North Fork Coeur d'Alene River Subbasin Watershed Restoration Effectiveness Review – Sediment Reductions and Biological Response



September 2013

Prepared by:
Kajsa Stromberg
Ed Lider
Chris James

With special assistance from:
Dave Funk, PIBO-Effectiveness Monitoring Program staff,
and the Environmental Protection Agency

Cover photo: Tepee Creek in restoration project area.

Citation: Stromberg, K., E. Lider and C. James. 2013. North Fork Coeur d'Alene River Watershed Restoration Effectiveness Review – Sediment Reductions and Biological Response. Report to Environmental Protection Agency, Boise, ID.

Contact: Kajsa Stromberg, Watershed Coordinator, Idaho Department of Environmental Quality. 2110 Ironwood Pkwy, Coeur d'Alene, ID 83814. (208) 666-4633 Kajsa.Stromberg@deq.idaho.gov.

Table of Contents

Introduction 5

Phase 1. Estimating Sediment Load Reductions 9

Objectives 9

Methods 9

Results 13

Discussion 18

Phase 2a. Forest Road Decommissioning Effectiveness Monitoring 20

Objectives 20

Methods 20

Results 25

Discussion 39

Phase 2b. Bioassessments 43

Objectives 47

Methods 47

Results 53

Discussion 66

Conclusions 69

Acknowledgements 71

References 72

Appendix A. Description of Sediment Load Estimation Model

Appendix B. Sediment Load Estimation Model Script

Appendix C. BURP Site Photographs

Appendix D. PIBO Site Photographs

Appendix E. Phase 1 Sediment Model Results

Appendix F. 2009 BURP Data Summary

Appendix G. 2009 PIBO Data Summary

Appendix H. Water Quality Success Stories

This page is blank for correct double-sided printing.

Introduction

The North Fork Coeur d'Alene River Subbasin (HUC 17010301), located in northern Idaho, drains an 895-square mile watershed with more than 1,100 miles of streams. The mountainous subbasin is heavily forested and most of the watershed (94%) is managed by the USDA Forest Service (USFS) as part of the Idaho Panhandle National Forests, Coeur d'Alene River Ranger District. Timber management in the area began more than 100 years ago and greatly contributed to the economic development of the area. Intensive timber harvest occurred throughout much of the subbasin beginning in the early 1900s with flume and log drives, and continued from 1930 into the mid-1990s with develop of railroads and extensive road building. Many of these historic roads were abandoned with little or no maintenance, until restoration activities began in the late 1980s.

Water quality assessments in the North Fork Coeur d'Alene River Subbasin have revealed water quality impairments to coldwater aquatic life and salmonid spawning due to sediment, temperature, habitat alterations, and metals (cadmium, copper, lead, nickel and zinc). Most of the assessed streams in the subbasin are considered water quality impaired by one or more pollutants.

In 2001, DEQ and partners completed a subbasin assessment and total maximum daily loads (TMDLs) for the North Fork Coeur d'Alene River Subbasin (DEQ 2001). The subbasin assessment listed most streams as water quality impaired, and the TMDLs primarily focused on the subbasin-wide problem of excessive sediment. Consequently, sediment load reduction targets were established for all streams in the subbasin.

Forest roads have been identified as primary sources of sediment loads to the North Fork Coeur d'Alene River and tributaries. An extensive legacy road network in this subbasin has altered sediment and water yield regimes. As overland flow travels over a dirt road, road surface fines can be picked up and transported to streams. Riparian roads can encroach on stream channels and floodplains. Since floodplains dissipate hydraulic energy, an encroaching road narrows the floodplain that is normally available to a stream and hydraulic energy is increased. High energy water in streams contributes to bank erosion. If the road is close enough to the stream, then erosion of the road fill itself can contribute a large amount of sediment into the stream. Stream crossings are especially vulnerable to delivering sediment to streams. Many roads used long ago for logging operations were abandoned with culverts in place. Culverts require regular maintenance to prevent plugging and failure, and abandoned roads with culverts in place may be at high risk for contributing sediment.

Water quality improvement projects conducted by the USFS have been a vital component of TMDL implementation in this subbasin. The USFS has been actively conducting watershed and fisheries restoration for more than two decades. Overall in this subbasin, these activities have improved more than 1,000 miles of road and 30 miles of streams through restoration and

implementation of water quality best management practices (BMPs). Large-scale restoration has been completed in more than 19 watersheds and site-specific restoration in numerous other watersheds. Site-specific work is road treatment or culvert removal on an individual road or series of roads. Large-scale restoration is where significant road systems and streams have been restored within a watershed. An example of large-scale restoration is within the Yellowdog and Downey creek watersheds. In these two watersheds, the USFS has treated more than 125 miles of legacy roads, removing 64 channel crossing, removing 4 miles of encroaching roads, constructing over 320 pooling structures, and placing 2,121 cover logs.

