Riparian Ecosystems and Fish Habitat

Babine Watershed Monitoring Trust Project 2005-1

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Report to Babine Watershed Monitoring Trust

Introduction

This project supports monitoring efforts in the Babine watershed. Following analysis (see Monitoring Framework at www.babinetrust.ca), the Babine Watershed Monitoring Trust identified Project 2005-1 as a high priority (BWMT 2005). The stated goal of the project is to "*examine the status of riparian forest ecosystems adjacent to fish-bearing and non-fish-bearing streams in the Nichyeskwa Creek watershed*". In essence this project aims to provide missing indicator data to allow estimation of risk to riparian ecosystems and to fish habitat.

To achieve this aim, the project estimates the disturbance frequency in natural riparian forests along different types of streams, calculates the age-class distribution of natural plus managed riparian forest, and then uses the methods described in the Monitoring Framework to estimate risk to riparian ecosystems and fish habitat (www.babinetrust.ca). Three types of data, with increasing resolution, provide information on riparian forest status. First, existing forest cover databases describe forest age and canopy cover around streams of different types. Second, new remote data updates existing data and investigates the current status of buffers in managed stands. Third, new field data allows verification of information collected remotely. In the process of analysing different types of data, we assess the utility of each method of collection.

As a secondary aim, the study also uses the collected information to investigate means of reducing the uncertainty related to blowdown in natural and managed riparian forests. If risks of blowdown are low, existing data and operational prescriptions would be sufficient to estimate the amount of standing riparian forest; conversely, if blowdown is extensive, adequate monitoring would require collection of new remote and/or field data. We consider the possibility of using canopy cover as a remote indicator of blowdown disturbance. Utility of canopy cover as an indicator would require that low canopy covers due to edaphic factors be separable from low canopy covers due to within-stand disturbance.

Finally, the study also locates stream reaches with managed and unmanaged pairs of sites for future monitoring.

The scope of this study precludes a complete analysis of the functionality of riparian forest with different levels of disturbance. Hence, (as per the expert workshop that designed this project) we assume that the amount of standing riparian forest, related to the natural amount for a particular stream type or ecosystem, acts as a surrogate for functionality.

Because of difficulty accessing data, the geographic scope of this project is limited to the Bulkley TSA portion of the Nichyeskwa watershed.

Existing Data

Methods

Data Compilation

We collated readily available data (Table 1).

Table 1. Data layers available to describe riparian ecosystems in the Nichyeskwa watershed.

Data	Description	Source
TRIM	Paper; water features based on 1996 stream inventory; contour lines	Ministry of Forests
TRIM	Digital; water features based on more recent stream inventory; contour lines	ILMB
Forest Cover	Paper maps	Ministry of Forests
Forest Cover	Digital Vegetation Resources Inventory (VRI)	ILMB
Fish Streams	1:5,000 fish and fish habitat inventory (based on 1996 stream inventory)	Triton Environmental Consultants Ltd 1999
Orthophotos	Paper	ILMB
Operational Planning Maps	1:5,000 maps for all cutblocks	PIR
Predictive Ecosystem Mapping (PEM)	Wetland features	Ministry of Forests
Watershed boundaries	3rd order watersheds	ILMB

Obtaining digital data has recently become more challenging, and hence more costly, with the change from Forest Cover to Vegetation Resources Inventory formats. Accessing VRI for the Kispiox portion of the Nichyeskwa was beyond the scope of the budget for this project; hence we focussed on the Bulkley portion.

Unfortunately, terrain mapping has not been completed for the Nichyeskwa (but is available for portions of the Babine north of the study area). Hence, we were unable to delineate floodplains and fans reliably.

We used contour lines on paper TRIM maps to calculate stream gradient rather than using a digital elevation model.

Study Sub-basins

We selected six 3rd and 4th-order sub-basins within the Bulkley portion of the Nichyeskwa for study. From the 12 available sub-basins, we randomly chose three on the north side and three on the south of the Nichyeskwa River (Figure 1). Five of the sub-basins include harvested blocks. All six have portions in the SBSmc2; five include area in the ESSFmc. Some of the sub-basins include extensive wetlands at lower gradients. Further stratification was not possible given the limited number of sub-basins.

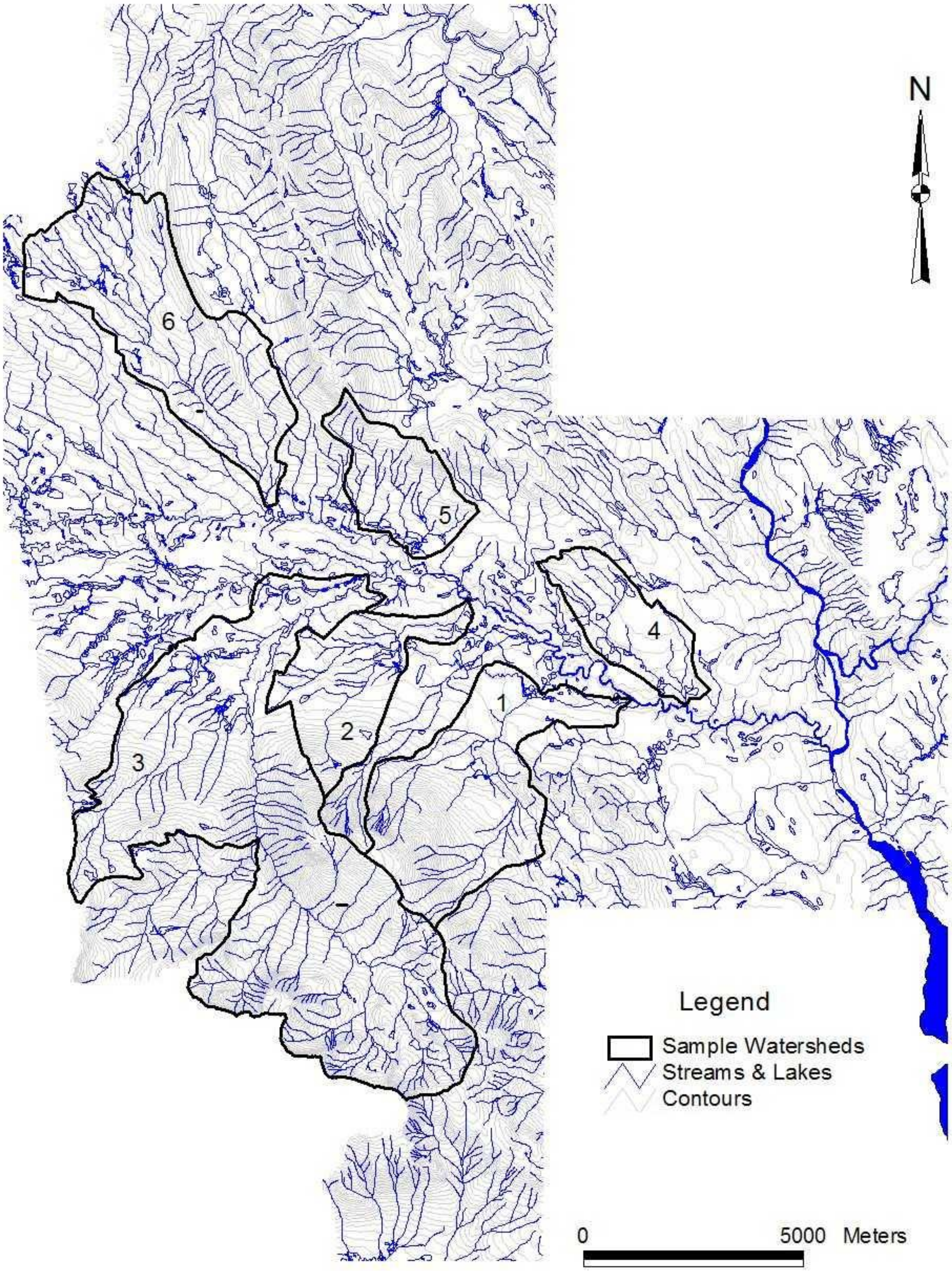

Figure 1. Six study watersheds in the Nichyeskwa Watershed.

Stream Classification

We used TRIM to locate streams and a combination of TRIM and PEM to define wetlands. We suspect that the latter method underestimates the amount of wetlands in the area. We investigated the possibility of including polygons defined as NPBr (non-productive brush) in the forest cover database to expand wetland coverage, but rejected this approach as too inclusive, particularly because we were unable to field-verify sites as wetlands within the scope of the project.

Within each sub-basin, we classified individual stream reaches, considering type (presence/absence of gulleys and wetlands), presence of fish (based on the Fish Stream Inventory), stream order (based on mapped streams from digital TRIM), stream gradient (>20%, 8 – 20%, 4 – 8%, < 4%), stream width (based on S1 – 6 classification for the sub-set of streams investigated in Fish Stream Inventory), aspect and biogeoclimatic subzone (ESSFmc and SBSmc2). Sub-basins included from 18 to 103 individual reaches (total of 302 reaches described).

