Prince George Small Streams Project

1999 – Present

Introduction

The management of small-stream riparian zones is particularly important because small streams are a prominent feature in watersheds. Their cumulative channel length can represent upwards of 70% of the total channel length within a watershed. Despite their prominence within watersheds, their riparian zones are often afforded little to no retention. Such was the case in British Columbia under the Forest Practices Code, which did not specify riparian reserve zones for S4 streams (< 1.5 m bankfull width and fish-bearing).

To address this issue, in 1999 the Prince George Forest District implemented a local policy to address resource agencies' concerns regarding riparian harvesting near S4 streams. The S4 policy focussed on maintaining 50-75% of natural stream shading, adequate short- and long-term supplies of large woody debris, and streambank root structure, and preventing mineral and organic fines from reaching the stream channel.

Figure 1: A stable piece of woody debris with an oblique orientation at the Chuchinka site.

The purpose of the policy was to communicate the guiding principles that the District Manager (DM) would use to structure his thought processes when making a statutory decision regarding the approval of a cutting permit. The policy specified five management objectives including:

1. Maintain 50 - 70% of the natural levels of shading and light intensity reaching the stream surface and forest floor.
2. Maintain an adequate long- and short-term supply of large woody debris (LWD) in the stream channel.

3. Maintain natural root structure adjacent to streams with particular emphasis on minimizing soil disturbance within 5 m of the stream channel.
4. Do not overload the stream with an excessive supply of fine organic debris (FOD).
5. Concentrate retention (both patch cut and single tree) in the most critical portion of the riparian management zone (RMZ), which is the 10-15 m closest to the stream.

To assess the effectiveness of this policy, in May 2001 the B.C. Ministry of Forests in partnership with the federal Department of Fisheries and Oceans and Pierre Beaudry & Associates Ltd., and with funding from Forest Renewal British Columbia (subsequently Forest Investment Account), initiated the Prince George Small Streams Project.

This co-operative field project was designed to scientifically evaluate if the Prince George District Manager (PGDM) policy was maintaining the necessary ecological attributes for healthy fish habitat. The project was designed to quantify the temporal, geographic, and among-stream natural variations in late summer / fall temperatures, and to detail channel morphometrics and substrate descriptions, erosion sources, litterfall, shade, benthic invertebrates, periphyton biomass, water chemistry, nutrients, woody debris, the downstream export of organic material, and invertebrate drift.

The project provides an interdisciplinary research approach to the study of a small-stream riparian zone management prescription in the central interior of British Columbia. It was developed to assess the physical, chemical, and biological response of small streams to the riparian retention strategy within an adaptive management framework.

Secondary project objectives included evaluating the effect of riparian harvesting on natural disturbance regimes (e.g., blowdown) on the ecology of small streams, evaluating the effectiveness of the PGDM Policy as a partial-cut silviculture alternative for the management of riparian areas adjacent to small streams, and increasing knowledge about the dominant watershed process controlling the ecology of small streams and how these processes can be managed for sustainability.

Study Site Description

Eight S4 streams within the interior Sub-Boreal Spruce biogeoclimatic zone of BC were monitored for this project. The streams were located in three geographically distinct forest types within the Tagai Lake (three streams), Chuchinka Creek (two streams), and Bowron River (three streams) watersheds, with each forest type containing two to four streams whose riparian areas were scheduled for harvesting within 2 years. These were selected to represent the range of forest conditions observed in the Prince George District.

The Tagai Lake streams were located in lodgepole pine-dominated stands of the SBSdw2 biogeoclimatic variant, which is dry and has the warmest climate within the Prince George Forest District. The Chuchinka Creek streams were in a spruce-dominated stand in the SBSwk1 variant, which is one of the cooler and wetter biogeoclimatic units in the district. The Bowron River sites were also within spruce-dominant stands but are in the SBSvk variant, which is the wettest unit in district and also quite cool.