Currently, DEQ and the North Fork Coeur d'Alene River Subbasin Watershed Advisory Group are performing a "Five Year Review" of the 2001 TMDL. Idaho state law stipulates that DEQ and watershed advisory groups will review TMDLs every five years to evaluate the water quality criteria, instream targets, pollutant allocations, assumptions and analyses upon which the TMDL and subbasin assessment were based. During the five year review of the 2001 subbasin assessment and TMDLs for sediment, implementation activities are reviewed to assess whether TMDL load reduction targets have been reached and whether beneficial uses support have been attained.

The review of TMDL implementation effectiveness for the North Fork Coeur d'Alene Subbasin began with a two-phase pilot study conducted by the USFS and DEQ. Phase 1 focused on modeling and Geographic Information Systems (GIS) analysis for evaluating achievement of sediment TMDL goals. A modeling approach was used based on the 2001 TMDL, the USFS WATSED model, and GIS-based analysis similar to DEQ's current methodology for sediment TMDL. A GIS analysis was used to evaluate changes in watershed metrics between the 1998 Coeur d'Alene Geographical Assessment and present day conditions. Nineteen watersheds were selected for these analyses based on the extensive restoration and water quality improvement projects that have taken place there (Figure 1). In these watersheds, 50 to 80 percent of headwater roads have been decommissioned, riparian roads have been removed, and/or instream restoration has been conducted. These watersheds are the most likely candidates to show attainment of sediment load reduction targets and beneficial use support.

Phase 2 focused on field verification of modeling results to evaluate progress towards attainment of beneficial uses and collect the data needed to show beneficial use support. Phase 2a included evaluation of specific best management practices (BMPs) for watershed restoration techniques such as removal of stream crossings. Phase 2b included bioassessments of eight pilot streams using protocols from DEQ's Beneficial Use Reconnaissance Program (BURP) protocols and the PIBO Effectiveness Monitoring program. An additional side objective was to determine whether PIBO bioassessment data could be used through DEQ's Waterbody Assessment Guidance and Small Stream Ecological Assessment Framework for waterbody assessment purposes.

This effort provided watershed-scale recovery data. BMP effectiveness investigations provided important information to validate assumptions about restoration techniques and to improve the cost-effectiveness of future efforts. When combined with 2008 modeling results, the bioassessment field verification provided important effectiveness, validation and compliance monitoring. Since modeling results and field results demonstrate attainment of beneficial uses, four stream assessment units will be candidates for "de-listing" in the 2012 Integrated Report by DEQ and could be listed as supporting beneficial uses rather than impaired by sediment. Success stories were published for these four candidate streams (Appendix H).

Watershed Restoration in the North Fork Coeur d'Alene River Subbasin

Management of riparian and wetland areas in the Idaho Panhandle National Forests Forest Plan (USFS 1987) are guided by the Inland Native Fish Strategy (INFS, USFS 1995). This direction has standardized riparian management across 22 National Forests in the inland northwest. In summary, the goals for riparian management are to establish and maintain healthy functioning watersheds, riparian areas, and associated fish habitats. These goals include maintenance and restoration of water quality; stream channel integrity and processes, including sediment regime; management of instream flows; meadow and wetland integrity; productivity and diversity of native and desirable non-native plant species; and protection, maintenance, and/or restoration of riparian and stream channel function needed to support invertebrates, fish, and associated terrestrial species.

Over more than two decades, watershed restoration in the North Fork Coeur d'Alene River Subbasin has been largely led by the USFS and focused on treatment of forest roads as well as instream habitat improvements. Overall in this subbasin, these activities have improved more than 1,000 miles of road and 30 miles of streams through restoration and implementation of water quality best management practices (BMPs). Large-scale restoration has been completed in more than 19 watersheds and site-specific restoration in numerous other watersheds. Site-specific work is road treatment or culvert removal on an individual road or series of roads. Large-scale restoration is where significant road systems and streams have been restored within a watershed. An example of large-scale restoration is within the Yellowdog and Downey creek watersheds. In these two watersheds, the USFS has treated more than 125 miles of legacy roads, removing 64 channel crossing, removing 4 miles of encroaching roads, constructing over 320 pooling structures, and placing 2,121 cover logs.

