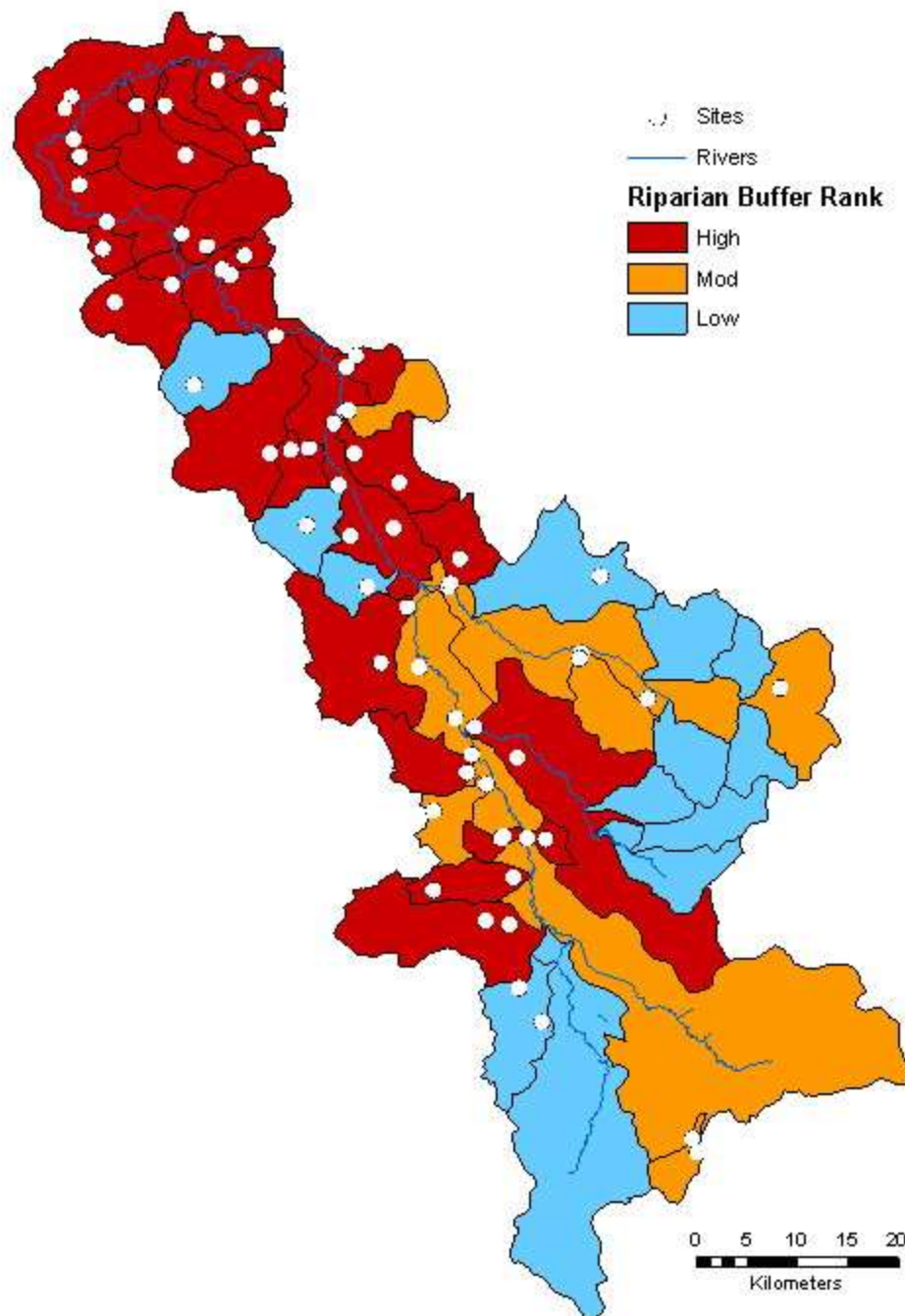


Figure 6: Riparian buffer risk map for each sub-basin using scores identified during the 1994-1996 IWAP. The 70 RREE sample sites assessed during the 2007 study are identified by white circles.



