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Report 2.4.4:
Level IV Channel Classification

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Abstract

The Level IV evaluation was the most detailed watershed assessment completed as part of the multi-year study to determine the effects of human-use activities on fish and fish habitat. The work was a follow-up to detailed channel longitudinal and cross-section surveys that were completed in 1984 and 1985. Those initial surveys were completed at six sites within the Tri-Creeks experimental basin including Upper and Lower Wampus Creek, Upper and Lower Deerlick Creek, and Upper and Lower Eunice Creek. These sites represented a range of different forest harvest treatments including minimal disturbance, approximately forty percent harvest with retention of riparian buffer strips, and forty percent harvest including no retention along major watercourses.

No changes to stream banks or other fish habitat attributes were detected in the 1984-1985 surveys, which occurred between two and six years after harvest. The authors expected that other trees and shrubs would replace the bank protection afforded by the roots of the stream-side harvested trees as they became established. As a result, they did not anticipate major stream bank changes in subsequent years along the stream where no retention occurred.

We found no significant decreases in residual pool depth or mean pool spacing in any of the sites. However, we detected a decrease in the mean length of undercut bank in one of the no-retention sites. These findings suggest that retention of stream-side trees is important for the maintenance of undercut bank features in medium-sized streams. In addition, the negative fish habitat impacts were not immediately apparent and may take up to two decades before they become detectable. These impacts are likely to be long lasting.

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Introduction

For this project we selected a hierarchical watershed and stream assessment approach that included four levels consistent with Rosgen and Silvey (1996). Level I was a GIS-based geomorphic characterization of study area basins and reaches. Level II was a field-based morphological characterization of the stream channel and its associated floodplain. Level III was a field assessment of pool depth and frequency, which in turn was related to watershed, reach, and land-use characteristics. This report, Level IV, was based on a level survey completed in 2001, as a follow-up to a historic level survey completed in 1984 and 1985.

The historic channel survey was one component of a report titled "Hydrologic, hydrogeologic, thermal, sediment, and channel regimes of the Tri-Creeks Experimental Basin (Andres et al. 1987). A total of six surveys were completed within the three study area watersheds. Wampus, Deerlick, and Eunice Creek watersheds were of particular interest because of the range of treatments that were applied between them. Eunice Creek watershed had very little harvest prior to the historic channel survey, while approximately forty percent of Deerlick and Wampus Creek watersheds were harvested (Andres et al. 1987). When stream-side forests were harvested between 1981 and 1983 in Deerlick Creek, buffer strips were not retained. However, in the pre-survey harvest in Wampus Creek, buffer strips were retained. During the 1984-1985 stream channel surveys, no changes to stream banks or channel attributes were detected, nor were they expected (Andres et al. 1987). Therefore, the purpose of this Level IV assessment was to determine if long-term changes to important fish habitat attributes, including pools and undercut banks, did eventually occur in association with the different types and extent of forest harvest within the three watersheds.

Methods

2.1 Pool Depth and Spacing

The two pool parameters selected for this study were residual pool depth and pool spacing. Residual pool depth was defined as the difference between the maximum pool depth and the riffle crest depth, or pool outlet depth (Province of British Columbia 2001). Pool spacing was the distance separating like-features, including riffle crest or pool bottom, between successive pools. Both residual pool depth and pool spacing were calculated for individual pools and were averaged for the entire reach.

2.1.1 Determining Pool Characteristics from Historic Longitudinal Profiles

The Alberta Research Council measured historic longitudinal profiles, including minimum bed level, at six Tri-Creeks locations in 1984-1985 (Andres et al. 1987). There were two locations in each watershed, including Upper and Lower Wampus Creek, Upper and Lower Deerlick Creek, and Upper and Lower Eunice Creek. Survey methods were not described and were likely completed with rod, level, and tape. Elevation and distance information from each longitudinal profile was presented in graphical format and archives containing original distance and elevation data were not located. As a result, historic pool information had to be extracted from the graphed profiles from each of the six Tri-Creeks locations (Figure 1).