Many descriptive variables were correlated. We inspected correlation matrices and loadings in principle components analyses to reduced the variable set and avoid multi-collinearity. Stream order and width were strongly correlated ($r_p = 0.45$, $p<0.001$ Bonferroni-corrected). We selected stream order for analysis because width was unavailable for many reaches and because size-classes based on S1 – S6 classification overlap (i.e. width classes are inconsistent between streams with and without fish) and are hence less precise. Within stream order, gradient provided additional information (Figure 2). Wetland and gulley presence were strongly correlated with subzone (gulley $r_p = -0.43$, $p < 0.001$; wetland: $r_p = 0.37$, $p < 0.001$). The first principle component was dominated by gradient and subzone, the second by order and width, and the third by aspect. Including subzone, gradient and order and analysing by separate sub-basins best captures the variables. Further reduction of variables (to provide sample sizes adequate for analysis) clustered steep streams (> 8%) versus gentle streams (< 8%), and small (order 1 and 2) versus moderately-sized (order 3 and 4) streams. The final variable set includes biogeoclimatic subzone, gradient (steep, gentle), size (small, moderate) and presence of fish. Fish streams are analysed separately as fish presence has been surveyed or is estimable in less than half of all reaches.

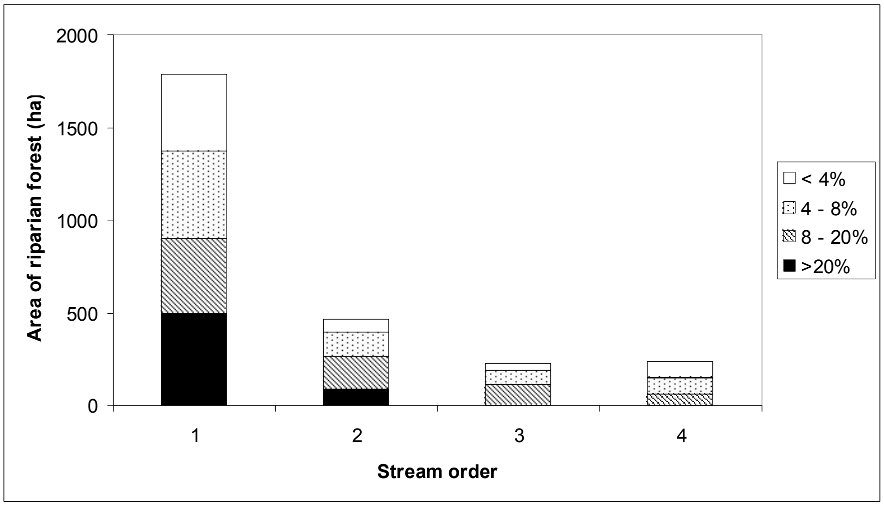

Figure 2. Area of riparian forests (within 60-m ribbons around streams) around streams of different size and gradient in six sub-basins of the Nichyeskwa watershed..

We delineated riparian forest along the streams of the study sub-basins. Because we were not able to refine riparian ecosystem boundaries based on field checks within the scope of the project, we used GIS techniques to draw a ribbon at 60m from water features. Stream density was too high to use 100-m ribbons; overlap complicated analyses unacceptably. Sixty-metre strips are sufficiently wide to include most ecological functions of riparian forest. In most cases, the water-land interface may not extend even that far, hence the selected distance is ecologically precautionary. Following initial analyses, we considered the necessity of examining narrower ribbons to plot risk to ecological function in relation to different buffer widths and to allow field calibration of actual risk. Results indicated that this step was not necessary.

At stream confluences, rather than overlapping riparian ribbons, we bisected the angle between stream reaches and assigned half to each reach, ensuring that each individual reach had a unique polygon of riparian forest. Such remote classification of riparian forest is useful for monitoring, but needs field verification before being used in operational planning.

Natural Riparian Forest Composition

We examined the age-class and canopy cover distributions of forest within riparian ribbons. We calculated natural age-class distribution based on the proportion of forest in each 20-year age class in the unharvested portion of the watershed. Because the distinction between age-classes 8 and 9 is notoriously unreliable (Banner, personal communication), we combined these two classes, and classified all forest over 140 years as old. We estimated disturbance frequency and return interval based on the past 140 years (the period of reliable data; method 1 as described in Price and Daust, 2003), and used a negative exponential equation to estimate the expected percent over 250 years old for a given disturbance frequency (Wong et al. 2002).

Harvesting within Riparian Forests

We calculated the age-class distribution of all riparian forests (i.e. unharvested and harvested) in the study area, for comparison with natural composition. Existing databases include buffers reserved at the edges of blocks, but do not include data on within-block retention in riparian areas. They hence underestimate the amount of unharvested riparian forest. We modified the amount of unharvested riparian forest by examining operational plans for blocks within the four sub-basins in which we collected new data. Where buffers (5-m machine-free zones and 20 – 30-m riparian management zones) were included in plans, we assumed complete retention with in the first 5m, and 25% retention throughout the next 15 – 25m.

Applying Data to Risk Curves

To estimate risk, we followed the methods and curves given in the Knowledge Base for the Babine Watershed (www.babinetrust.ca). The indicator of risk examines the deviation between the area of riparian forest in a given age-class and natural area of forest. Because most forest in the study area is naturally old, we focussed on forest over 140 years old for analysis. Because there was insufficient area within each sub-basin for individual analysis, we combined all sub-basins.

For exploratory data analyses, we use $\alpha = 0.1$, and consider all p-values below 0.2 as worth future investigation.

Results

Stream Types

The most common stream types running through forest in the study sub-basins were small, steep streams in the ESSFmc and small, gentle streams in the SBSmc2 (Table 2). Moderately-sized, gentle streams in the ESSFmc and moderately-sized, steep streams in the SBSmc2 were the rarest stream types. In addition, a total of 395 ha of forest surrounded wetlands.

Table 2. Area of riparian forest (within 60-m ribbons around streams) along each stream type within each of six sub-basins of the Nichyeskwa watershed. "Small" = order 1 and 2; "moderate" = order 3 and 4; "gentle" = < 8% gradient; "steep" = > 8% gradient.

		Forested area per sub-basin (ha)						
Subzone	Stream type	1	2	3	4	5	6	Total
ESSFmc	Small, steep	186	23	564	0	78	175	1026
	Small, gentle	0	0	34	0	0	363	397
	Moderate, steep	12	0	132	0	0	7	151
	Moderate, gentle	0	0	0	0	0	83	83
SBSmc2	Small, steep	18	7	0	0	81	33	139
	Small, gentle	99	184	179	147	64	10	683
	Moderate, steep	19	0	0	0	6	0	25
	Moderate, gentle	54	20	78	0	14	39	205

Natural Riparian Forest Composition

Most unharvested forest within 60m of streams in six sub-basins of the Nichyeskwa was classified as old within existing databases (Figure 3). More forest was old in the ESSFmc than SBSmc2 subzone, but there were no discernible differences among riparian forests as a function of stream order or gradient (subzone: $F_{1,19} = 9.1$, $p = 0.007$; order: $F_{1,19} = 0.9$, $p = 0.4$; gradient: $F_{1,19} = 0.5$, $p = 0.5$; no significant interactions; general linear model blocked by sub-basin).

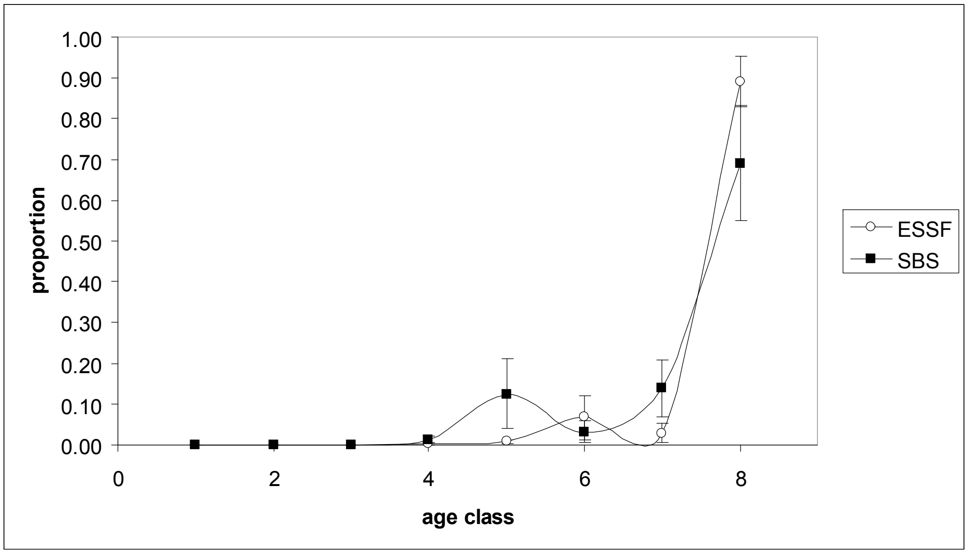

Figure 3. Natural age-class distribution in riparian forests (within 60-m ribbons around streams) in six sub-basins of the Nichyeskwa watershed. Bars are standard errors. ESSF = ESSFmc; SBS = SBSmc2.

For the ESSFmc, natural disturbance frequency within these riparian forests over the past 140 years has been 0.07 ± 0.04%/year, equivalent to a return interval of 1,370 years and to 83% of forest over 250 years old, or 91% over 140 years. For the SBSmc2, natural disturbance frequency has been 0.22 ± 0.11%/year, equivalent to a return interval of 460 years and to 58% of forest over 250 years old, or 73% over 140 years, under natural disturbance conditions. These estimates assume no repeat disturbances in the same area over the period used for calculation. Given the lack of any natural stand-replacing disturbances documented over the past 60 years, this assumption does not seem unreasonable.