Duration of restoration in individual watersheds varied from one or two years up to more than 15 years. Watersheds where restoration activities occurred over a short period were associated with large watershed scale projects that treated a significant number of roads and streams within the watershed. Where activities occurred over a longer period, restoration was related to funding that only allowed treatment in smaller drainages and restoration took place in phases.

The focus of the past road restoration work conducted by the Idaho Panhandle National Forests was to reduce the effects of roads on beneficial uses, increase stream stability, and promote watershed recovery where increased sediment and increased water delivery were identified as major stressors to watershed functions and downstream fish habitat conditions. With these issues in mind, the focus of restoration was on road segments with the highest potential to deliver sediment and excess water to the stream network. Both active and potential sources of sediment along forest roads were targeted during watershed restoration activities. These included stream crossings and roads adjacent to streams, where active and potential sources of road-related sediment created the highest risk to downstream beneficial uses. Prescriptions for decommissioning a road varied and included full recontouring, partial recontouring, ripping, end-hauling, or abandonment.

Removal of undersized culverts behind large stream crossing fills represents a proactive management strategy in reducing the impacts of legacy roads on downstream beneficial uses. Treatment of stream channel crossings involved the removal of all fill material and culverts as well as recontouring the road 33 to 100 meters (depending on fill depth of the culvert) on each side of the channel (Moll *et al*, 1996). Design criteria included the construction of three to five in-channel stream gradient control structures (either log or rock) to retain sediment and prevent further erosion at the disturbed site. Additional Best Management Practices (BMPs) included use of straw bales as in-channel settling ponds, seeding and use of large organic debris to reduce surface erosion and improve soil conditions, and promote revegetation.

Treatment of riparian roads involved re-contouring the road prism or removal of fill material to reconstruct the floodplain or mimic the original hillslope. Treatments for roads in headwaters have been variable. From the 1980s to the early 1990s, most roads were fully recontoured. In the late 1990s to present, most of these upper hillslope road segments were closed and water-barred; others were scarified and ripped deeply to break down heavy compaction. In cases where high mass wasting or landslide potential existed, roads were recontoured.

Phase 1. Estimating Sediment Load Reductions

Objectives

1. Reproduce the original TMDL sediment loading model to estimate sediment load reductions achieved through watershed restoration.

2. Use sediment load reduction estimates to determine whether TMDL goals are likely to have been attained.

Methods

A model was developed to estimate sediment load reductions achieved through watershed restoration in the North Fork Coeur d'Alene River Subbasin. Ideally, the sediment load estimation model used for the North Fork Coeur d'Alene River Subbasin sediment TMDLs (DEQ 2001) would have been used to estimate sediment loads before and after restoration, and the results could then be compared directly to TMDL load allocations. Unfortunately, the model used in the TMDLs cannot be completely reproduced from the available records. Because the original model could not be completely reproduced, DEQ and USFS developed a new model designed to duplicate the outputs of the 2001 model as closely as possible. For this report, the sediment load model from the original sediment TMDL will be called the 2001 sediment TMDL model and the sediment load model developed during this project will be called the sediment TMDL evaluation model.

Much of the North Fork Coeur d'Alene River Subbasin is underlain by rocks of the Belt Supergroup, which is primarily composed of quartzites, argillites, and limestone (Ross, 1963). Previous studies on road erosion rates in the Belt Supergroup indicate that soils derived from the Belt Supergroup are resistant to erosion (Packer, 1967; Sugden and Woods, 1963). At the time of this study, extensive data existed for erosion rates on drivable or open road systems from sources such as the Water Erosion Prediction Project (WEPP), but there were few datasets for erosion rates from restored roads (Kolka and Smidt 2001; Luce 1997; Madej 2001, USFS 1997 unpublished). The USFS Coeur d'Alene Ranger District looked at road recontouring, decommissioning and channel crossing removal, but this monitoring did not quantify sediment production. They looked at types of erosion (e.g., rills, gullies and sloughing) as well as vegetative cover, but provided no quantitative data. Madej (2001) examined erosion on recently closed roads in comparison with closed non-restored roads in Redwood National Park. This study indicated that erosion processes and sediment delivery to streams still existed on restored sites but was significantly less than non-restored sites (Madej, 2001). Limited studies have been conducted evaluating sediment concentrations and turbidity during culvert removals (Foltz *et al*, 2008). Studies have also been conducted evaluating the effects of road decommissioning on stream habitat in Montana (McCaffery *et al*, 2007), but there are few watershed-scale studies looking at the responses of beneficial uses to restoration efforts in the Clean Water Act context.