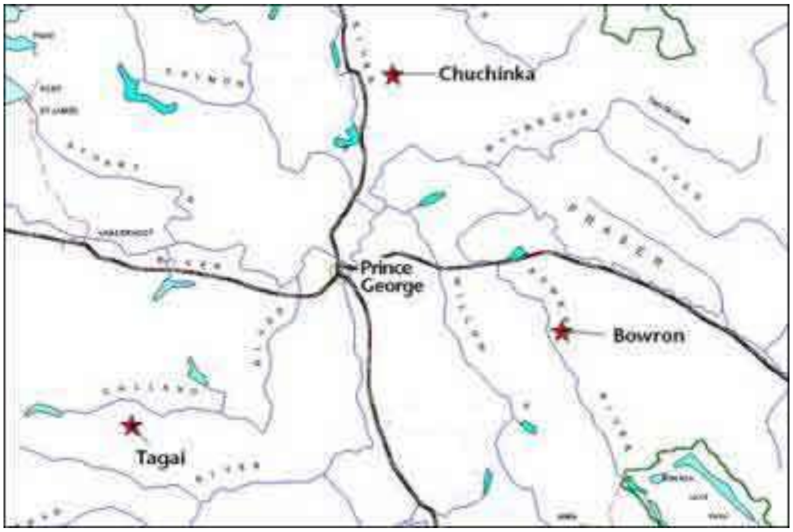

Figure 2: General location of the Tagai Lake, Chuchinka Creek, and Bowron River streams monitored during this project.

Study Design

The experimental design selected for this study was the before-after-control-impact paired (BACI-P) design, and it was chosen because it is a statistically robust design for impact assessment studies. The BACI-P requires sampling of environmental variables before-and-after the treatment in areas designated as treatment and control sites. Treatment effects are identified by comparing before and after treatment samples between and within sites using statistical analyses such as ANOVA, regression, or time series analysis.

The eight study streams were selected on the basis that they were:

1. Located in the Prince George Forest District
2. Not yet harvested
3. Scheduled for harvest using the DM Policy within the next 1-3 years
4. Less than 1.5 m in width and classified as an S4 (fish-bearing) stream
5. Of a gradient less than 12%
6. Within reasonable road access

Each of the three main watersheds also included an independent (proximal), forested control stream, and each study stream had a reach located upstream of the cutblock that would remain forested (non-logged) to serve as an additional experimental control. Stream reaches of 50 m in length were monitored within the overall proposed cutblock boundaries (treatment reaches) as well as outside of any proposed harvesting (control reaches). Each proposed harvesting unit therefore comprised at least one study reach and a paired control (upstream as well as in a nearby adjacent stream), consistent with a BACI-P study design.

Figure 3.1 & 3.2: Overview of the Bowron (left) and Chuchinka (right) study streams following streamside harvesting.

The PGDM policy provides several strategies to meet the riparian management objectives based upon stand conditions. Given the adaptive management context of the study it was decided that the lowest-retention prescription was the best starting point. As a result, the minimum retention level of 10 overstorey trees (> 15 cm dbh) per 100 m of stream length was prescribed for all sites.

Detailed monitoring began in the spring of 2002, allowing for a full pre-harvest sampling period from spring melt to freeze-up. Harvesting of the cutblocks began in 2003 and was completed at the Bowron sites in December 2002, at the Chuchinka sites in July 2004, and at one Tagai site in March 2004 (the other being logged in July 2004). Post-harvest data collection for the Bowron cutblocks began in May 2003, August 2003 for the Chuchinka sites, and April 2004 and September 2004 for the Tagai sites.

Response Variables

The Prince George Small Streams study is an interdisciplinary study incorporating the disciplines of hydrology, forestry, fisheries science, and aquatic ecology. Accordingly, the project was subdivided amongst program partners to facilitate achievement of project objectives. The main project components and response variables that were measured, together with their respective co-ordinators, are listed below.

Channel morphology (Pierre Beaudry & Associates [PBA])

- Channel width and depth
- Sediment sources

Large woody debris and windthrow (PBA and Department of Fisheries and Oceans [DFO])

- Large woody debris (LWD) counts
- LWD source distance and modelling
- Windthrow assessment
- Shade and litterfall

Climate, stream discharge and turbidity (DFO)

- Climate
- Discharge
- Turbidity

Air and stream temperature (B.C. Ministry of Forests and Range [MFR])

- Riparian air temperature
- Stream temperature
- Temperature modelling

Water chemistry (DFO)

- Stream nutrients
- Dissolved organic matter

Stream biota and productivity (DFO)

- Periphyton
- Benthic invertebrates
- Fish

Figure 4: Measuring bankfull width at the Chuckinka control stream (above).

