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Small Stream Riparian Retention: the Prince George Small Streams Project

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Introduction and Background

The Prince George Small Streams Project was initiated in the Prince George Forest District in 2001 to assess the effectiveness of the Prince George District Manager's policy (PGDM 1999) to maintain the riparian functions and fish habitat values of small streams that are less than 1.5 m bankfull width. This extension note provides a project overview and highlights specific findings to inform forest professionals about small stream riparian management in the Central Interior of British Columbia. A more complete description of the project and all of its findings can be found on the British Columbia Ministry of Forests and Range Fish-Forest Interaction website¹ and in a forthcoming 6-year synthesis report that will be available on the Ministry's publications website.² Although this project was developed under the Forest Practices Code (FPC) regulatory regime, it is equally relevant today because the lack of mandatory riparian reserves for small (class S4) fish-bearing streams in the FPC remains unchanged in the current For-

est Planning and Practices Regulation (FPPR s. 47(4)). Furthermore, current emphasis on professional reliance underscores the importance of making research findings available to forest professionals so they can formulate appropriate forest practices for managing riparian areas adjacent to small streams.

In 1999, the Prince George District Manager expressed concerns about the effectiveness of FPC riparian management regulations that allow for zero tree retention along S4 streams. In accordance with section 41(1)(b) of the FPC, the District Manager must be satisfied that an operational plan for harvesting will "adequately manage and conserve" forest resources in the area addressed by the plan. Following a review of the scientific literature and reporting by resource professionals, the District Manager approved a policy designed to address the biological and physical habitat requirements of small fish-bearing streams (S4). The policy's purpose was to guide resource professionals in preparing operational plans and to guide the statutory decision-maker when approving those operational

¹ Fish-Forest Interaction website: www.for.gov.bc.ca/hre/ffip

² www.for.gov.bc.ca/scripts/hfd/pubs/hfdcatalog/index.asp

plans. Although the District Manager recognized that most if not all forest licensees would be guided by section 41(1)(b) of the FPC to leave adequate amounts of forest retention along S4s to address fish habitat requirements, he wanted to ensure that minimum retention levels proposed in plans would adequately address fish habitat concerns. Following the introduction of the PGDM policy, a 6-year before-after-control-impact study (2001–2006) was initiated in three different watersheds to investigate the physical, chemical, and biological responses to the implementation of the PGDM policy. This interdisciplinary study was completed by the Ministry of Forests and Range in collaboration with Fisheries and Oceans Canada and Pierre Beaudry and Associates.

The PGDM policy outlines several riparian management strategies, depending upon riparian stand conditions. The retention prescription of 10 overstorey trees (> 15 cm dbh) on each side of the stream per 100 m of stream length was selected for study because it is the lowest retention option allowed by the policy (Figure 1). In addition to maintaining fish habitat conditions, the PGDM policy had five specific management objectives:

1. to maintain 50–70% of the natural levels of shading and light intensity reaching the stream surface and forest floor;
2. to maintain an adequate long- and short-term supply of large woody debris (LWD) in the stream channel;
3. to maintain natural root structure adjacent to streams, with particular emphasis on minimizing soil disturbance within 5 m of the stream channel;
4. to not overload the stream with an excessive amount of fine organic debris; and

5. to concentrate retention (both patch and single tree) in the most critical portion of the riparian management zone, which is the 10–15 m closest to the stream.

Study Sites, Response Variables, and Experimental Design

Thirteen small stream watersheds were selected for study (Figure 2).