For this project, 19 watersheds that had significant watershed restoration completed within the past 25 years were analyzed using the newly developed sediment TMDL evaluation model (Figure 1). These watersheds were selected because they were most likely to have attained sediment TMDL goals because of extensive restoration – 50 to 80 percent of headwater roads were decommissioned, large proportions of riparian roads were removed, and/or in-stream restoration was accomplished.

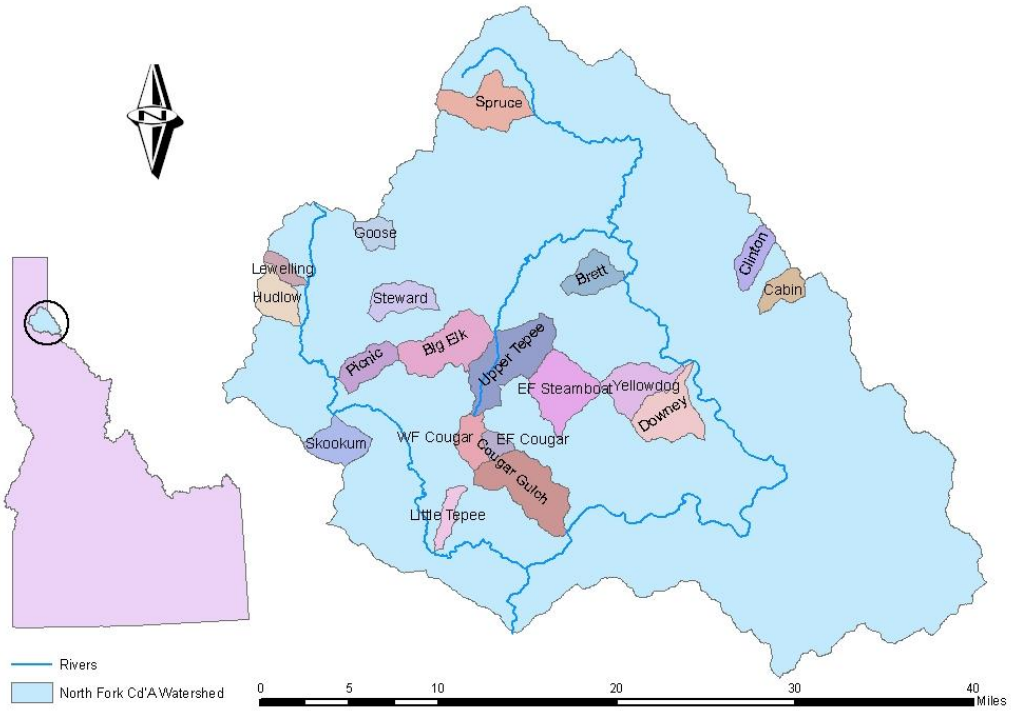


Figure 1. Nineteen watersheds selected for sediment model evaluation due to extensive restoration projects conducted in the past 25 years.

The original 2001 sediment TMDL model estimated natural background sediment loads, existing sediment loads for that time, and target sediment loads (DEQ 2001). These target loads were the maximum annual sediment loads allowable that would fully support cold water aquatic life and were set at 150% of the estimated natural background annual sediment load. These targets of 150% natural background were then established as the sediment TMDL load allocations. At the time, there were no waste load allocations specified because no point-source discharges were known in the subbasin. Sediment load estimates were simple and based on a geospatial analysis of land use with associated sediment delivery coefficients.

The sediment TMDL evaluation model developed for this project attempted to duplicate the 2001 sediment TMDL model as closely as possible and also employed updated practices such as those used in the Fish Creek sediment TMDL (DEQ 2008). Like the 2001 sediment TMDL model,

the load estimates were simple and based on a geospatial analysis of land use with associated sediment delivery coefficients.

Roads were identified in the 2001 subbasin assessment and TMDLs as major sources of sediment to streams in this subbasin. Sediment load contributions from roads are also a primary component of the 2001 sediment TMDL model and the sediment TMDL evaluation model. In both cases, sediment delivery from roads was estimated using a relationship between an approximated road condition rating and an estimated sediment production rate (tons/mile/year) for that rating (DEQ 2001, DEQ 2008).

The road condition rating used was an approximated Idaho Department of Lands (IDL) cumulative watershed effects (CWE) road score of 16.5 for all roads in the subbasin. The CWE protocol is a rapid field survey of roads with scores based on observations of erosion. A high CWE road score is related to high sediment delivery coefficients (IDL 2000). No CWE surveys have actually been conducted in the watershed so a value of 16.5 was applied throughout the subbasin for the 2001 sediment TMDL model. The sediment production rate associated with that road score was 3.64 t/mi/yr. These are rough estimates of sediment production from roads due to the lack of specific road condition data and because the relationship between CWE score and road surface erosion is derived from Kaniksu granitic land types. In the case of Belt geology, as in the North Fork Coeur d'Alene River Subbasin, it is a conservative overestimate (DEQ 2001, DEQ 2008).