Canopy cover distribution within riparian forests varied with biogeoclimatic subzone and stream gradient. The effect of stream gradient was stronger in the ESSFmc than SBmc2, with higher mean canopy cover around steeper streams (Figure 4; effect of subzone: $F_{1,17} = 3$, $p = 0.1$; gradient $F_{1,17} = 3.2$, $p = 0.09$; subzone x gradient interaction: $F_{1,17} = 3.5$, $p = 0.08$).

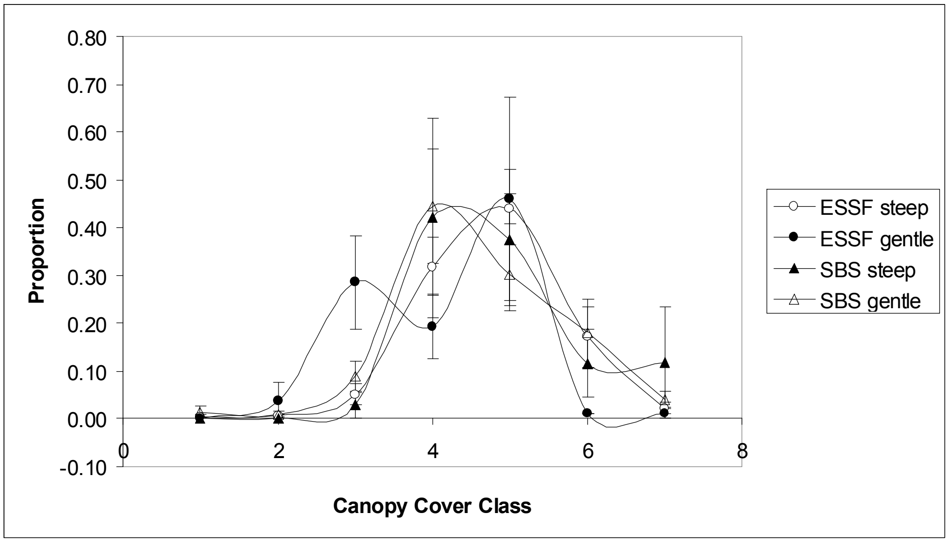

Figure 4. Canopy cover distribution in riparian forests (within 60-m ribbons around streams) in six sub-basins of the Nichyeskwa watershed. Bars are standard errors. “Gentle” = < 8% gradient; “steep” = > 8% gradient. ESSF = ESSFmc; SBS = SBSmc2.

<u>Harvesting within Riparian Forests</u>

In sub-basins 1, 2 and 4, operational plans did not provide new information to modify the database. Cutblocks in these sub-basins included no within-block buffers: small streams within blocks were unbuffered, and block edges were designed to leave reserves next to moderate-sized fish streams. Several blocks in sub-basin 3, however, included buffers around small streams. Incorporating these in-block buffers increased the percent of unharvested forest around small, gentle streams by 2% in the SBSmc2 and 4% in the ESSFmc.

The largest area of riparian forest harvested, within 60-m ribbons, was around small streams with a gentle slope in the SBSmc2 (Table 3). Harvesting removed a mean of 15% of the forest around these streams (range 11 – 27% by sub-basin; Table 4). Proportionately, the most harvesting has occurred around moderately-sized, steep streams in the SBSmc2, where almost half of the area was harvested. However, this particular type of stream covered very little area; most of the affected area (about 11 ha) was within a single cutblock in one sub-basin. In addition, part of the reach included in this particular cutblock was on gentler terrain, and perhaps should be included with streams of gentle slope. All other classes had 5% or less harvested. Because harvesting levels are currently so low, even given ecologically precautionary 60-m buffer widths, it was not necessary to examine narrower buffers.

Appendix 1 gives maps of each sub-basin, showing all streams, GIS buffers and harvesting.

Table 3. Area of riparian forest harvested (ha within 60-m ribbons around streams) of each stream type combined from six sub-basins of the Nichyeskwa watershed. "Small" = order 1 and 2; "moderate" = order 3 and 4; "gentle" = < 8% gradient; "steep" = > 8% gradient.

		Steep	Gentle
ESSFmc	Small	13	9
	Moderate	4	0
SBSmc2	Small	8	106
	Moderate	12	15

Table 4. Percent logged in riparian forests (within 60-m ribbons around streams) of each stream type in each of six sub-basins of the Nichyeskwa watershed. Stream types with dashes are not present. Sub-basin 6 has not yet had any harvesting activity. "Small" = order 1 and 2; "moderate" = order 3 and 4; "gentle" = < 8% gradient; "steep" = > 8% gradient.

		Sub-basin						
Subzone	Stream type	1	2	3	4	5	6	Total
ESSFmc	Small, steep	0	0	2	--	3	0	1
	Small, gentle	--	--	22	--	--	0	2
	Moderate, steep	0	--	3	--	--	0	2
	Moderate, gentle	--	--	--	--	--	0	0
SBSmc2	Small, steep	0	25	--	--	7	0	5
	Small, gentle	18	16	12	11	27	0	15
	Moderate, steep	60	--	--	--	6	--	48
	Moderate, gentle	13	13	1	--	29	0	7

Of 587 ha of riparian forest around streams containing fish (classed as S2 – S4), 49ha (8%) have been logged. Logging around fish streams represents 30% of total logging, while fish streams only represent 21% of the total stream reaches included in analysis.

<u>Applying Data to Risk Curves</u>

Consistent with the proportion of riparian forest logged (Table 4), the deviation from natural levels of riparian forest over 140 years is low for most stream types (Table 5). These deviations can be used to assess risk as described in the Knowledge Base for the Babine Watershed.

Table 5. Deviation from natural percent of old forest (within 60-m ribbons around streams) around each stream type combined for six sub-basins of the Nichyeskwa watershed. Numbers in **bold** are above the cut-off for low risk based on the risk curves given in the Knowledge Base. Sub "Small" = order 1 and 2; "moderate" = order 3 and 4; "gentle" = < 8% gradient; "steep" = > 8% gradient.

			All streams		Fish streams	
Subzone	Stream type	Natural % > 140 years[1]	% of riparian forest >140 years	% deviation from natural[2]	% of riparian forest >140 years	% deviation from natural[2]
ESSFmc	Small, steep	91	91	0	76	16
	Small, gentle	91	86	5	--	--
	Moderate, steep	91	89	2	85	7
	Moderate, gentle	91	66	27	64	**30**
SBSmc2	Small, steep	73	64	12	50	**32**
	Small, gentle	73	61	16	60	18
	Moderate, steep	73	43	**41**	43	**41**
	Moderate, gentle	73	59	19	60	18

[1] For calculation of natural % old, see "Natural Forest Composition" above.
[2] % deviation from natural = 1 – ([% of riparian forest > 140 years] / [natural % > 140 years])

For riparian ecosystems, the risk curves in the Knowledge Base estimate that risk is low for sensitive ecosystems (e.g. floodplains, steep streams with high potential for debris flow) when riparian forest deviates less than 10% from natural, and for less-sensitive ecosystems (e.g. small streams not susceptible to sedimentation), when riparian forest deviates less than 30% from natural (Figure 1.8 of Knowledge Base).

We assume that streams measured fall into the "less sensitive" category for risk estimation. Given this assumption, and based on the deviations from natural in Table 5, riparian ecosystems around most stream types within the SBSmc2 and the ESSFmc are currently at low. The single exception, moderate, steep streams in the SBSmc2, is due to a single cutblock within a rare stream type (see discussion above). Field checking is necessary to classify sensitivity of reaches.

Risk to fish habitat is estimated as low provided that more than 80% of natural structure around fish streams is maintained (Figure 5.1 of Knowledge Base). The analyses show that for most stream types, deviation from natural forest (assumed as a coarse-filter indicator of structure) is less than 20%. Again, the single cutblock in the moderate, steep, SBSmc2 streams affects a large portion of this rare type. The slightly higher deviation for moderate, gentle streams in the ESSFmc (30%) is due to a low level of natural old forest in an unharvested watershed, and hence unrelated to logging. Similarly, the 32% deviation for small, steep streams in the SBSmc2 is only partially related to logging. At a coarse-filter scale, current risk is low.

New Remote Sampling

Methods

Within the six sample watersheds, we used orthophotos and operational planning maps to select sites to sample from the air. Selected sites met one or more of three criteria: riparian buffers in or adjacent to cutblocks, paired stream reaches (within cutblocks and above cutblocks in unharvested forest), and randomly-selected unharvested reaches. The first set of sites was intended to update the current status of buffers in managed stands, the second set to provide treatment/control pairs for future monitoring of buffer conditions over time, and the third to verify the natural baseline estimated from remote digital data (see above).

We flew in a helicopter at about 300m above the ground and took digital photographs from directly above the sample sites, with the photographer leaning out of the open helicopter door. Unfortunately, it was not possible to use a belly-mounted video recorder with real-time GPS. A second photographer used a video camera patched into the helicopter's audio system to gather a continuous record of the flight path. The available budget allowed us to sample four of the six study sub-basins (including all but one of the basins with cutblocks; a CD of air photos is included with this report).