FIGURE 1 *The Chuchinka treatment cutblock showing the riparian buffer (arrow) for the treatment stream, October 2003.*

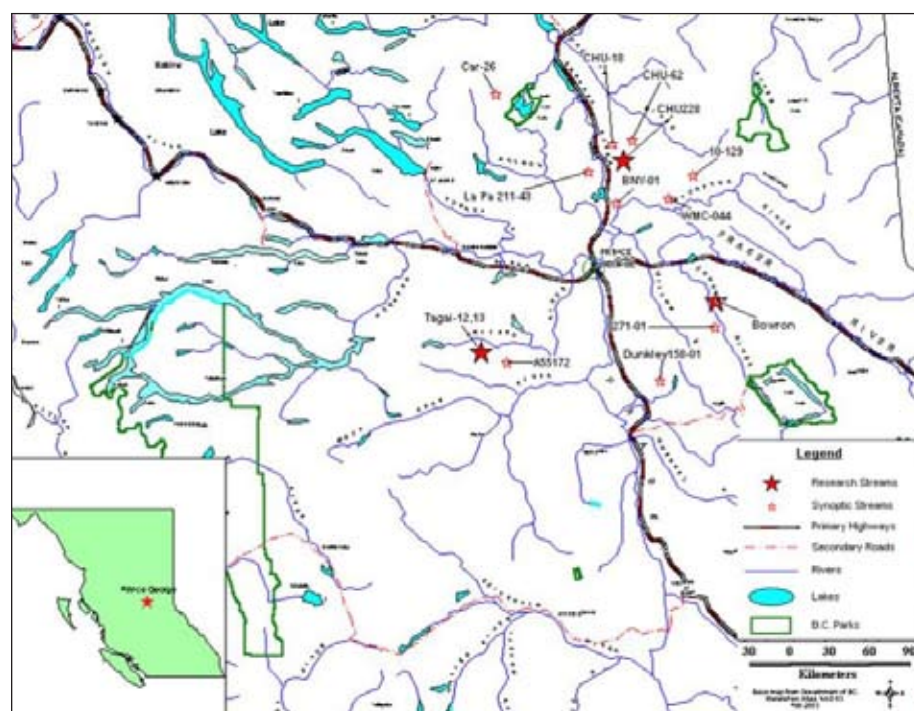


FIGURE 2 *Prince George small streams study sites. Hollow stars identify the synoptic study sites; filled stars identify the detailed study sites.*

Each of these streams was studied over a 6-year period from 2001 to 2006, comprising 1–3 years of pre-harvest and 3–5 years of post-harvest study. Ten of these sites were assessed synoptically for physical channel response to riparian harvesting by Pierre Beaudry and Associates. The remaining three watersheds were research streams (Table 1) that were studied by all partners using a suite of chemical, physical, and biological response indicators (Table 2).

The study employed a before-after-control-impact paired (BACI-P) design (Schwarz 1998). This design was considered the best approach for determining treatment effect because it provides both spatial and temporal control for assessing change within the treatment reaches. The BACI-P is a statistically robust design for impact assessments that require sampling of environmental variables before and after the treatment is applied in treatment reaches for comparison with untreated control sites.

Results

The research team developed a summary table of project results for ready use by forest professionals during operational planning (Table 3). The table provides an overview of findings, specifies a level of management concern for each stream and riparian characteristic affected by the riparian harvesting, and highlights considerations for mountain pine beetle salvage harvesting in the British Columbia Interior. Although the PGDM policy was successful in meeting four of its five management objectives, it was not successful in maintaining the overall fish habitat values of the small streams studied. The following changes resulted from the PGDM minimum prescription and were of highest concern:

TABLE 1 Summary of research stream channel characteristics studied by all partners

Site	Bankfull width (m)	Wetted width (m)	Bankfull depth (m)	Slope (°)	Aspect	Primary substrate (mm)	BEC unit ¹
Bowron							
Control	1.1	1.1	0.3	1	NW	5–25	SBSvk
Bowron T1	0.9	0.7	0.3	2		5–25	
Bowron T2	0.8	0.5	0.4	7		< 2	
Chuchinka							
Treatment (Chu 228)	1.5	1.1	0.3	2	SW	50–100	SBSwk1
Control	1.7	1.4	0.5	1		2–25	
Tagai							
Control	1.0	0.8	0.4	2	NE	< 2	SBSdw2
Tagai 13	1.2	0.8	0.3	7		25–50	
Tagai 12	1.2	1.1	0.2	7		organic	