Figure 7: Reference stream in the Swamp sub-basin (left photo) showing undercut banks, coniferous riparian vegetation, coarse substrate, and old stable LWD in the stream. A harvested stream section in the A sub-basin (right photo) showing a lack of undercut banks, lack of coniferous in the riparian zone, fine sediments along the substrate, and recently created LWD piles.

The Routine Riparian Effectiveness Evaluation

The RREE was developed in 2004 by the B.C. Ministry of Forests to assess the efficacy of current harvesting practices and policies in maintaining stream and riparian function. The evaluation uses 15 indicators, each of which is assessed by several questions to determine the level of riparian and stream function. The number of failed criteria determines the level of ecological function, namely properly functioning (> 2 criteria failures), properly functioning but at risk (3-4 criteria failures), properly functioning but at high risk (5-6 criteria failures), and not functioning properly (> 6 criteria failures).

A properly functioning stream has a stream and its riparian zone that withstand normal peak flood events without experiencing accelerated soil loss, channel movement, or bank movement, is capable of filtering runoff, and can store and safely release water. The riparian protocol expands on this FPC definition to include the ability of the riparian habitat to maintain an adequate root network and large woody debris (LWD) supply, provide shade to limit changes to the bank microclimate, and support adequate fish habitat.

The RREE requires the selection of a homogeneous sample reach, which is identified as being at least 30 channel widths long. As surveyors travel the sample reach they collect point and continuous indicator information that address the 15 main questions in the RREE. These can be subdivided into stream and riparian categories as follows:

Stream indicators	Riparian indicators
• channel bed disturbance • channel morphology (Figure 8) • aquatic connectivity • fish cover diversity • moss abundance (Figure 8) • fine sediments • aquatic invertebrate diversity • windthrow frequency • channel bank disturbance	• large woody debris supply • disturbed or bare ground • shade and bank microclimate • vegetations response • weedy species



Figure 8: Counting LWD and measuring pool length (left photo), calculating moss coverage on streambed cobbles and boulders (right photo).

Summary of Main Findings

RREE Assessment of Upper and Lower Basin Sites

The Bowron River watershed has not fully recovered from the large-scale salvage harvesting activities that took place between the 1970s and 1980s. Most the upper and lower stream reaches were found to be either not properly functioning or functioning at high risk compared to the reference sites, which were functioning at low risk or properly functioning (Figure 9).

The upper basin locations show a stronger response, with 21 of 29 sites having lower levels of function (i.e., not properly functioning or functioning at high risk) compared to 17 of 30 lower basin sites.

The difference in response between the upper and lower sub-basin locations can be attributed primarily to failures of the riparian criteria. Upper basin sites generally had little to no riparian buffer and so most of the riparian questions received a “no” answer, downgrading the classification from properly functioning.

In contrast, lower basin sites had larger buffers and as a result, fewer failures of the riparian indicators. Riparian zone silviculture efforts following the salvage harvesting program were unsuccessful in many areas because natural deciduous and shrub growth were more successful at establishing than planted coniferous trees.