We delineated forest types on the resulting photographs, recording taxa (coniferous, deciduous, mixed, non-forested), structural stage, canopy cover and % snags for each type. We compared these polygons with the polygons listed in the remote digital database (VRI) and summarised inconsistencies. We were particularly interested in estimates of canopy cover as a potential indicator of within-stand disturbance.

Results

The low-level helicopter flight was very instructive. Our principle observation was that blowdown was very rare in the selected sites. None of the buffers we checked had blowdown observable from the air. We flew over one cutblock with an apparently blown-down buffer, but this block was not within our sample, and there is no stream documented in the TRIM database that corresponds with the observed location. We planned to investigate this anomalous site during field work, but foot access proved too difficult (blowdown was observed at the block edge during field sampling).

Still photographs proved more useful than a continuous video recording for analysis, although the video was useful for verifying the location of the still photographs given the somewhat erratic flight path (shortest distance between selected sites rather than a grid pattern), rapid succession of photographs, and communication difficulties. Communication with the photographer was difficult given the methodology of hanging out of the helicopter door—a belly-mounted camera, when available, would be much easier to control and document.

The resulting photographs captured riparian forest at a more detailed scale than the existing VRI data. In some cases, the existing database included small wetlands, floodplains and patches of more open forest including deciduous trees within larger upland forest polygons. However, in general, the canopy cover measured from photographs correlated well with the existing database for the set of polygons with forest cover (Figure 5). At higher canopy closures, the existing database slightly over-estimated cover (perhaps by missing riparian sub-polygons), but this effect was fairly minor, requiring further samples for statistical testing.

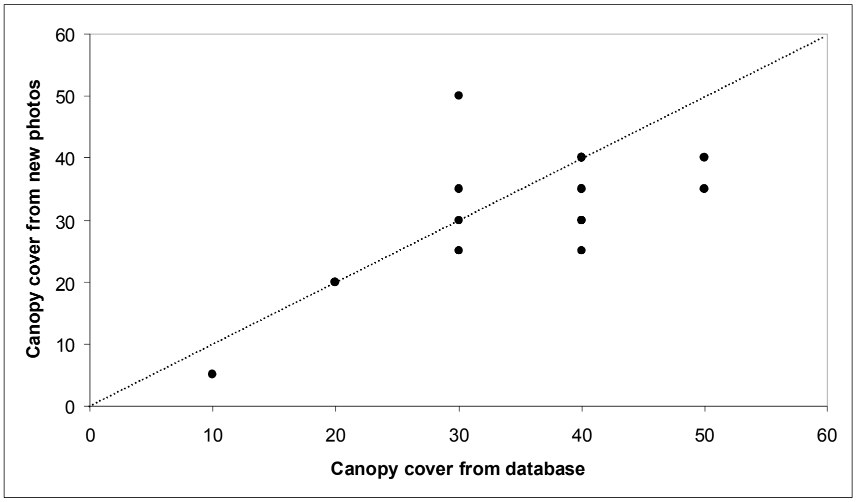

Figure 5. Canopy cover as measured from new, low-level air photos and taken from existing VRI database. The dashed line represents an exact match.

The percent of snags measured from the new air photos did not correlate well with canopy cover (Figure 6). Stands with a deciduous component had the lowest canopy cover and proportion of snags, while stands with balsam-bark-beetle disturbance obvious on the photographs had the highest proportion of snags (Table 6). The deciduous stands likely represent more open, riparian stands rather than stands that have undergone blowdown or other partial disturbance. These patterns are suggestive, but more data are needed to further elucidate any patterns in riparian canopy cover in relation to disturbance.

Table 6. Canopy cover and snags in three classes of stands (mean ± se; BBB = balsam bark beetle).

Forest type	N	Canopy cover (%)	Snags (%)
Coniferous	13	35 ± 2	13 ± 2
Deciduous > 10%	5	26 ± 5	11 ± 2
Coniferous with BBB	3	32 ± 2	17 ± 2

While flying over mechanically-mounded cutblocks, we noticed that stream channels appeared to have moved from within buffers. The water table was particularly high during our flight, and many of the pits created by mounding were linked by water. The remaining pits contained pooled water. Because of concerns that harvesting may alter hydrology (Price et al. 2003), we selected one of these cutblocks for closer observation during field sampling.

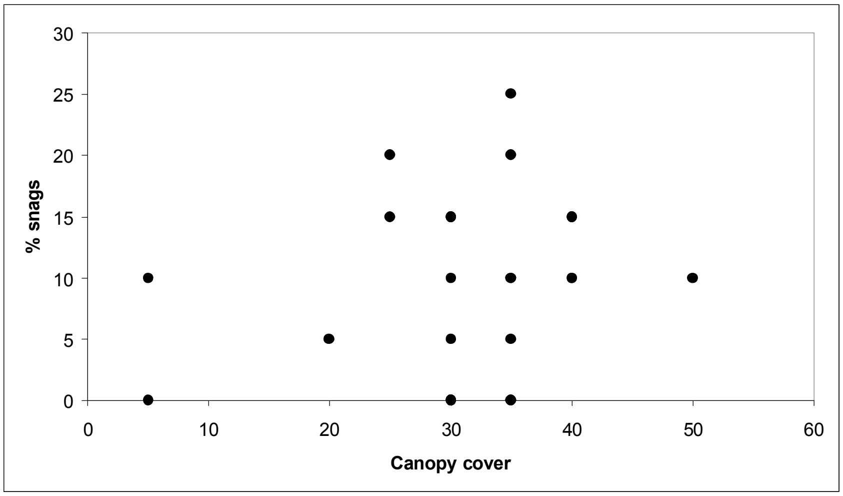

Figure 6. Proportion of snags in stands with different densities of canopy cover.

New Field Sampling

Methods

<u>Sample Sites</u>

We selected a small number of sites for field sampling, with the goals of determining the reliability of existing and new remote sampling and of testing field methodologies for linking canopy cover and blowdown. We chose sites meeting one or more of three criteria: a) a cutblock with potentially wandering streams as identified from the new air photos, b) blocks with in-block and edge buffers to examine stand structure and to look more closely for blowdown missed remotely, and c) pairs of sites within and above cutblocks (i.e. treatment and control) for potential future monitoring. The limited field budget precluded extensive field work and meant that we had to avoid sites with difficult access. Hence, we were unable to sample the block with apparent blowdown (as photographed from the helicopter, see above). We completed 11 plots in two sub-basins (Table 7).

Table 7. Sites selected for new field work.

Block	Sub-basin	Reach	Stream type	Treatment	Reason for selection
583-3	3	42.2	SBSmc2, small, gentle, no fish	In-block buffer around small stream	Potentially wandering channel; stand structure; paired plot
583-3	3	42.2	SBSmc2, small, gentle, no fish	Unharvested	Paired plot
583-4	3	39	ESSFmc, small, steep, no fish	In-block buffer around small stream	Stand structure
583-6	3	38	ESSFmc, moderate, steep, fish	Edge buffer next to moderate, fish stream	Stand structure; paired plot
583-6	3	38	ESSFmc, moderate, steep, fish	Unharvested	Paired plot
537-4	3	46	SBSmc2, moderate,	Edge buffer next to	Stand structure; paired plot

			gentle, fish	moderate, fish stream	
537-4	3	46	SBSmc2, moderate, gentle, fish	Unharvested	Paired plot
537-2	3	46	SBSmc2, moderate, gentle, fish	Edge buffer next to moderate, fish stream	Stand structure
520-2	2	5	SBSmc2, small, gentle, fish	Edge buffer next to moderate, fish stream	Stand structure; paired plot
520-2	2	5	SBSmc2, small, gentle, fish	Unharvested	Paired plot
537-1	2	15	SBSmc2, moderate, gentle, fish	Edge buffer next to moderate, fish stream	Stand structure

Sample Methods

To investigate the possibility of wandering streams, we ran transects through cutblock 583-3, perpendicular to the three in-block channels. From the air, the stream channels in this cutblock were not visible, and water appeared to form channels outside the buffer strips. We checked within and beyond buffers for the presence of a stream and checked culvert location.

To investigate stand structure within buffers, we counted the number of live trees by diameter class (10-cm increments), snags by diameter and decay class, and coarse woody debris (originating within the plot) by diameter and decay class within 10 x 50m plots. We located the plots parallel to the stream channel and with the midpoint 10m from the stream, hence examining tree structure from 5 – 15m from the water. Where buffers were too narrow, we placed plots within the existing buffer, and decreased the width of the plot to 5m as necessary. We also recorded information on site series and stand age (based on a single core of a co-dominant tree), coarsely assessed the functionality of buffers with various levels of blowdown, considering bank stability, shade and in-stream structure.

Analysis

To test for the presence of blowdown, we compared the number of recent downed wood (decay class 1) in unharvested and buffer plots. To compare stand structure in unharvested and harvested riparian forest and to look for distinct riparian vegetation potentially missed in VRI databases, we looked at the number of trees and the ratio of live to dead trees.

Results

The streams in cutblock 583-3 have not wandered, but the pit/mounding mechanical treatment of the block may have influenced water movement. During field work, completed in July, water still filled most of the potholes created by mounding. Some of these potholes were elongated and likely represent a wet horsetail seep. From the air, earlier in the year, with a higher water table, some of these potholes appeared linked and may have contained flowing water. In general, the cutblock is very wet, with dispersed seepage throughout. Other cutblocks in similar terrain that appeared similar from the air were not checked in the field.