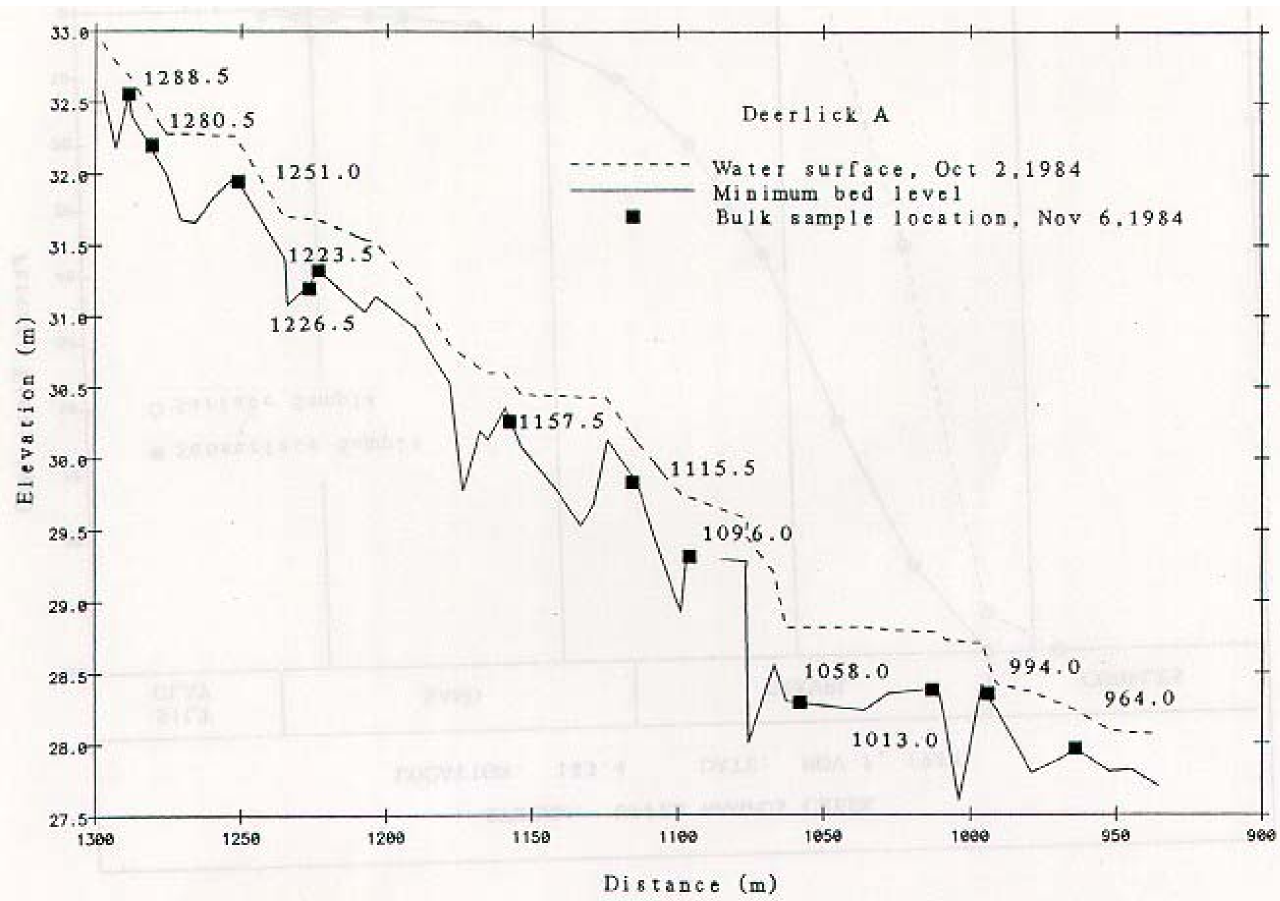

Figure 1. Historic longitudinal profile of Deerlick Creek obtained from "Hydrologic, hydrogeologic, thermal, sediment, and channel regimes of the Tri-Creeks Experimental Basin (Andres et al. 1987).

To extract pool information from historic figures, we determined the scale for both elevation and distance, and labeled channel profiles with riffle crests, pool bottoms, and potential pools (Figure 2). Only pools greater than 30 cm in depth were included in this study. The residual pool depth and the distance between pools was measured to the nearest millimeter on the figure, recorded in a Microsoft Excel spreadsheet, and converted to real distances based on scale conversions. All figure measurements and conversions were checked by other staff members to ensure data integrity.