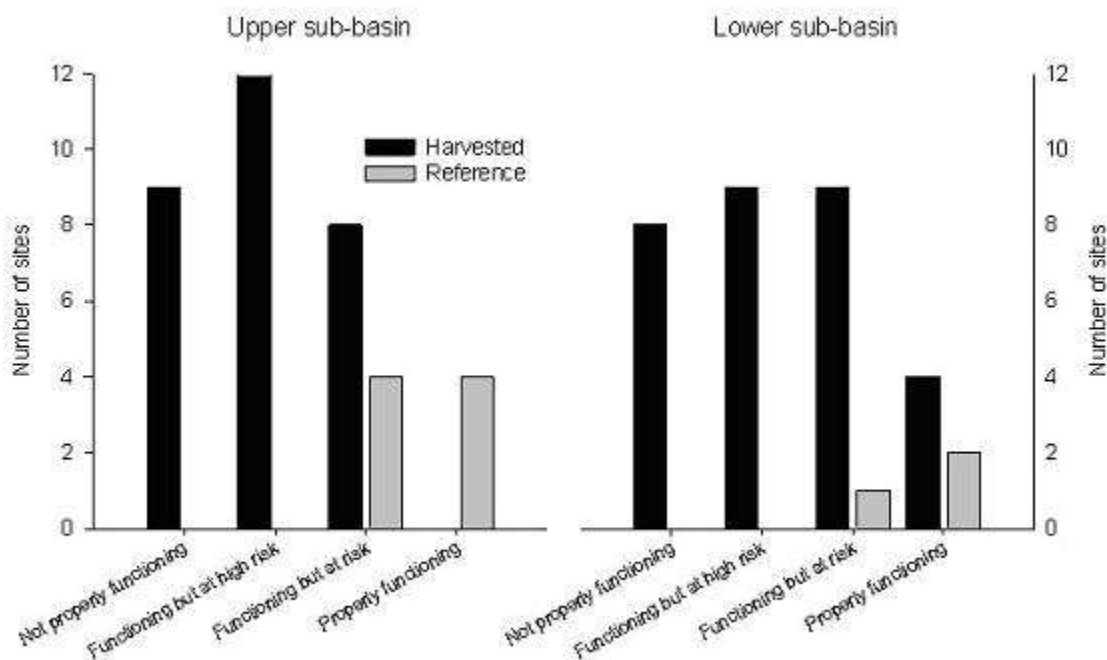


Figure 9: Routine riparian effectiveness evaluation level of function scores for upper and lower stream sample reaches in the Bowron River Watershed.

Comparison to IWAP Scores

The RREE scores follow a similar pattern to the IWAP scores (Figure 10). Low-risk sites often had higher RREE scores, indicating a higher level of function when compared to the moderate- and high-risk sites. The upper basin low-risk group scored significantly higher than moderate- and high-risk groups (ANOVA $P < 0.05$).

There were no significant differences among the lower-basin categories, and this may be due to the presence of a wider buffer that led to slightly higher RREE scores. These findings indicate that there is some value to using the level 1 IWAP as a riparian risk planning tool in forest management.

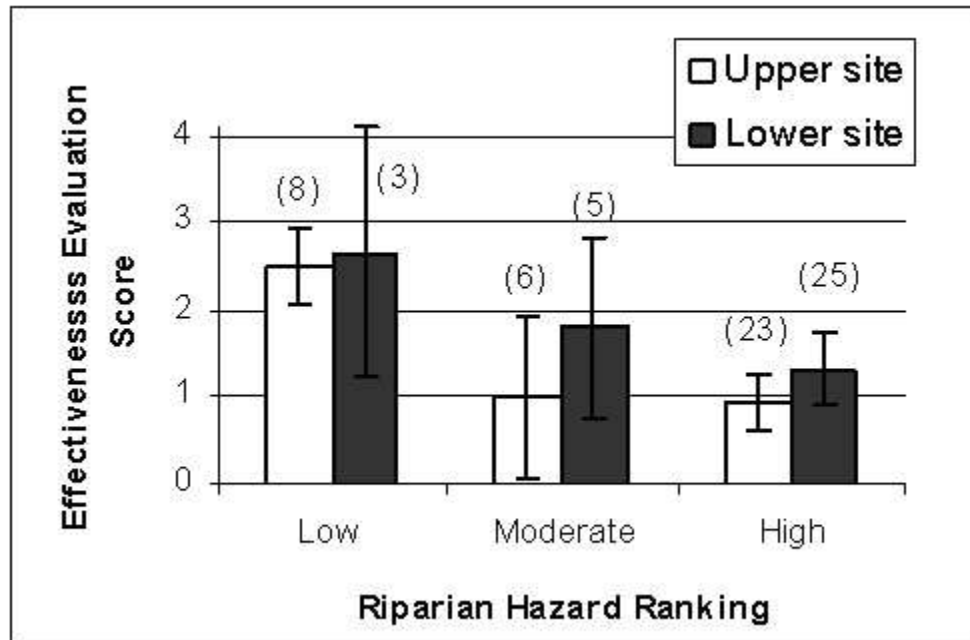


Figure 10: Interior Watershed Assessment Procedure (IWAP) riparian hazard rankings and the corresponding Routine Riparian Effectiveness Evaluation (RREE) scores as identified by their position in the sub-basin. Effectiveness evaluation scores range from 0 (not properly functioning) to 3 (properly functioning) and error bars represent the 95% confidence intervals.