The four plots in unharvested riparian forest contained no recently-fallen coarse woody debris, whereas 4/7 plots in buffers had recent downed wood (mean = 1.6 ± 0.6 pieces originating in each 500ha plot). In one plot, the downed wood had originated directly from harvesting (i.e. the pieces had been cut); the remaining plots contained trees that had blown down. Two logs in one plot were predisposed to blowdown by pathogens; predisposing factors were not obvious elsewhere. Recent blowdown occurred in 20 and 30-m buffers; none was observed in plots in 5-m or 50-m buffers.

Buffers were at least as wide as prescribed. Some buffers contained more structure than included in the site plan, perhaps because of the presence of unmerchantable fir. One of the two narrow (5-m) buffers contained no live trees bigger than 25 cm diameter (prescribed retention within the buffer, as allowed by pre-harvest silvicultural prescription, was below this size). The other narrow buffer included some trees above 25 cm diameter. One pair of plots around a moderate-sized stream were located in an alder floodplain—an open forest type with very little dead structure. This forest type was missed by remote databases. Other plots showed no obvious trends in stand structure (Appendix 2 shows comparisons of paired natural and buffer plots). Given the small number of samples and variation in buffer width and ecosystem type, this lack of any general pattern is not surprising.

Table 8 summarises the prescriptions and current status for each harvested site.

Table 8. Prescriptions and current status for harvested blocks including buffers around streams in sub-basins of the Nichyeskwa watershed.

Block	Prescription	Current status	Blowdown
583-3	5-m machine-free zone with retention of poles saplings and scattered intermediates and snags; 20-m riparian management zone	5-m buffer with live and dead trees, then trail, then "shadow buffer" with lower retention; except for smallest dbh class, similar number of live and dead trees as control within 5-m of channel	None
583-4	5-m machine-free zone with retention of poles saplings and scattered snags; 20-m riparian management zone	5-m buffer with small live trees (all < 25cm dbh) and few snags; downed wood all left from harvesting; very different from control	None
583-6	Block boundary about 20 m from stream, above slope break	No apparent impact of harvest on buffer; similar number of live and dead trees as control	One piece/500 m^2
537-4	Block boundary about 50 m from stream	No apparent impact of harvest on buffer; similar number of live and dead trees as control	None
537-2	Block boundary about 20 m from stream	No apparent impact of harvest on buffer (no control plot)	None
520-2	Block boundary about 30 m from stream, above slope break	No major impact of harvest on buffer; similar number of live trees as control; some blowdown	Three pieces/500 m^2
537-1	Block boundary about 30 m from stream, above slope break	No major impact of harvest on buffer; (no control plot); some blowdown	Three pieces/500 m^2

Discussion

The primary goal of this project was to examine the status of riparian forest ecosystems within the Nichyeskwa Creek watershed. For the sub-basins examined, classification of streams by biogeoclimatic subzone, size and gradient captured the variation present among streams. Unharvested riparian forests around streams was mostly old, with relatively open canopies.

Deciduous trees were rare, found principally on narrow floodplains. Forest harvesting has, to date, affected a small portion of the riparian forest (within a 60-m ribbon) around the streams in the Bulkley portion of the Nichyeskwa watershed. In the ESSFmc, harvesting primarily affected forest around small, gentle streams. In the SBSmc2, harvesting affected all stream types. Streams containing fish were somewhat disproportionately harvested (likely because fish and harvesting avoid steep terrain).

Risk analysis, based on the relationships provided in the Knowledge Base for the Babine Watershed (BWMT 2005) found that the current levels of harvesting within forests 60m from streams poses low risk to ecological function or fish habitat within the Bulkley portion of the Nichyeskwa Creek watershed. Exceptions to low risk were due to rare stream types, or to low levels of natural old forest in sub-basins. These analyses do not include assessment of conditions of individual stream reaches.

A secondary goal of the project was to investigate means of reducing uncertainty about blowdown in riparian forests. The air survey found that blowdown is not a significant problem in the studied area. Field plots were able to detect very low levels of blowdown in buffers, relative to unharvested controls, that was missed by air photos. Essentially, field work corroborated the observation from the air that blowdown poses little risk in the Bulkley portion of the Nichyeskwa watershed.

A third goal was to examine the utility of three different sets of data. The existing databases capture most variables needed to estimate risk to riparian forest and fish habitat for purposes of monitoring. They do not document in-block buffers, but these are currently rare in the watershed, altering the assessment of current indicator condition very little (2 – 4% in our data). As harvesting continues, examination of operation plans may be useful to modify estimates. Existing Vegetation Resource Inventory data are likely sufficient to describe riparian forest around small, steep streams, but they may not be sufficiently precise to document narrow floodplains and wet, brushy areas in gentler terrain and around moderately-sized streams.

The helicopter survey and low-level photographs worked well to monitor buffer status. Communication between navigator and photographer is difficult when the photographer has to hang out of the helicopter. A belly-mounted, remote-controlled camera might be more effective. The still photographs were more useful than the video recording for efficiency of analysis. Videos might be useful for more detailed studies.

The limited number of field plots provided extra information about blowdown. There were insufficient plots to detect general patterns in structure within buffers and unharvested riparian forest—pairs of sites showed different patterns. The lack of blowdown, while beneficial for planning management, prevented a full test of our methodology and analysis of canopy cover in relation to within-stand disturbances.

We noted a potential hydrological impact in mounded cutblocks. A field survey concluded that the original stream channels still carried water, but examination before and after harvest, particularly during periods of high water table are necessary to eliminate the possibility of changed water flow.

We found and surveyed four pairs of sites appropriate for future monitoring. The data for these plots are included in Appendix 2.

Recommendations

1. Use existing databases to provide indicator data for other areas of the Babine Watershed. If blowdown in other areas is similar, existing databases, modified by silvicultural prescriptions, will be sufficient for coarse-filter monitoring in accordance with the indicators included in Babine Watershed land-use planning.
2. Fly over other watersheds to document levels of blowdown. Unless blowdown is more prevalent in other watersheds, field work should not be necessary for coarse-filter monitoring.
3. If blowdown levels are higher elsewhere, investigate the relationship between canopy cover as visible on low-level air photos and downed wood as measured in the field. Limited field plots on recent downed wood are the most efficient means of collecting relevant data on levels of blowdown.
4. Select further pairs of sites for monitoring, particularly if blowdown levels vary. Locate controls upstream of harvest. Try to match ecosystems and stream type.
5. Check the hydrology in mounded cutblocks during high water levels. If possible, check hydrology before and after harvest and mounding in similar stands.