¹ SBSvk: Sub-Boreal Spruce Very Wet Cool; SBSwk1: Sub-Boreal Spruce Wet Cool Willow; SBSdw2: Sub-Boreal Spruce Dry Warm Blackwater

TABLE 2 Research partners, response variables measured, and program responsibilities

Ministry of Forests and Range	Fisheries and Oceans Canada	Pierre Beaudry and Associates
Air temperature	Fine sediment transport	Shade
Stream temperature	Streamflow	Large woody debris dynamics
Project management	Shade and litter fall	Channel morphology
	Nutrients	Stream sediment supply
	Dissolved organic matter	
	Periphyton	
	Benthic macroinvertebrates	
	Fish	

- Long-term supply of LWD (objective 2) was not met using the PGDM minimum prescription. This characteristic is particularly important for interior small streams because they tend to be low-energy streams that do not receive woody debris from upstream areas. Instream LWD generally originates from the riparian area near where it is observed in the stream. A source-distancing study of active instream LWD indicated that 77–98% of all active instream LWD originated from within 10 m of the stream bank (Figure 3).
- Litter fall quantities decreased and composition changed after removal of riparian overstorey.
- Decrease in shade led to an increase in summer daily mean and maximum stream temperatures (Figure 4). Greater differences in temperature between control and treatment streams occurred during warmer summers. The highest increase in daily maximum temperatures was approximately 3.0°C in the Chuchinka treatment stream, which has a southern exposure.

TABLE 3 Prince George Small Streams Project result summary, including level of management concern for stream and riparian characteristics as well as management implications for small streams in areas affected by the mountain pine beetle