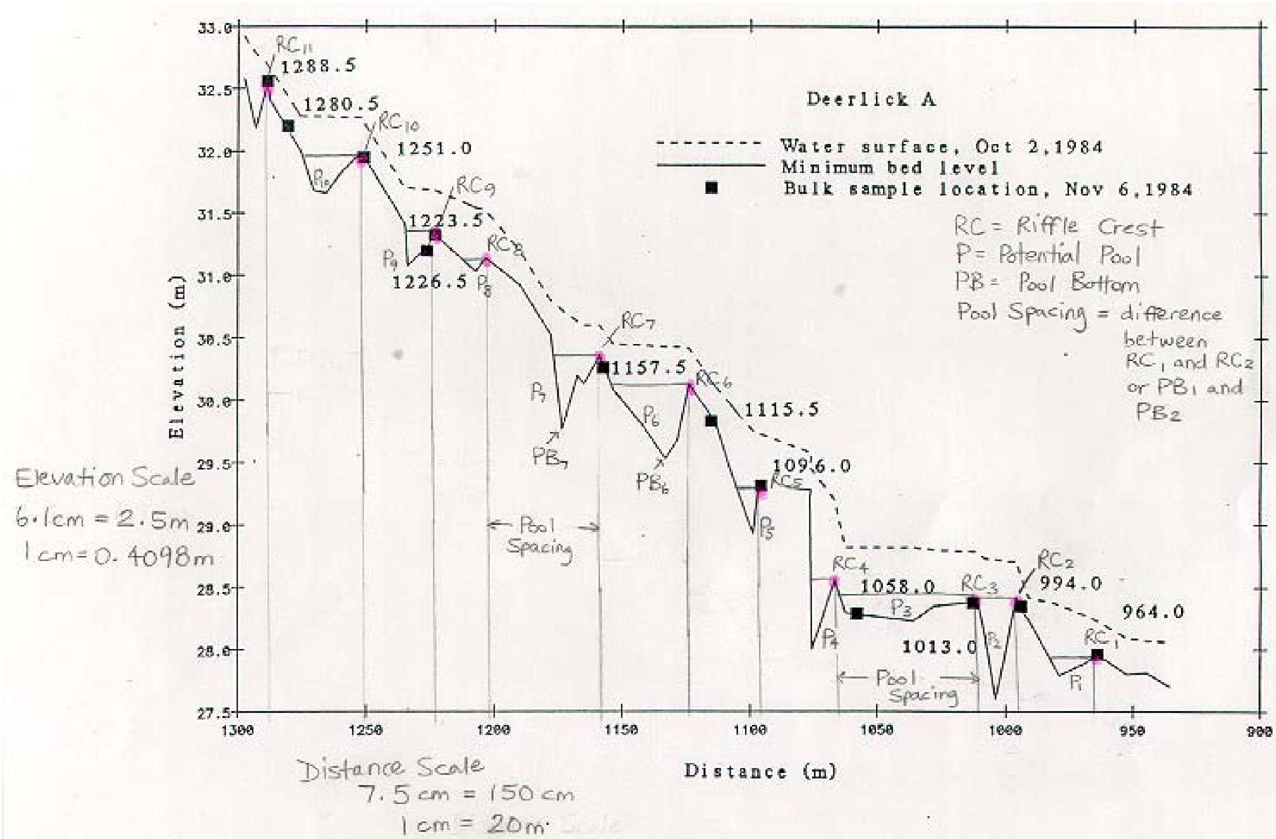

Figure 2. Historic longitudinal profile of Deerlick Creek obtained from "Hydrologic, hydrogeologic, thermal, sediment, and channel regimes of the Tri-Creeks Experimental Basin (Andres et al. 1987) labeled with riffle crests, potential pools, pool bottoms, pool spacing, and conversion factors.