In the sediment TMDL evaluation model, similar to the Fish Creek sediment TMDL (DEQ 2008), the relationship between road score and sediment production was converted from t/mi/yr to t/acre/yr. This accounted for a typical road prism 40 feet wide and included the cut and fill slopes and the roadbed. Since there are 4.848485 acres in a polygon one mile long and 40 feet wide, the relationship became $y = (0.0005x^3 – 0.0136x^2 + 0.3089x)/4.848485$ with road sediment production in units of t/ac/yr. For roads with a CWE score of 16.5, this amounted to an estimated sediment production of approximately 0.75 t/ac/yr.

The proximity of roads to streams affects the efficiency of sediment delivery to stream channels. In both models, sediment delivery coefficients were 100% for portions of roads within 200 ft of a stream and 10% for roads outside of that buffer (Table 2). Besides roads, land use in the nineteen modeled watersheds is almost entirely forest management by the USFS. Sediment delivery coefficients from forested land use were adopted from the Fish Creek sediment TMDL model (DEQ 2008) (Table 1).

Coefficients of sediment delivery were also assigned based on land use depending on the timing of timber management and extent of canopy alteration. Harvests older than five years were considered "recovering." Harvests older than ten years were deemed recovered and assigned the "natural background" delivery coefficient. "Recovered" and "recovering" designations were estimated from water yield and vegetation recovery curves (USFS 1991). There is very little

private property in the modeled watersheds and that land use was assigned the natural background sediment delivery coefficient due to the minimal development in those watersheds.

Table 1. Land use descriptions and associated sediment delivery coefficients for the sediment TMDL evaluation model.

Land Use	*Description*	*Sediment Delivery Coefficient (tons/acre/year)*
High Canopy Alteration	Regeneration harvest within 5 years	0.21
Medium Canopy Alteration	Liberation harvest or commercial thin within 5 years	0.07
Low Canopy Alteration	Salvage cut or improvement cut within 5 years	0.025
Recovering	Any harvest type 5-10 years old	0.024
Recovered or Natural Background	Any harvest type older than 10 years or no harvest history	0.023
Roads Near Stream Crossing	Forest roads within 200 ft of a stream crossing	0.75
Upland Roads	Forest roads more than 200 ft from a stream crossing	0.075

Harvest activity data were obtained from the Timber Stand Management Record System (TSMRS) internal Forest Service timber harvest database, which provided a list of every timber harvest on the Coeur d'Alene River Ranger District from 1907 to 2007. Each harvest record contained the following important fields: timber stand number, stand acres, harvest acres, and type of harvest. The harvest type was associated with a sediment delivery coefficient as in Table 2. However, not all harvest units comprised an entire stand. We calculated an area-weighted adjusted delivery coefficient for these occurrences.

There were also instances when multiple harvest activities occurred in the same timber stand within the ten year window when land use delivery coefficients are different than natural background. These occurrences were also assigned with an area-weighted delivery coefficient and then collapsed by stand number with a pivot table in a spreadsheet. The resulting flat file was then joined to the timber stand GIS layer.

The 2001 sediment TMDL model was generated manually by a GIS technician using standard overlays and data management techniques. This project produced a Python script to automate

the process (Appendix B). The script performs all the overlays then collects sediment delivery coefficients, multiplies them by the area of the associated polygon, and then sums the sediment delivery for the entire watershed. The script's inputs are as follows: clipped, single-record polygons for each watershed to be analyzed, an unclipped timber stand layer with delivery coefficients, an unclipped stream layer, and an unclipped road layer with CWE scores. The output is a dissolved, single record polygon containing the sum total sediment delivery for that watershed. The script is able to make many passes through multiple watersheds and multiple points in time.

For this study, the script was used in 19 watersheds (Figure 1) for two points in time, 1986 and 2007. The 1986 date was used to estimate sediment load conditions prior to the sediment TMDLs development using approximately the same data used in the 2001 sediment TMDL model. The 1986 results are considered the pre-restoration sediment load estimates. The 2007 date contained the most current completed set of information depicting all the forest conditions and road restoration within the subbasin. The 2007 results are considered the post-restoration sediment load estimates for this study. A comparison reveals the sediment load reductions achieved through watershed restoration on the landscape.