Stream or riparian characteristic	Associated natural ecological functions	Variables measured in small stream project	Interactions with other stream processes	Expected time frame for changes to occur from riparian harvest ^a	Significant changes to stream/ riparian characteristic?	Level of concern for negative impacts to occur when using District Manager policy	Type of stream most sensitive to this change	Implications for small streams in mountain pine beetle zone
Streamflow regimes	<ul style="list-style-type: none">controls rates of downstream transport of sediment, large woody debris, organic mattercontrols rates of channel migration and bank erosiondetermines amount and quality of fish habitat (e.g., M9 pool depths)affects fish passage and movement	<ul style="list-style-type: none">continuous stream stage datastage discharge curves	<ul style="list-style-type: none">sediment transportchannel morphologyinvertebrate driftdownstream export of nutrients/organic matter	Short to medium term	Insufficient long-term data from this study to assess; increased spring peakflows observed in other regional studies	Not applicable	Related to amount of watershed harvested; District Manager (DM) riparian treatment has limited effect	Increased flows caused by reduced evapo-transpiration (dead and salvaged trees) suggests more riparian retention to control bank stability and erosion
Fine sediment transport	<ul style="list-style-type: none">affects natural stream substrate condition (e.g., spawning gravels, invertebrate substrates)maintains concentrations of suspended sediment within natural biological tolerances	<ul style="list-style-type: none">continuous turbidity data	<ul style="list-style-type: none">sediment sourcesinvertebrate and periphyton abundancesuspended sediment effects on fish	Short to medium term	Yes (from roads and trails, not riparian treatment)	LOW	Changes were related to quality of stream crossings, not riparian treatment	Because of potential for high road density, good erosion and sediment control at stream crossings is very important
Stream sediment supply	<ul style="list-style-type: none">maintains stream substrate condition (e.g., spawning gravels, invertebrate substrates, pool depths)	<ul style="list-style-type: none">identify stream sediment sourcesassess stream bank tree windthrow	<ul style="list-style-type: none">channel morphology and substratebank stability	Short to medium term	No significant change; sediment supply maintained within natural range	LOW	Lacustrine parent material	Because of very high road density, good erosion and sediment control at stream crossings is very important
Channel morphology	<ul style="list-style-type: none">natural variability in morphology features (e.g., pools, riffles, undercut banks) enhances diversity and influences biological productivity	<ul style="list-style-type: none">stream width and depth	<ul style="list-style-type: none">streamflow regimessediment transport and supplylarge woody debrisbank stability	Long term	No significant change yet, however may be affected in the long term by reduced large woody debris supply	MODERATE	All except bedrock-controlled channels	Riparian retention important for bank stability as flows will increase
Large woody debris	<ul style="list-style-type: none">stream structural diversity, channel morphologyretention of organic matter and sedimentsfish cover and habitatrefuge for organismssubstrate for growth	<ul style="list-style-type: none">large woody debris in stream (quantity and age classes)riparian recruitment distanceriparian composition	<ul style="list-style-type: none">sediment transportstreamflowsfish and stream productivity	Long term	No significant change yet; however, modelling predicts a significant decrease in the future	HIGH	DM policy provides insufficient long-term supply of large woody debris for all riparian types studied, with the worst impact being in ecosystems dominated by spruce and subalpine fir	Retention of both dead and green riparian trees important (more than District Manager policy suggests)
Shade	<ul style="list-style-type: none">controls direct solar heatingminimizes ultraviolet radiation exposure of biotadetermines photosynthetically active radiation for periphyton growthprovides cover for fish	<ul style="list-style-type: none">canopy densityangular densiometersolar pathfinder (direct solar exposure)	<ul style="list-style-type: none">temperatureperiphytoninvertebratescover for fish	Short term	Yes, a significant decrease	HIGH	“Temperature-sensitive” streams; ultraviolet exposure of streams with low dissolved organic carbon; loss of cover for fish; south-facing streams	Potentially reduced shade (fewer pine); more retention required
Water temperature regimes	<ul style="list-style-type: none">cool water source (headwater streams)affects all stream productivity processesaffects fish growth and health; egg survivalstream invertebrate community composition, productivity and drift	<ul style="list-style-type: none">water temperatures	<ul style="list-style-type: none">all stream biota and productivity processes	Short to medium term	Yes, a significant increase	HIGH	Designated temperature-sensitive streams and those supporting temperature-sensitive species such as bull trout; south-facing streams	More retention may be required in areas where shade is reduced from canopy loss. Road crossings should be minimized to decrease stream exposure.
Litter fall	<ul style="list-style-type: none">dominant source of organic matter for headwater stream productivity	<ul style="list-style-type: none">litter fall trapscanopy density	<ul style="list-style-type: none">invertebrates • nutrientsmicro-organisms	Short term	Yes, a significant decrease	HIGH	All streams	Loss of litter inputs may affect productivity of mountain pine beetle streams
Inorganic nutrients	<ul style="list-style-type: none">inorganic nitrogen and phosphorous availability affects stream productivity and organic matter processing	<ul style="list-style-type: none">nitrogen water chemistryphosphorous water chemistryconductivitydischarge	<ul style="list-style-type: none">periphytonorganic matter processinginvertebrate production	Short to medium term	Increased nitrogen in Bowron riparian may have minimal effect on watershed nutrient processes (vegetation, soils)	LOW	All streams	Changes in watershed vegetation and soil disturbance from salvage activities may affect soil and stream nutrients
Dissolved organic matter	<ul style="list-style-type: none">natural sunscreen in water that protects against ultraviolet exposure of biotaorganic matter source for microbial communities	<ul style="list-style-type: none">dissolved organic carbonultraviolet absorptiondirect solar radiation exposure (solar pathfinder)	<ul style="list-style-type: none">shade and direct solar radiation exposuretemperature • litter fallinorganic nutrients	Short to medium term	No changes detected; riparian area may have minimal effect on watershed organic matter processes (vegetation, soils)	LOW	All streams	Changes in watershed vegetation and soil disturbance from salvage activities may affect soil and stream dissolved organic matter inputs
Periphyton	<ul style="list-style-type: none">attached algae are important organic matter source for invertebrate production	<ul style="list-style-type: none">seasonal periphyton accrual rates and maximum biomass	<ul style="list-style-type: none">invertebrates • light • temperaturesuspended sedimentinorganic nutrients	Short to medium term	Yes/No; remained low in some streams (nutrient limited), increased in others (light limited)	LOW	All streams	Changes in stream nutrients and shade will determine response of periphyton communities
Invertebrate drift	<ul style="list-style-type: none">primary food source for resident fishproduction for downstream export to fish habitat	<ul style="list-style-type: none">24-hr drift netsdischarge	<ul style="list-style-type: none">benthic invertebrateswater temperature • dischargefish growth and health	Short to medium term	Yes, but biological effects of community changes difficult to assess	MODERATE	All streams	Productivity affected by changes in stream shade, nutrients, litter fall, and periphyton
Benthic invertebrates	<ul style="list-style-type: none">source of invertebrate driftinstream processing of organic matter	<ul style="list-style-type: none">Surber sampling	<ul style="list-style-type: none">shade and ultraviolet radiationnutrients • litter fall • periphyton	Short to medium term	Yes, but biological effects of community changes difficult to assess	MODERATE	All streams	Productivity affected by changes in stream shade, nutrients, litter fall, and periphyton
Fish	<ul style="list-style-type: none">headwaters may be important spawning and rearing habitats for trout, salmon, and char, and supply cool, high-quality water to downstream reachesfishless headwater streams produce invertebrate food for downstream export to fish-bearing waters	<ul style="list-style-type: none">fish traps, species abundance, habitat use, lengths, weights	<ul style="list-style-type: none">stream productivityinvertebrate driftstream habitat and coverwater temperatures	Short to medium term	Ephemeral use of the streams complicates assessment	MODERATE	All fish-bearing streams	Changes in stream productivity may require adjustment of fish management policies