2.1.2 Current Profiles

Current data were collected with a Total Station and prism on adjustable prism pole. Digital easting, northing, and elevation data were imported into a Microsoft Access database. Distances between individual points along the longitudinal profile were obtained from the easting and northing data through the Pythagorean theorem. Cumulative distances along the survey were calculated and a current longitudinal profile was produced. For ease of viewing, the distance scale was displayed in 10 m increments and the elevation scale in 0.3 m increments. The profiles were labeled with riffle crests, pool bottoms, and potential pools. Residual pool depths and pool spacing were calculated from differences in appropriate distance and elevation data and recorded in a

Microsoft Excel spreadsheet. All profiles and results were checked by other staff members to ensure data integrity.

2.2 Undercut Banks

2.2.1 Historic Undercuts

The Alberta Research Council surveyed historic channel cross-sections, including undercut banks, at each of the six Tri-Creeks locations in 1984-1985 (Andres et al. 1987). Survey methods were not described and were likely completed with a rod, level, and sag tape. Permanent benchmarks were established at either one or both endpoints using either an iron post or spike in a tree. Although most benchmarks were identified with a unique number stamped onto a metal plate, we were not able to locate any data that referenced the benchmark number. As with the historic longitudinal profiles, historic cross-sections were presented graphically (Figure 3) and undercut information had to be extracted through a manual process.

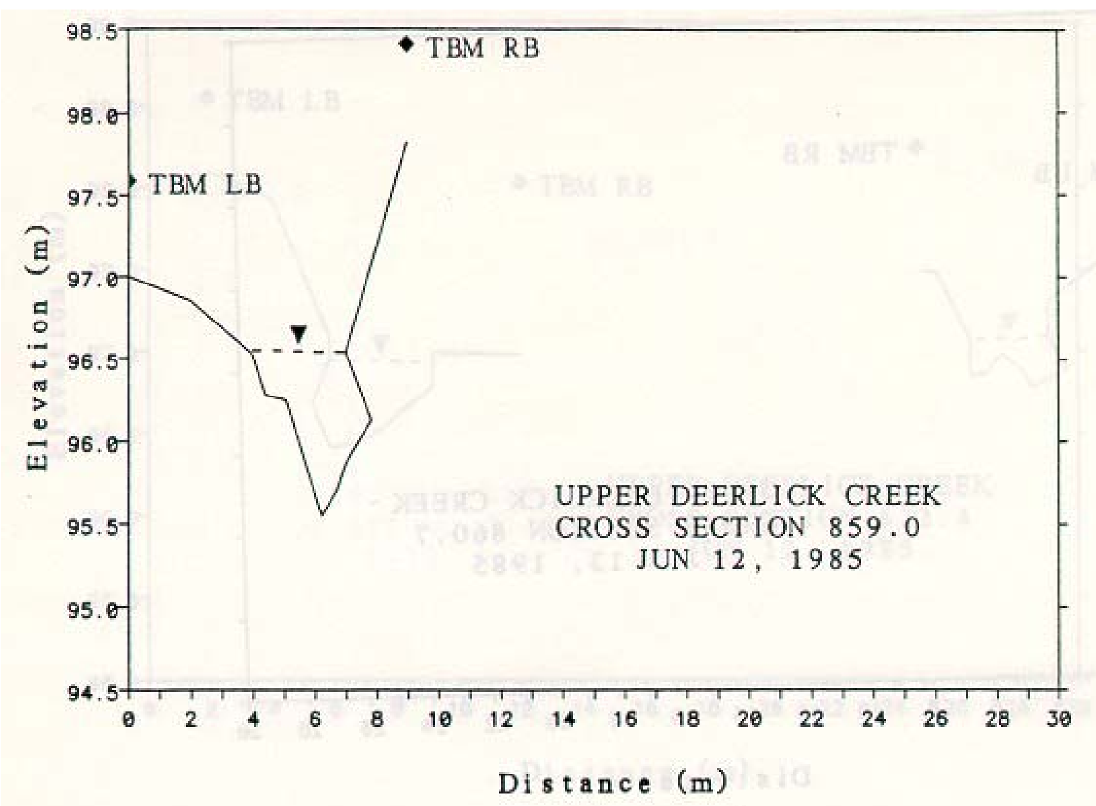

Figure 3. Historic cross-section obtained from "Hydrologic, hydrogeologic, thermal, sediment, and channel regimes of the Tri-Creeks Experimental Basin (Andres et al. 1987) showing undercut bank.