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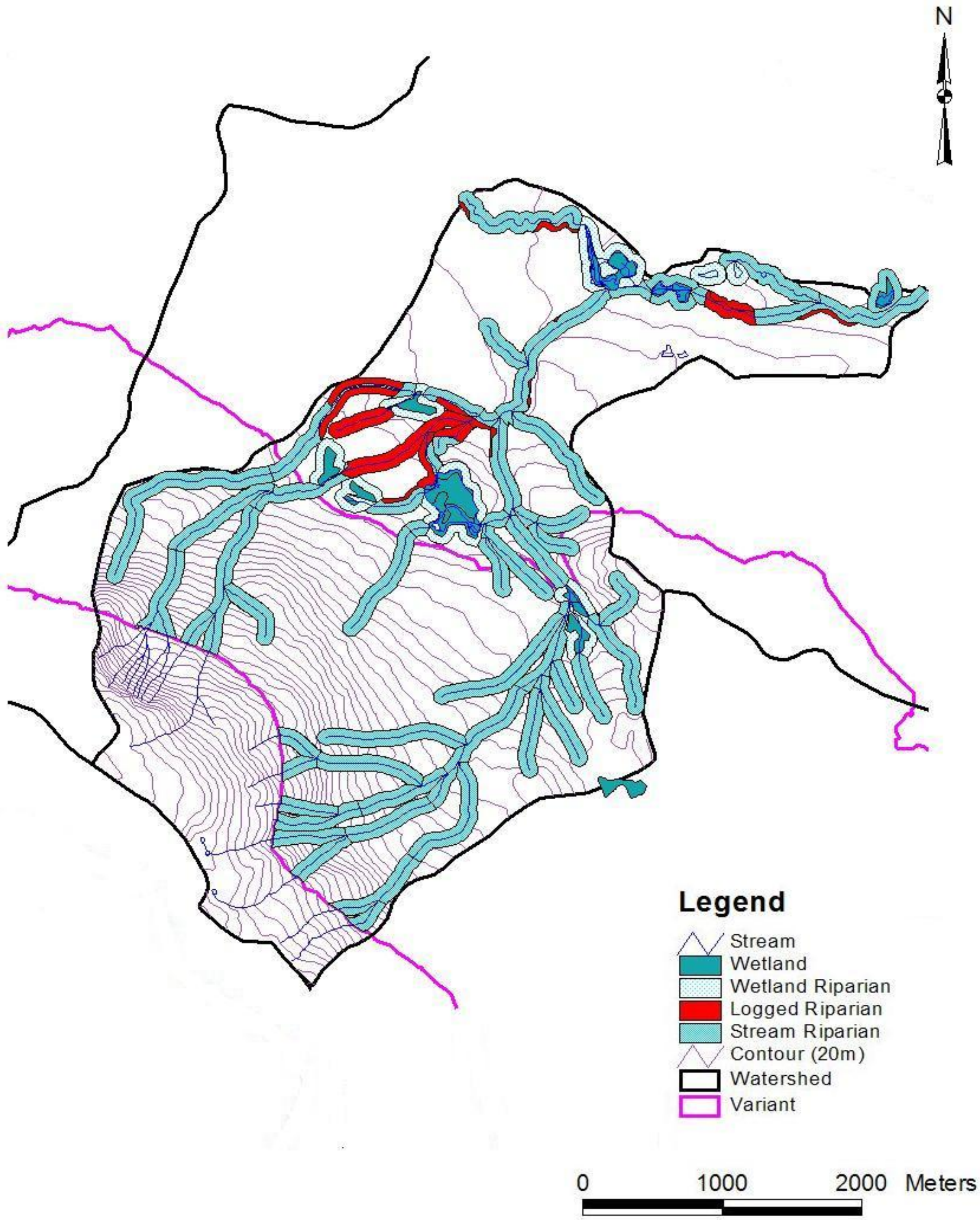
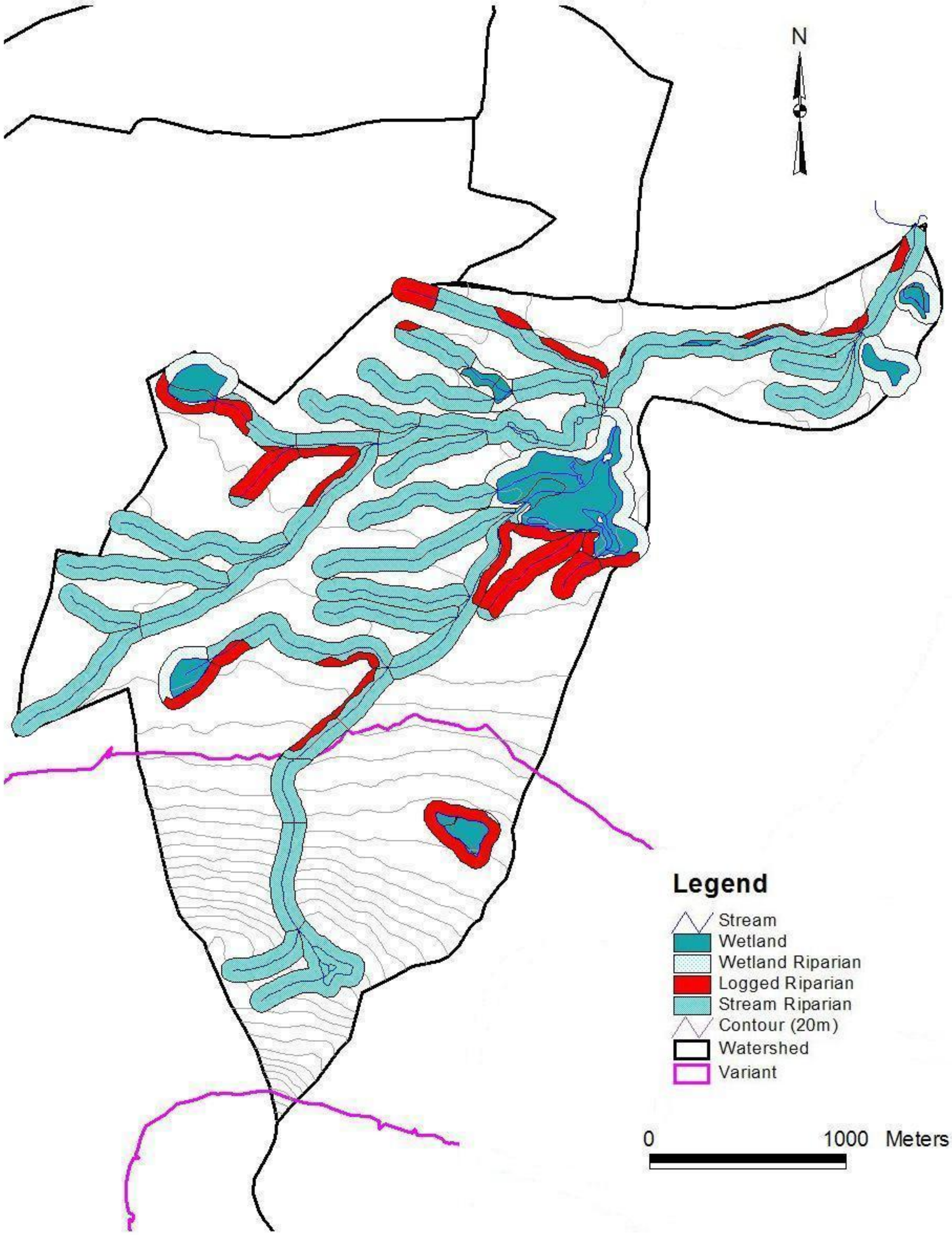
Price K, Suski A, McGarvie J, Beasley B, Richardson JS. 2003. Communities of aquatic insects of oldgrowth and clearcut coastal headwater streams of varying flow persistence. Canadian Journal of Forest Research 33:1416-1432.

Wong C, Sandmann H, Dorner B. 2002. Estimating historical variability of natural disturbances in B.C. Report to the BC Ministry of Forests.

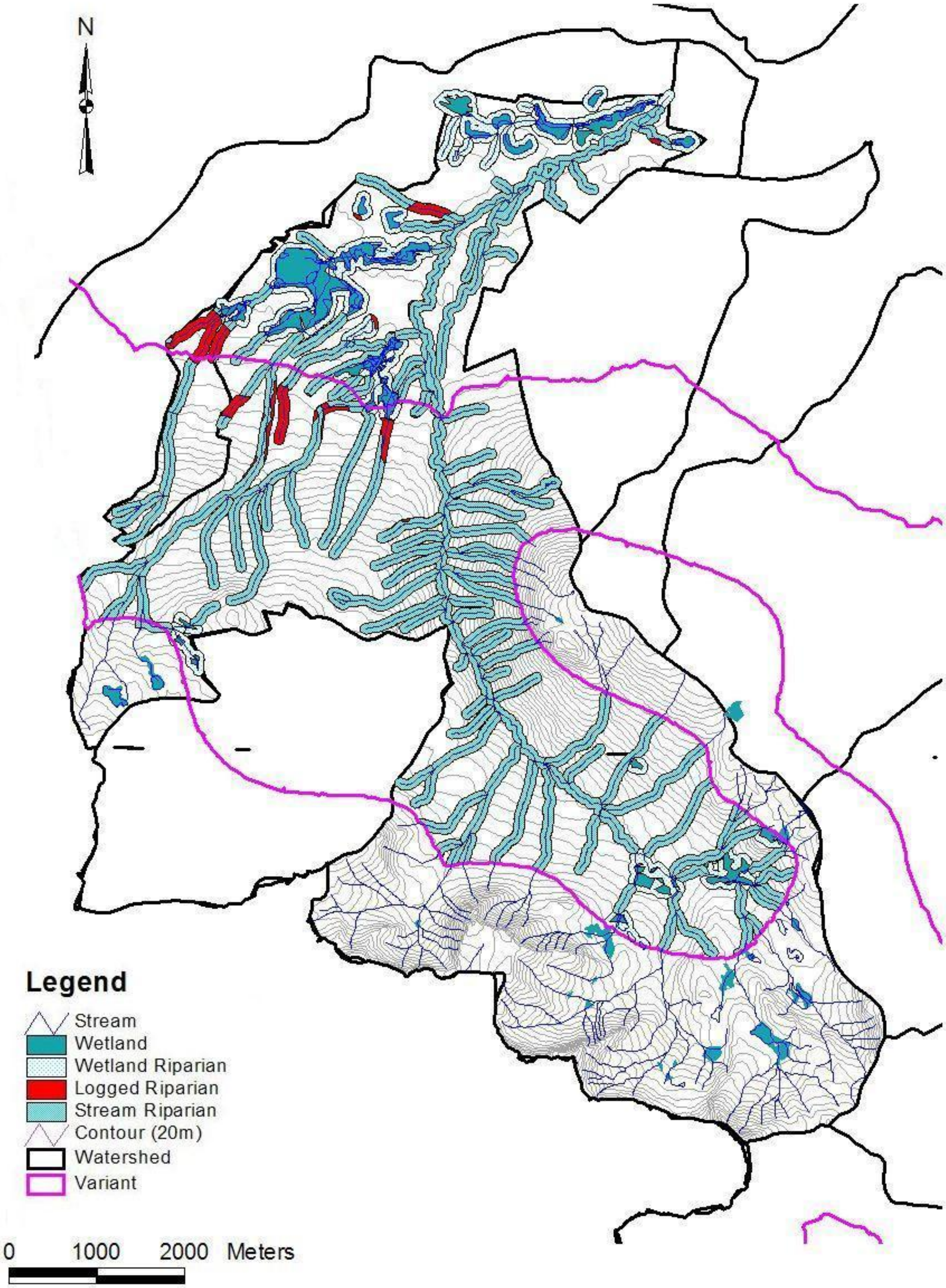
Appendix 1.Sub-basin maps.