a Short term = 0 – 5 years; medium term = 5 – 20 years; long term = > 20 years

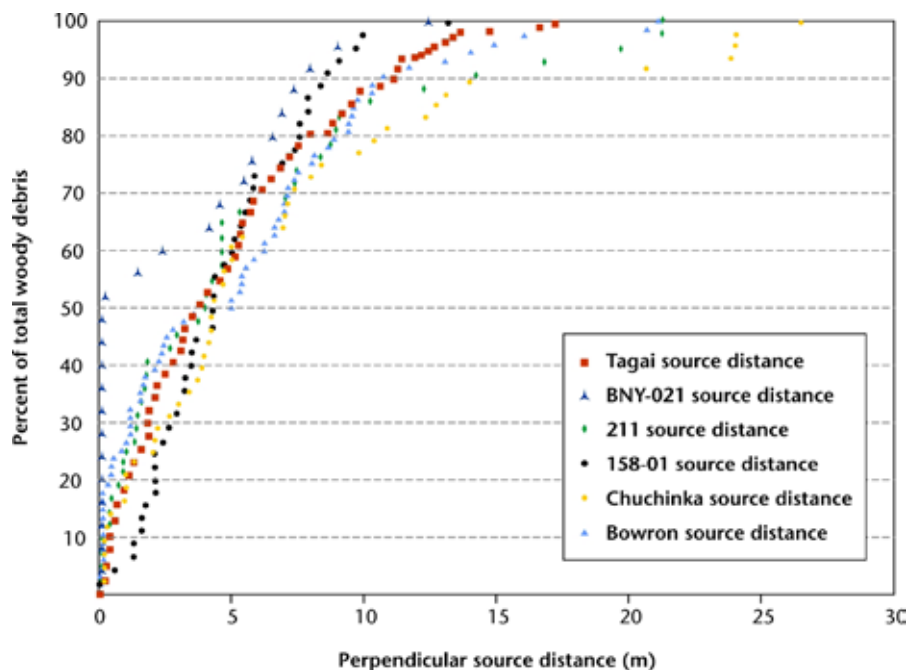


FIGURE 3 Cumulative contribution of woody debris at increasing distance from the stream bank.