The length of the undercut was measured backwards from a vertical line extending down from the edge of the bank overhang (Figure 4). The relative elevation of the maximum undercut was also determined. To determine these values, we extracted the distance and elevation information for all points used to create each of the original cross-section figures. These distances were recorded to the nearest millimeter and converted to meters using a conversion factor that was determined for each cross-section.

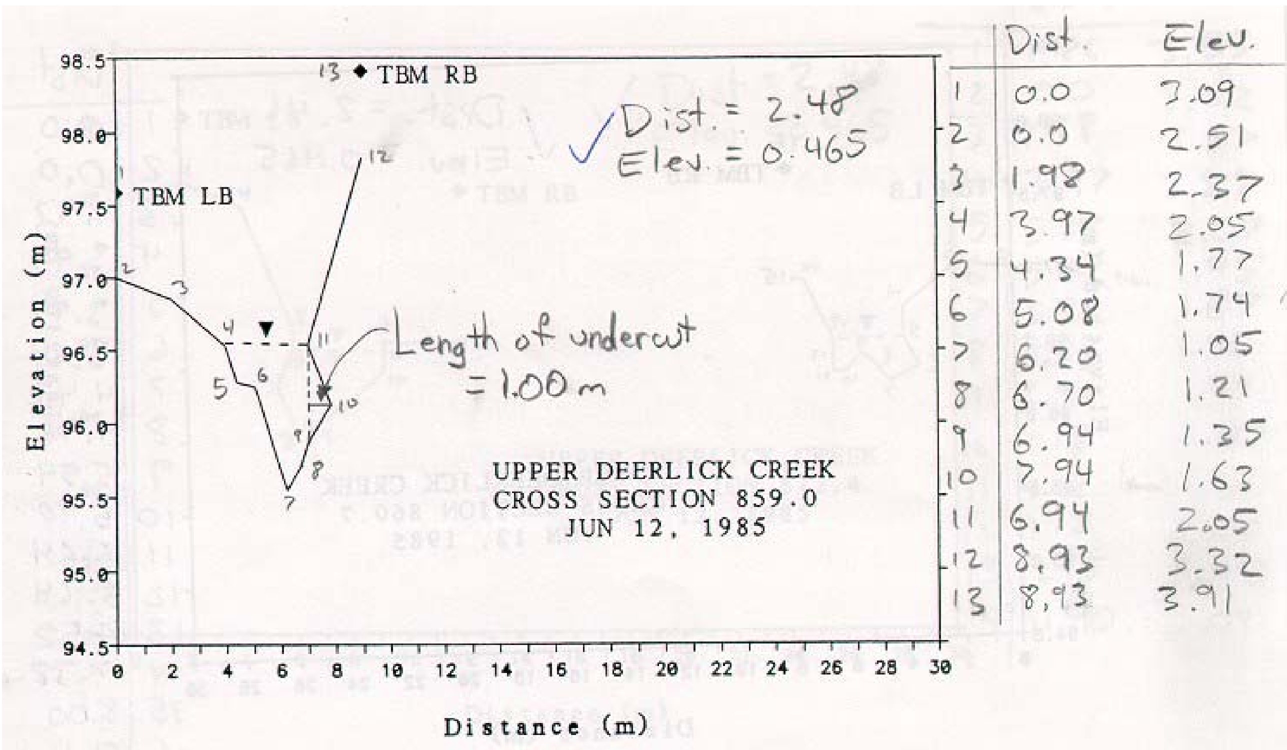

Figure 4. Historic cross-section obtained from "Hydrologic, hydrogeologic, thermal, sediment, and channel regimes of the Tri-Creeks Experimental Basin (Andres et al. 1987) labeled with conversion factors and distance and elevation measurements.

The length of undercut (under the bank) was calculated from the maximum extent of the undercut and the narrowest point on the corresponding bank (for example: undercut on right bank=5.35m; bank distance=5.89m; length of undercut=0.54m). All data was then imported into a Microsoft Access database, and checked by other staff members to ensure data integrity.