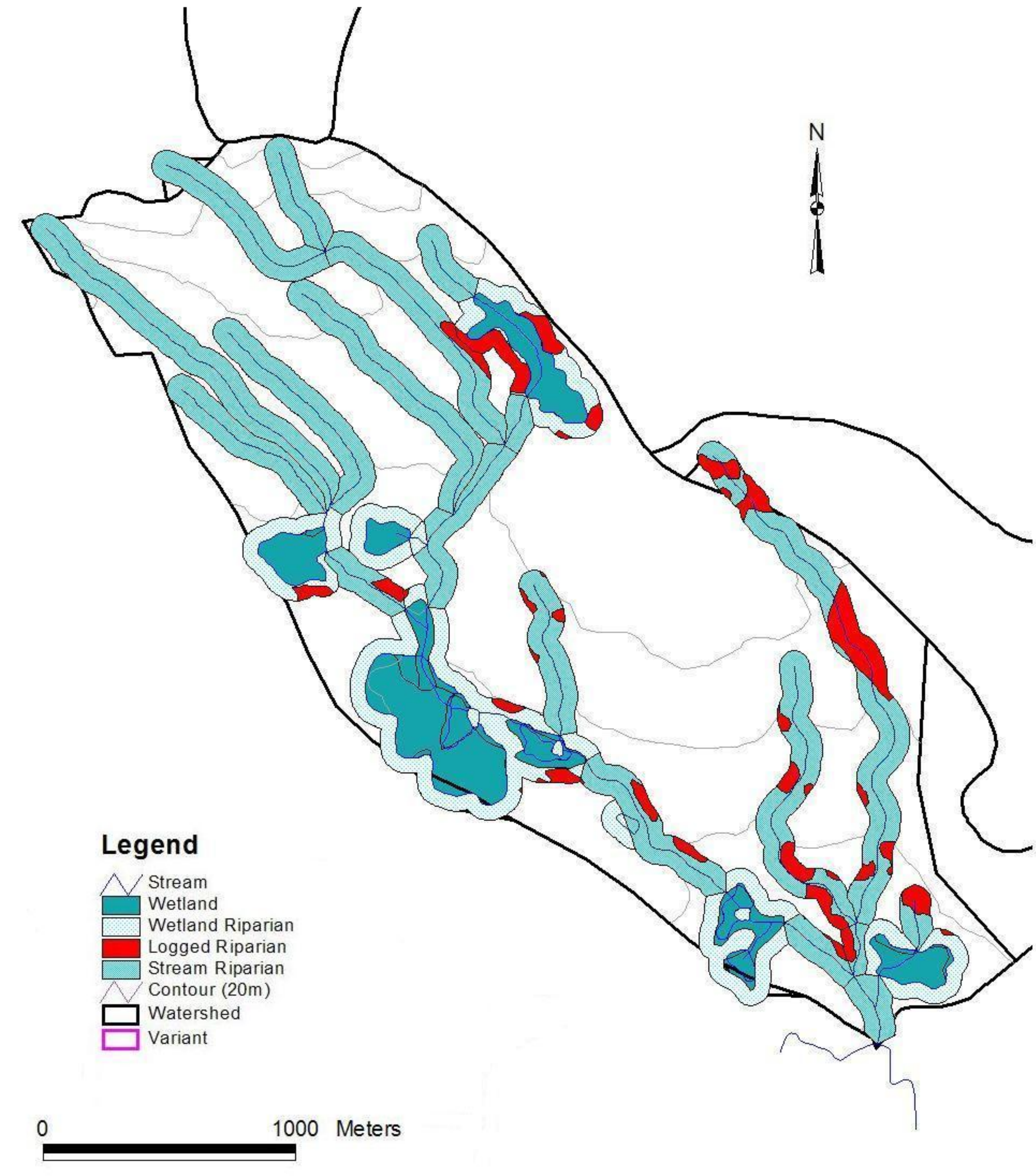
Sub-basin 1.


N
Legend
Stream
Wetland
Wetland Riparian
Logged Riparian
Stream Riparian
Contour (20m)
Watershed
Variant
0
1000 Meters

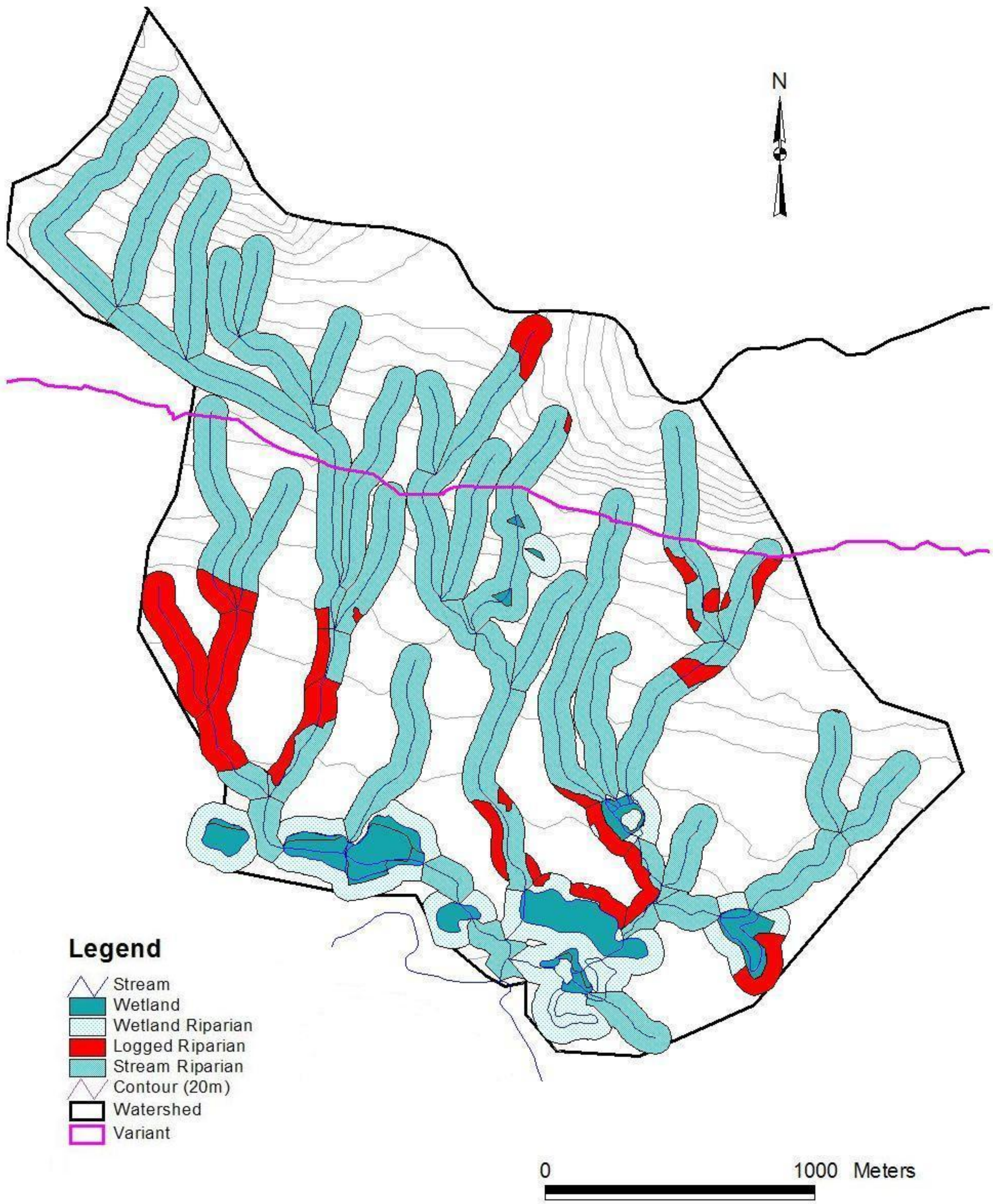
Sub-basin 2.


N
Legend
Stream
Wetland
Wetland Riparian
Logged Riparian
Stream Riparian
Contour (20m)
Watershed
Variant
0 1000 2000 Meters