Procedures for describing watershed characteristics for the sediment model were computed using data from the Idaho Panhandle National Forests' GIS data layers as described by Patten (unpublished). For information on the coverages used in this model, the reader should contact the IPNF aquatics program manager. For more detailed instructions on the sediment TMDL evaluation model and the actual Python script, see Appendices A and B.

Results

Sediment load estimates were calculated for 19 study watersheds using the sediment TMDL evaluation model and land use data from 1986 and 2007. The 1986 data represent conditions before the sediment TMDL was approved and before extensive watershed restoration. The 2007 data represent conditions after the sediment TMDL was approved and after extensive watershed restoration. Sediment loads in 1986 ranged from 61 t/yr in small watersheds to 930 t/yr in large watersheds (Figure 3). Load estimates in 2007 ranged from 34 to 461 t/yr. Reductions in sediment loads as a result of watershed restoration ranged from 1 to 57% and the average reduction overall was 33% (Figure 5). The greatest percent reduction was achieved in West Fork Cougar Gulch (57%) while the greatest absolute reduction was in Cougar Gulch itself (469 t/yr). The average sediment load reduction was 100 t/yr in the 19 study watersheds.

The sediment TMDL load allocations were based on a factor of 1.5 above natural background conditions and looking at the data this way helps to standardize loading over watershed area. In 1986, sediment load estimates ranged from 1.66 to 4.03 times natural background with an average value of 2.52 over natural background (Figure 4). This was reduced in 2007 to a range of 1.04-2.42 and an average value of 1.63 over natural background. Conditions in 2007 indicate 8 watersheds with sediment load estimates less than the TMDL target 1.5 times natural

background: Brett, Clinton, Downey, East Fork Cougar, Goose, Little Tepee, Picnic, and Spruce. Another 5 watersheds are estimated within 1.6-1.7 times natural background: Cabin, Cougar, Upper Tepee, West Fork Cougar, and Yellowdog. The remaining 6 watersheds range from 1.9 to 2.4 times natural background.

When evaluating all of the 19 study watersheds combined, the total annual sediment load decreased from 5,166 t/yr to 3,262 t/yr from 1986 to 2007 with a total load reduction of approximately 1,900 t/yr (Figure 2). Overall, the loading from these 19 watersheds dropped from 1.8 times natural background to 1.1 times natural background, well below the TMDL target of 1.5. This suggests significant cumulative reductions in sediment loads in the North Fork Coeur d'Alene River Subbasin as a result of watershed restoration activities.