Figure 5.1 & 5.2: Overview of the Tagai study streams following streamside harvesting (below).

Summary of Main Findings

Key findings from the main study components are summarized below.

Channel Morphology

- Measurement error associated with small-stream morphology can mask actual morphological changes in the stream, indicating that changes that may have occurred 2-4 years post-harvest are within the range of natural variability.
- Mean bankfull width and depth changes observed in treatment streams were statistically similar to control streams.
- Channel morphology responses will be temporally variable, therefore, these early responses may not represent future conditions.
- Blowdown was highest immediately following logging operations (within the first year post-harvest) and was found to increase sediment sources while not always contributing to in-stream woody debris.
- Sediment sources increased in the Bowron and Tagai treatment streams following harvesting, with the largest increase observed in the Tagai streams the first year following harvesting.

Figure 6.1 & 6.2: Tagai pre- (left) and post-harvesting (right) sediment sources.

Large Woody Debris & Windthrow

- 77-98% of all in-stream LWD was recruited within 10 m of the streambanks, with lower recruitment levels observed in stands with taller stems (e.g., spruce vs. pine).
- Large woody debris (LWD) source distance was easier to record for source material closest to the stream.
- LWD layering and orientation indicated material that was ready to replace in-stream decaying
- LWD was from the previous stand.
- Recruitment was primarily due to wind, with pine showing more windsnap than the spruce and fir stands.

- Most (~50%) in-stream woody debris was ≤ 15 cm diameter, consisting of branches, tree tops, and immature stems.
- The minority (≤ 15%) of in-stream woody debris was ≥ 30 cm diameter.
- On average, the number of in-stream LWD pieces was 11-15% of riparian stand density within 15 m of the channel, regardless of the stand type.
- Pine sites had more small in-stream material due to branch excision during tree growth, and the stem exclusion phase when young pine compete for light.
- Blowdown was highest the first year post-harvest, with 25% of the ensuing blowdown contributing to in-stream LWD.
- Shade levels were variable across stands and BEC zones, with deciduous stands having lowest shade values (~60%) compared to coniferous (~80%), and the drier pine stand (SBSdw2) having lower values than the wetter spruce and fir (SBSwk1, SBSvk).
- Incident solar radiation increased fourfold following logging.
- Litterfall quantity decreased and the type of litterfall changed, with fewer needles and reproductive parts collected following harvesting.

Figure 7.1 & 7.2: Measurement of woody debris at Bowron (left)
and suspended woody debris at Tagai (right).

Climate, Stream Discharge & Turbidity

- Precipitation levels were variable among years, with 2006 being the driest year of the research period.
- Air temperature conditions were also variable among years, with 2001 and 2005 being the coolest years and 2004 and 2006 the warmest.
- Discharge in these small streams is closely linked to cumulative precipitation and summer rainstorm events.
- There were increases in turbidity levels in our treatment streams after harvesting.

Figure 8.1, 8.2 & 8.3: Change in riparian vegetation at Chuchinka post-harvest (2004, 2005, 2006).

Air & Stream Temperature

- Riparian air temperatures increased post-harvest in the treatment location. Mean daily air temperature differences between the control and treatment streams were upwards of 2°C.
- The difference between forested and cut locations was influenced by climatic conditions, with greater variance recorded in the warmer years of 2004 and 2006.
- Although shade levels were showing recovery (i.e., not statistically different between control and treatment by 2006), differences in air temperature remain, possibly as a result of the difference in shade quality. That is, shade measured at the stream surface is primarily controlled by understorey vegetation and streambank morphology as opposed to overstorey trees, which have a greater influence on riparian air temperature.
- Stream water temperatures increased upwards of 1-1.5°C for daily mean and maximum between treatment and control streams in the post-harvest period.
- Similar to air temperature, the observed difference between control and treatment stream water temperature was greatly influenced by local climate, with larger differences (2.4-2.6°C) being recorded in the warmest years.
- Observed post-logging increases in stream temperature were within the tolerance range of captured fish (rainbow trout). However, the observed increase in temperature would exceed the tolerance range for the more temperature-sensitive bull trout.