Other Findings

In addition to the information gathered specific to the RREE procedure, several other field based observations are worthy of note for their potential to influence forest management activities, including:

- Fish passage barriers-hanging culverts were observed on S4 streams that dropped 1-2 m downstream of main haul roads (Figure 11). Similarly, fish passage would be blocked by woody debris dams such as that observed at the mouth of Indian Point Creek during the summer of 2007 (Figure 11).



Figure 11: A hanging culvert at Saw sub-basin (left photo) and the woody debris jam below the bridge at the mouth of Indian Point Creek in August of 2007 (right photo).

- Heavy equipment operation on roads, landings, and occasionally in the riparian zone was found to compact and rut soil so that vegetation re-growth was limited decades after salvage harvesting (Figure 12).



Figure 12: Machine tracks within the riparian zone of Unnamed A sub-basin, harvested over 20 years ago (left photo) and a landing site that is over 20 years old in the Haggen Creek basin above site 2 (right photo).

- Riparian harvesting - salvaged riparian areas showed minimal conifer re-growth 20-30 years after harvesting. Instead, these areas were dominated by deciduous re-growth (typically alder and willow species), which may be inadequate for future LWD requirements. Even where riparian zones were replanted, survival rates were low or growth was poor, so riparian stand structure was quite different from unlogged sites, which typically included a mixture of tree species (Figure 13).



Figure 13: Riparian forests in a 30- (left photo) and 40-year stand (center photo) after harvesting (Purden Site 1, Tsus/Fly Site 2) showing a significant deciduous canopy compared to the reference site (right photo), which has more mixed species and conifers in particular (Swamp basin).

- Beaver activity in riparian zones and streams following salvage harvesting - in low-gradient systems can further decrease the level of watershed function and possibly fisheries productivity by storing water, sediment, and LWD, and possibly blocking fish passage at old crossings that have not been decommissioned (Figure 14).



Figure 14: Beaver dams and a beaver lodge located in upper and middle Bowron (left and right photo, respectively). Both of these beaver dams use a road to block the flow of water.

Application of Results & Future Directions

In summary, the Routine Riparian Management Effectiveness Evaluation (RREE) inventory of the Bowron River Watershed identified that there are significant resonant effects remaining from the large-scale salvage operations of the 1970s-1980s.

Riparian harvesting in the upper sites led to consistent failures of riparian indicators at these locations compared to the lower sites where larger buffers were retained. Riparian retention is necessary to control erosion, protect water quality, ensure long- and short-term supply of LWD, moderate shade and water temperature, and maintain the structural diversity and integrity of the riparian forest and stream habitat. In keeping with these observations the following best management practices are recommended:

1. Maintain sufficient stand structure and volume in the Riparian Management Zone to protect the Riparian Reserve Zone.
2. Minimize the use of heavy equipment in the Riparian Management Zone of watersheds with fine soil types to minimize soil disturbance.
3. Increase retention within the management zone for small and non-fish-bearing streams (S4-S6). In accordance with the *Riparian Management Area Guidebook*, retain and buffer all trees within 10 m of the streambank for S4 streams in low windthrow risk areas. This should also be considered an option for S5 and S6 streams.
4. Retain understorey and non-merchantable trees in the RMZ where harvesting activities occur. Also retain all trees with root networks that extend into a streambank.
5. Avoid depositing debris into stream channels by maintaining adequate buffer width in the riparian reserve and management zone. Where harvesting occurs near these zones, fall and yard away from streams. When slash and debris are inadvertently deposited, remove only those stems that can be lifted clear without damage to the channel bed or bank. For those that cannot be lifted clear, ensure that the stem and limbs do not obstruct stream flow or fish passage.
6. Brush and subsequently monitor replanted riparian zones to ensure that planted trees are growing efficiently.
7. Maintain natural drainage patterns. Natural drainage patterns must be considered and incorporated into road network design.
8. Ensure that erosion and sediment control plans are developed and followed during road construction in watersheds with sensitive soils.
9. Decommission road crossings once harvesting operations are completed and ensure that site rehabilitation is sufficient to prevent sediment delivery to the stream.
10. Remediate roads and landings, particularly those close to streams, promptly after harvest operations to prevent sediment delivery to the stream.

Acknowledgements

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