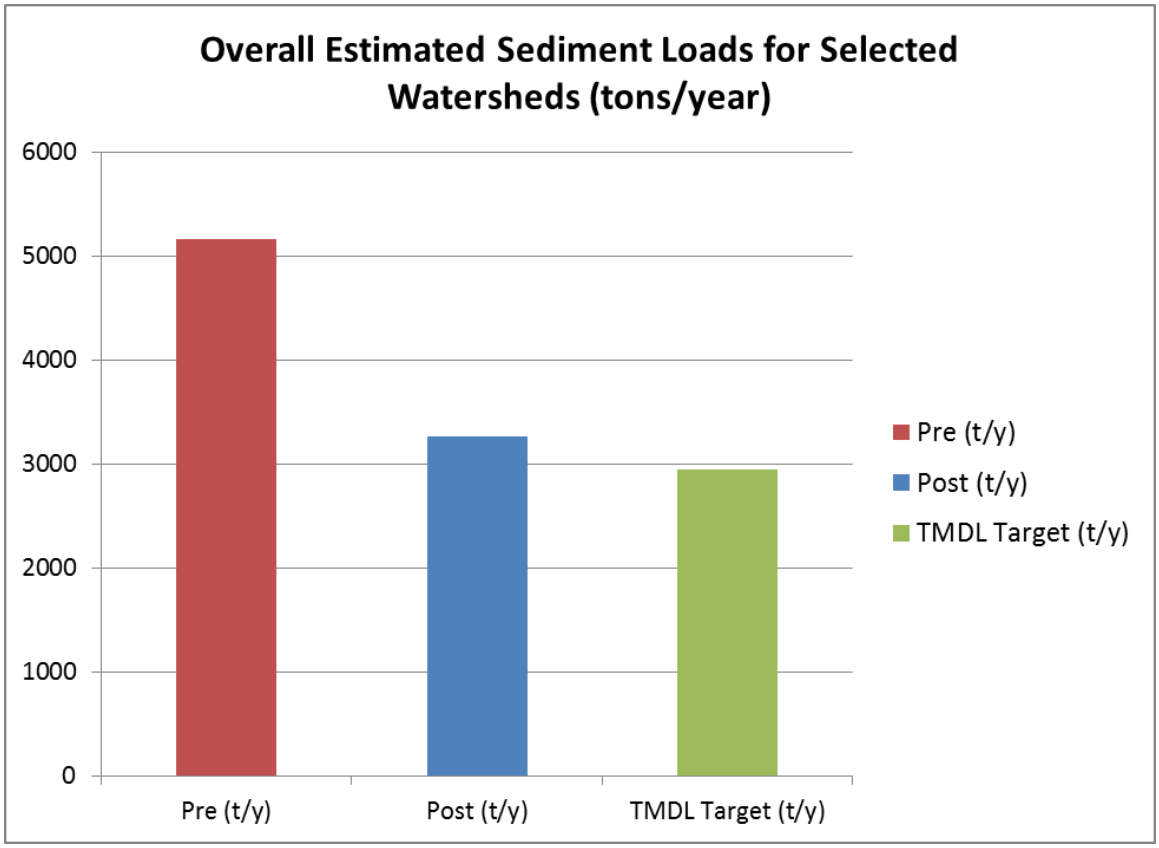


Figure 2. Combined estimates of annual sediment load in the 19 study subwatersheds.

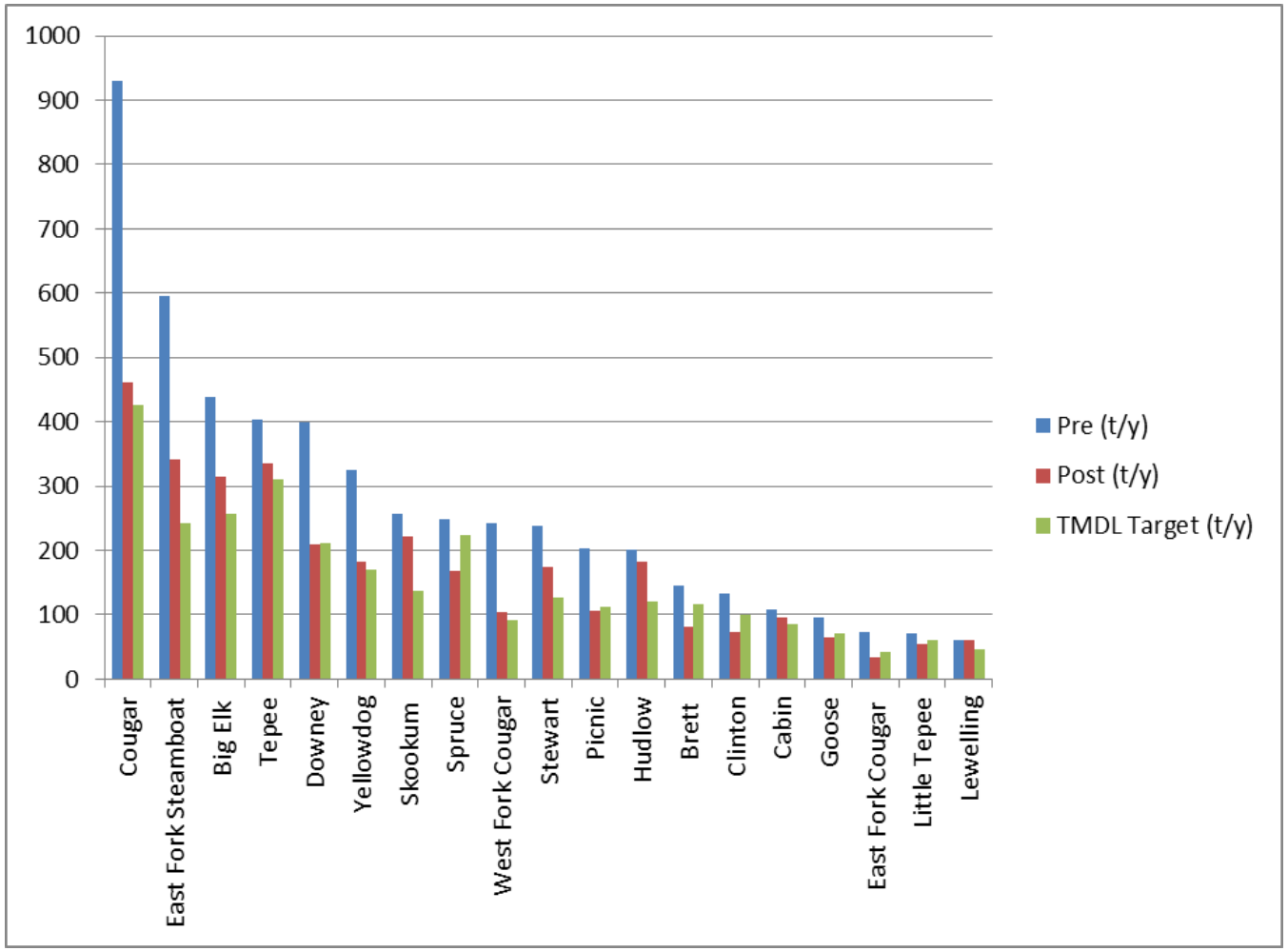


Figure 3. Annual sediment load estimates before and after restoration.