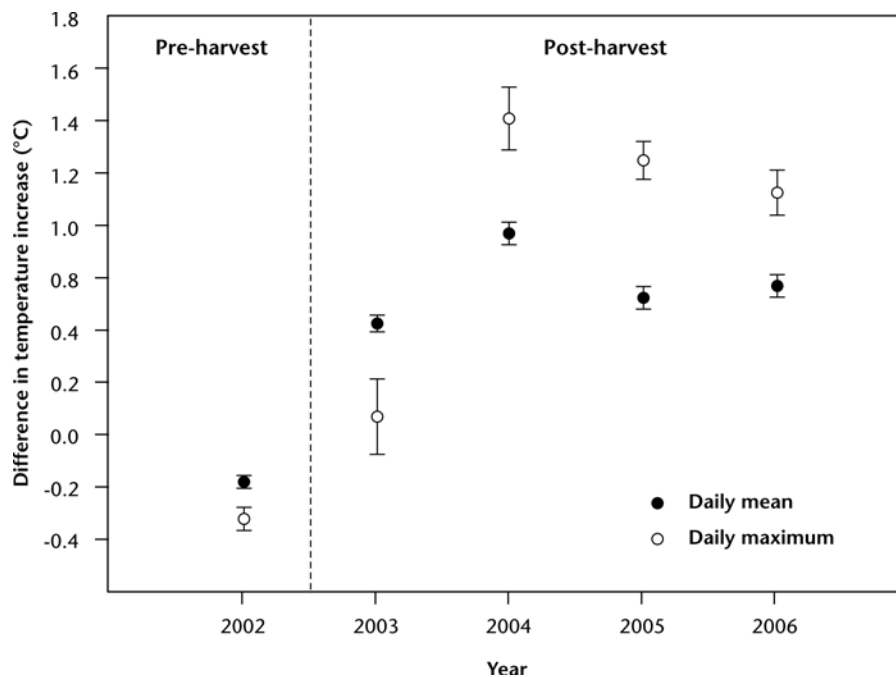


FIGURE 4 The difference in daily mean and maximum stream temperature increase between upstream and downstream sites of the Bowron control and T2 treatment stream before and after harvesting. During the pre-harvest period, temperature increase over the sample reach was similar between streams. In the post-harvest period the treatment stream temperature increased 0.3–1.5 °C more than the control stream.

Discussion and Recommendations

The PGDM minimum prescription did not maintain pre-treatment fish habitat conditions in the study streams. Accordingly, it should not be used as a riparian management prescription to meet the stated objectives for fish habitats. In accordance with fish, water, and biodiversity objectives for riparian zones (FPPR, s. 8), forest professionals should consider the following recommendations for riparian management best practices:

- To maintain long-term LWD supply with greater certainty, retain all trees within 10 m of the stream bank. This was also the best management practice recommended in the Riparian Management Area Guidebook for S4 streams in low and moderate windthrow areas in the British Columbia Interior (Province of British Columbia 1995). The loss of some riparian-zone trees to windthrow during post-harvest may occur, but it is important to consider that windthrow is the natural recruitment mechanism for LWD to interior streams.
- Where windthrow risk is moderate to high and there are concerns about blowdown, the 10-m reserve can be further buffered or protected through creation of windbreaks and additional retention within the remaining 20-m riparian management zone. Alternatively, selective harvesting of windthrow-prone trees that will fall away from the stream could be considered.

Increasing tree retention within the 10-m zone closest to the stream bank will address litter fall, shade, and water temperature characteristics in addition to LWD supply. Retaining overstorey within the 10-m zone

closest to the channel will help maintain pre-harvest litter fall conditions because the overstorey will continue to contribute litter fall while providing shade to the understorey. Greater stream shading levels from retained riparian overstorey should decrease solar insolation reaching the channel and will likely lead to a lower stream temperature response than that observed during this study.

Although this study was conducted in Central Interior streams and it best represents those conditions, the 10-m buffer zone recommended here can serve as a baseline for considering riparian retention in other regions. In warmer biogeoclimatic zones and/or those watersheds with temperature-sensitive streams, retention should be increased to mitigate potential water temperature responses. The 10-m zone should be maintained in cooler biogeoclimatic zones to ensure long-term LWD recruitment and litter fall inputs.

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