2.2.2 Current Undercuts

Current undercut lengths were measured at all historic cross-sections that were identifiable from benchmarks. Undercut lengths were determined with a rod and measuring stick. The rod was held vertically at the edge of the bank overhang and the maximum undercut length was measured backwards from the vertical rod. Undercuts were recorded separately for the right and left bank. All data was then imported into a Microsoft Access database, and checked by other staff members to ensure data integrity.

2.3 Data Analysis

Two sample t-tests (variances unknown) were used to test the hypothesis that the mean value of each habitat parameter was different ($\alpha = 0.20$). Individual measures were pooled for all tests. Due to the low confidence in pairing historic and current cross-sections, a paired test was not possible for undercuts. The undercut length for each cross-section was the sum of the left undercut and the right undercut.

Results

3.1 Residual Pool Depths

A significant change in mean residual pool depth between historic and current surveys was detected at one location, Lower Wampus Creek. This change was an increase in mean residual pool depth (Table 1).

Table 1. Comparison of historic and current residual pool depths at six locations in the Tri-Creeks study area.

Site	Year	Mean Residual Pool Depth (cm)	n	Standard Deviation	Variances Equal ?	t - value	Significance
Upper Wampus Creek	1985	65.2	4	20.7	no	0.536	0.619
	2001	59.1	7	12.6			
Lower Wampus Creek	1985	30.0	4	0	no	- 4.602	0.01*
	2001	36.0	5	2.9			
Upper Deerlick Creek	1985	44.7	6	15.7	no	0.378	0.719
	2001	42.1	15	7.6			
Lower Deerlick Creek	1985	55.6	5	16.0	yes	0.000	1.0
	2001	55.6	5	16.1			
Upper Eunice Creek	1985	36.7	3	7.4	yes	- 0.219	0.837
	2001	38.0	3	7.5			
Lower Eunice Creek	1985	36.0	6	9.4	no	0.141	0.893
	2001	35.4	7	3.3			

* Indicates a significant difference between historic and current survey with 80 % confidence.

3.2 Pool Spacing

No changes in pool spacing between historic and current surveys were detected at any of the six sites in Wampus, Deerlick, and Eunice Creek watersheds (Table 2).

Table 2. Comparison of historic and current pool spacing at six locations in the Tri-Creeks study area.

Site	Year	Mean Pool Spacing (m)	n	Standard Deviation	Variances Equal ?	t - value	Significance
Upper Wampus Creek	1985	48.6	4	11.9	yes	0.132	0.899
	2001	47.1	6	19.9			
Lower Wampus Creek	1985	108.6	4	117.4	yes	0.110	0.916
	2001	99.4	4	120.4			
Upper Deerlick Creek	1985	45.9	6	34.9	no	1.395	0.215
	2001	25.4	14	14.0			
Lower Deerlick Creek	1985	47.6	5	21.6	yes	- 0.272	0.793
	2001	55.0	4	56.7			
Upper Eunice Creek	1985	37.6	3	19.2	yes	0.165	0.879
	2001	34.5	2	24.4			
Lower Eunice Creek	1985	35.5	6	16.0	yes	1.203	0.257
	2001	23.4	6	18.7			

* Indicates a significant difference between historic and current survey with 80 % confidence.

3.3 Undercut Banks

Changes in mean undercut bank lengths were detected at two of the six sites (Table 3). At Lower Deerlick Creek there was a decrease in mean undercut bank length and at Lower Eunice Creek there was an increase in mean undercut bank length.

Table 3. Comparison of historic and current undercut bank lengths at six locations in the Tri-Creeks study area.

Site	Year	Mean Undercut Bank (cm)	n	Standard Deviation	Variances Equal ?	t - value	Significance
Upper Wampus Creek	1985	29.5	14	18.9	yes	- 0.286	0.779
	2001	33.3	3	31.8			
Lower Wampus Creek	1985	16.3	3	6.7	yes	- 1.315	0.211
	2001	22.3	12	7.1			
Upper Deerlick Creek	1985	36.8	24	21.1	yes	- 0.865	0.393
	2001	44.2	12	29.5			
Lower Deerlick Creek	1985	38.4	9	16.7	yes	1.838	0.079*
	2001	27.5	16	12.8			
Upper Eunice Creek	1985	31.5	15	12.5	yes	1.158	0.256
	2001	25.8	19	15.4			
Lower Eunice Creek	1985	22.8	10	10.3	no	- 2.318	0.028*
	2001	37.0	20	23.3			

* Indicates a significant difference between historic and current survey with 80 % confidence.