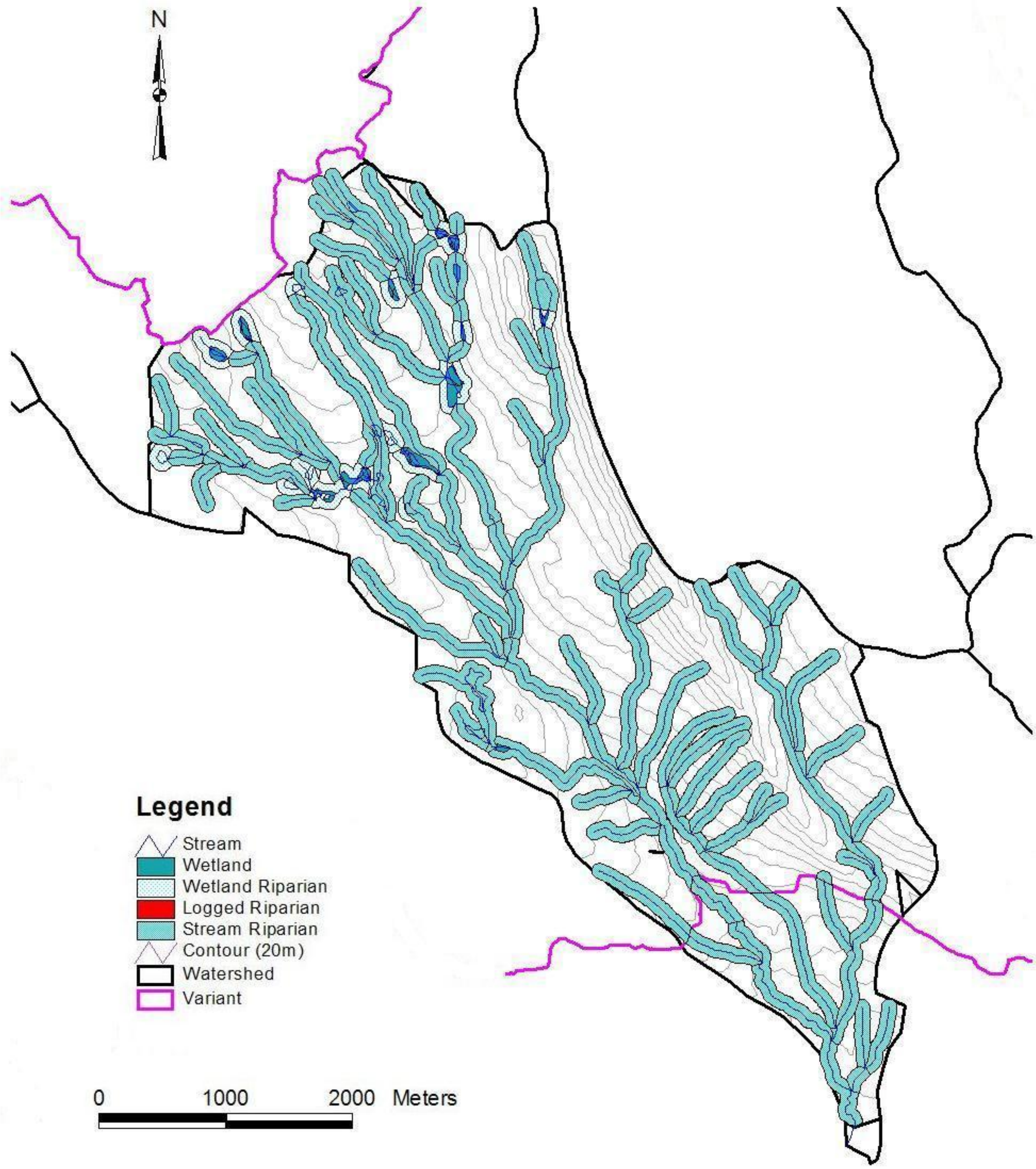
Sub-basin 3.


N
Legend
Stream
Wetland
Wetland Riparian
Logged Riparian
Stream Riparian
Contour (20m)
Watershed
Variant
0
1000 Meters

Sub-basin 4.


N
Legend
Stream
Wetland
Wetland Riparian
Logged Riparian
Stream Riparian
Contour (20m)
Watershed
Variant
0
1000 Meters

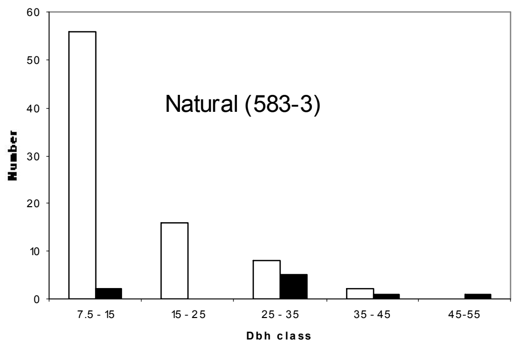
Sub-basin 5.

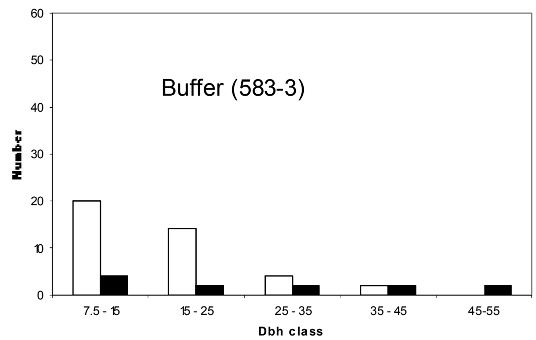

N
Legend
Stream
Wetland
Wetland Riparian
Logged Riparian
Stream Riparian
Contour (20m)
Watershed
Variant
0
1000
2000
Meters

Sub-basin 6.

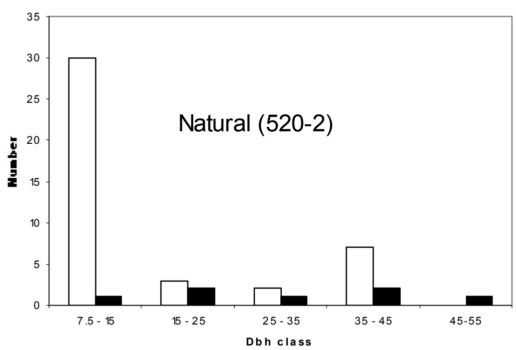
Appendix 2. Field Data for Paired Plots

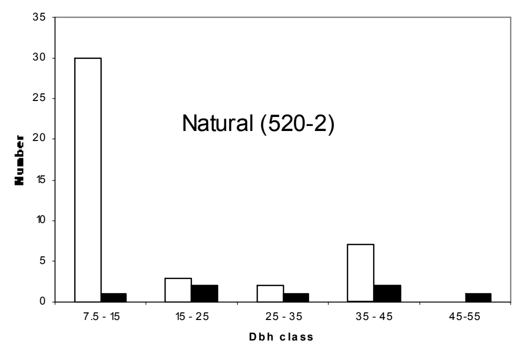
Stand structure diagrams for paired plots in unharvested ("natural") riparian forest and buffer forests. White bars represent live trees; black bars represent dead trees (standing and downed).



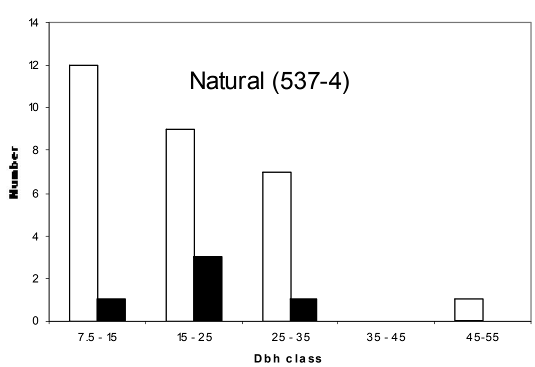


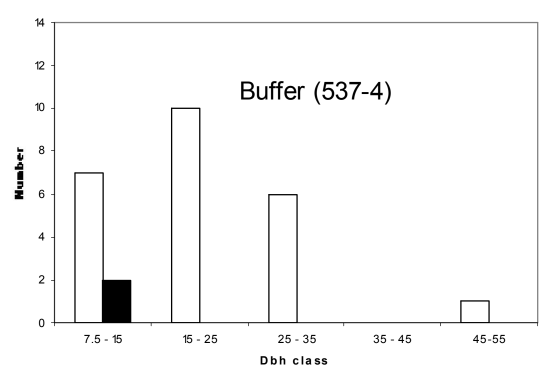
These plots in sub-basin 3 are well-matched for ecosystem and stream features. The buffer plot is within a cutblock. The control plot also serves as a pair with the buffer in CP 583-4.



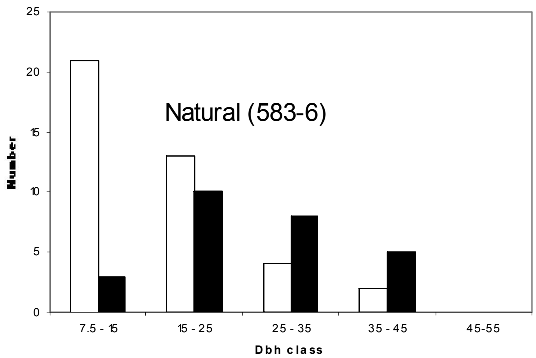


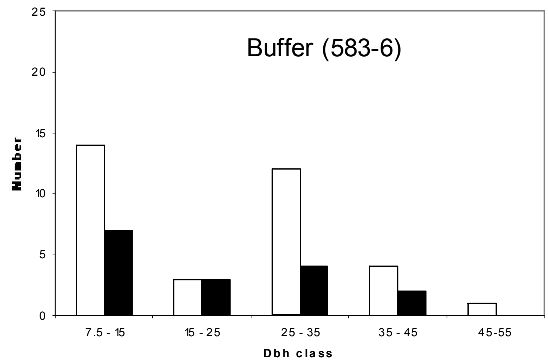
These plots in sub-basin 2 are well-matched for ecosystem and stream features. The buffer plot is within a 30-m wide reserve, on the edge of the block.





These plots in sub-basin 3 are well-matched for ecosystem and stream features (both are on alder floodplains). The buffer plot is within a 50-m wide reserve, on the edge of the block.





Even though located close together, these plots are not particularly well-matched, and probably less suitable for future monitoring. The natural plot is within an amabilis fir stand, while the buffer plot is within a spruce-dominated stand. Finding a better match was difficult given the limited field time. The buffer plot is within a 20-m wide reserve, on the edge of the block.