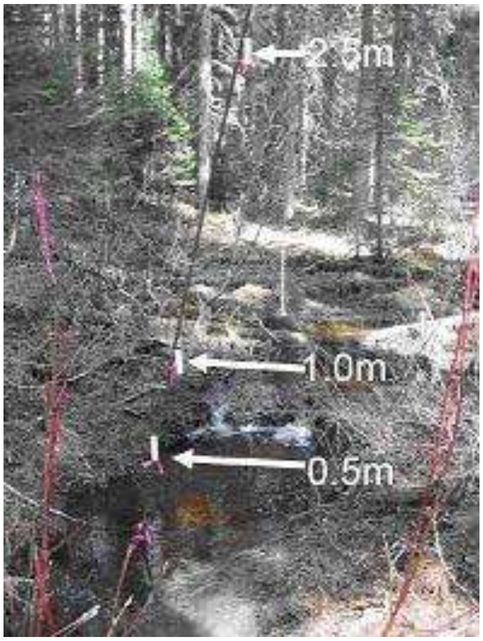

Figure 9: Air temperature monitoring station at the Chuchinka control site showing the 0.5-, 1.0-, and 2.5-m probes.

Water Chemistry

- There were large spatial and temporal variations in water chemistry parameters but no significant changes attributable to our specific logging and riparian treatments.
- The low levels of one of or both nitrogen and phosphorus imply nutrient limitation for periphyton and microbial production in these streams, resulting in overall lower stream productivity.
- The low levels of UV absorbance also indicate that some streams are naturally low in UV-absorbing dissolved organic matter (DOM) and have little natural sunscreen protection against increased exposure to direct solar radiation from riparian harvesting.

Figure 10: Stream biota and productivity.

- Relatively few stream productivity data have been collected for headwater streams in the Pacific Northwest in general and for small streams in the central British Columbia interior in particular, but, based on limited comparable data, our sub-boreal study streams are at the low end of the productivity scale.
- Stream periphyton was limited by nutrients, and accrual did not increase after forest harvest despite significant canopy reduction and solar radiation increases.
- Litterfall inputs of organic matter were reduced by 12-44% after harvesting.
- There were no detectable changes in benthic macroinvertebrate biomass or invertebrate drift biomass after harvesting.
- The invertebrate community composition shows a disturbance response to reductions in litterfall and shade and increased temperatures, transitioning to communities dominated by chironomid collector-gatherers.
- Fish survey data show that fish are not a reliable indicator of fish-bearing status in headwater streams where stream use is ephemeral.

Application of Results & Future Directions

The primary objective of this project was to assess the efficacy of the Prince George District Manager's Policy on maintaining small-stream ecosystem function. The prescription applied in this study was the policy minimum of retaining 10 merchantable stems per 100 m of stream channel. As applied, this prescription met objectives 1, 3, 4, and 5 listed above.

The policy will not meet objective 2, the provision of LWD over the short and long term. Source distance information and a LWD conceptual modelling exercise identified spatial limits for woody debris recruitment (10 m from the streambanks) in small streams, and conceptual limits on the amount of riparian harvesting. That is, the modelling exercise showed that harvesting in the riparian zone of northern interior small streams will lead to a gradual reduction of in-stream debris over several forest rotations because riparian harvesting diminishes the number of trees available for recruitment. Furthermore, unlike coastal systems, LWD in these small interior streams is not recruited from upstream areas.

In summary, this project was successful in meeting its primary objective to assess the efficacy of the PGDM policy. The policy, while successful in meeting many of its objectives for the studied watersheds, did not meet all objectives. As a result, we conclude that the policy is not sufficient to maintain small streams and small-stream riparian function in the northern interior of British Columbia and must be supplemented with further retention within the 10 m riparian area closest to the streams.

Figure 11.1 & 11.2: Riparian retention at two of the study streams within the Tagai Lake watershed.