3.4 Relationships Between Changes in Habitat Parameters and Changes in Land-use

Since the historic habitat data was collected there has been relatively little change in land-use at the six sites (Table 4). The change in percent of Eunice Creek watershed harvested was rated as medium. The density of permanent roads in Wampus Creek watershed was rated as medium due to a deactivation of roads in that watershed. However, Wampus and Deerlick Creeks had high levels of harvest prior to collection of historic habitat data and in Deerlick Creek buffer strips along the stream were not retained. Changes in stream bank stability following riparian harvest were not detected from the 1984-1985 surveys and the researchers anticipated that establishment of new vegetation would result in the maintenance of bank stability (Andres et al. 1987). However, we measured a significant decrease in overhanging bank length at one of the Deerlick Creek locations.

Table 4. Summary of changes in residual pool depths, pool spacing, and undercut banks between 1985 and 2001 at six locations within the Tri-Creeks study area.

Site	Significant change in mean residual pool depth	Significant change in mean pool spacing	Significant change in mean undercut bank length	Harvest Information ²			Index of Road Density ³		
				Historic % Harvested	Current % Harvested	Change	Historic	Current	Change
Upper Wampus Creek	no	no	no	high	high	low	high	low	med
Lower Wampus Creek	yes (+)	no	no						
Upper Deerlick Creek	no	no	no	high	high	low	med	low	low
Lower Deerlick Creek	no	no	yes (-)						
Upper Eunice Creek	no	no	no	low	med	med	low	med	low
Lower Eunice Creek	no	no	yes (+)						

* Indicates a significant difference between historic and current survey with 80 % confidence.
² Harvest Information: < 10% = low, 10-30% = medium, > 30% = high (Sherburne and McCleary 2003)
³ Index of Road Density: ≤ 0.2 = low, 0.3-0.4 = medium, ≥ 0.5 = high (Sherburne and McCleary 2003)

Discussion

4.1 Management Implications

Riparian harvest at Lower Deerlick creek corresponded to a compromise in the long-term protection of the overhanging stream banks, which are an important fish habitat feature. This change was not detectible in 1984-1985 and likely evolved over several decades as the root systems from the harvested stream-side coniferous trees slowly rotted. Similar changes would occur in a natural disturbance scenario, however, the loss of cover from eroding streambanks would likely correspond to an influx of large woody debris and instream cover and habitat complexity. These findings illustrate that large trees rooted along the streambanks of medium-sized streams, such as Deerlick Creek, provide an important bank stability function that is not duplicated by lesser vegetation once the trees are removed.

Plans to harvest trees growing along the banks of medium-sized streams should be carefully reviewed. In addition, a two decade delay in the measurable response of the stream ecosystem to riparian harvest occurred. This response time is beyond the time frame suitable for an adaptive forest management scenario. These findings illustrate the importance of protective measures during forest harvest for those trees growing adjacent to major streams.

4.2 Potential Additional Surveys

Pool volume data from the 1984-1985 surveys were presented graphically (Andres et al. 1987). Although pool depth and length measurements were collected during the 2001 surveys, pool width measurements were not. Therefore, future surveys could attempt to replicate pool volume estimates to determine if pool volumes have decreased as a result of channel degradation.

During a review of paired historic and current channel cross-sections, very few of the pairs had consistency in benchmark elevations and distances between cross-section end pins. These differences precluded a detailed analysis of changes in cross-section geometry for individual paired cross-sections. Additional reviews of the dataset are required to determine if alternative methods could be developed to decide whether or not aggradation of the channel has occurred with forest harvest.

Three parameters were selected for this habitat evaluation including residual pool depth, mean pool spacing, and length of undercut banks. Of these three parameters, the only one that captured a change in fish habitat associated with riparian harvest was length of undercut banks. Therefore, of the three variables, length of undercut banks is recommended for incorporation into future habitat assessments.

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