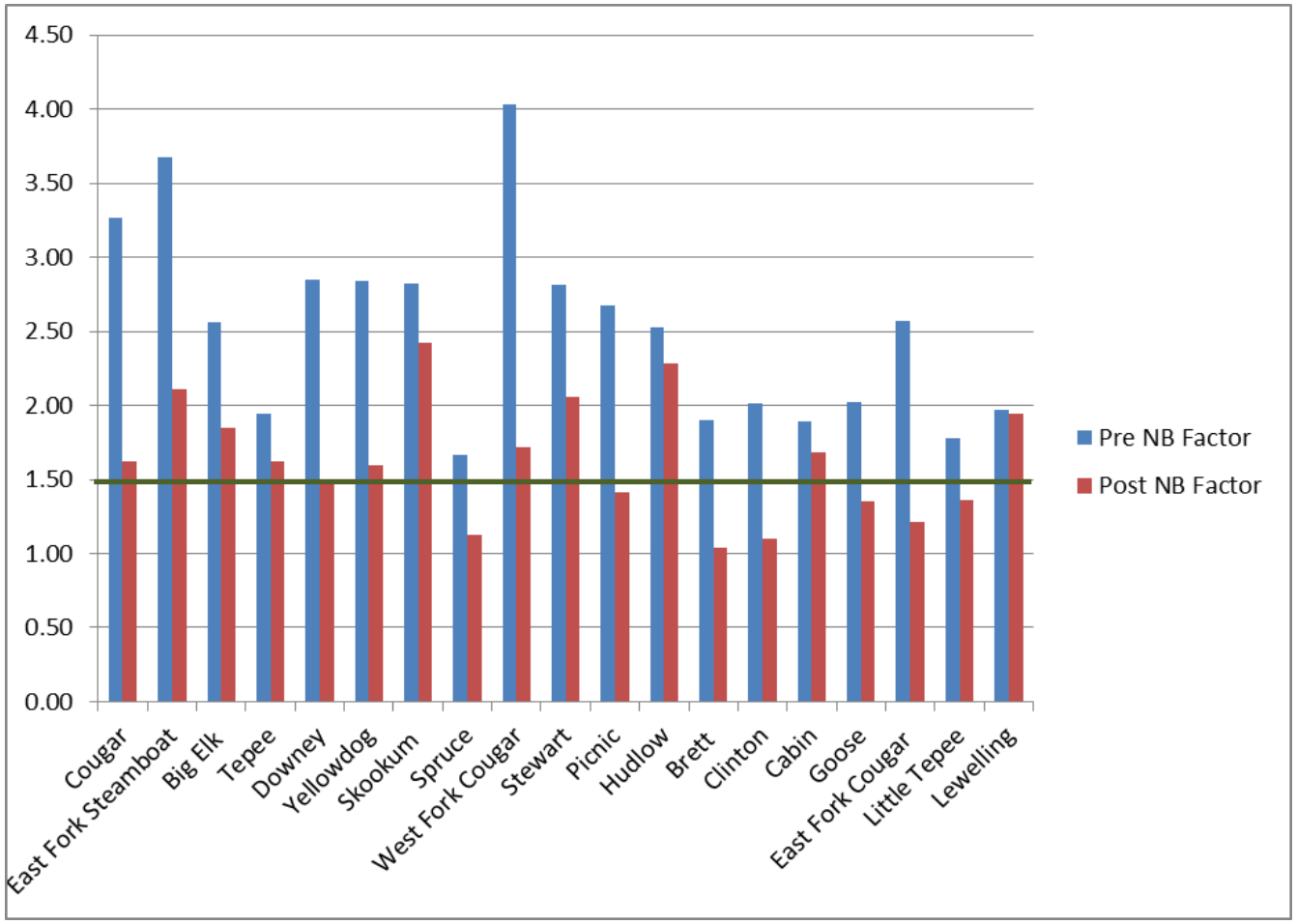


Figure 4. Annual sediment load estimates before and after restoration as a ratio to natural background estimates. The sediment TMDL target was 1.5 times natural background sediment loads and is depicted by the green line.

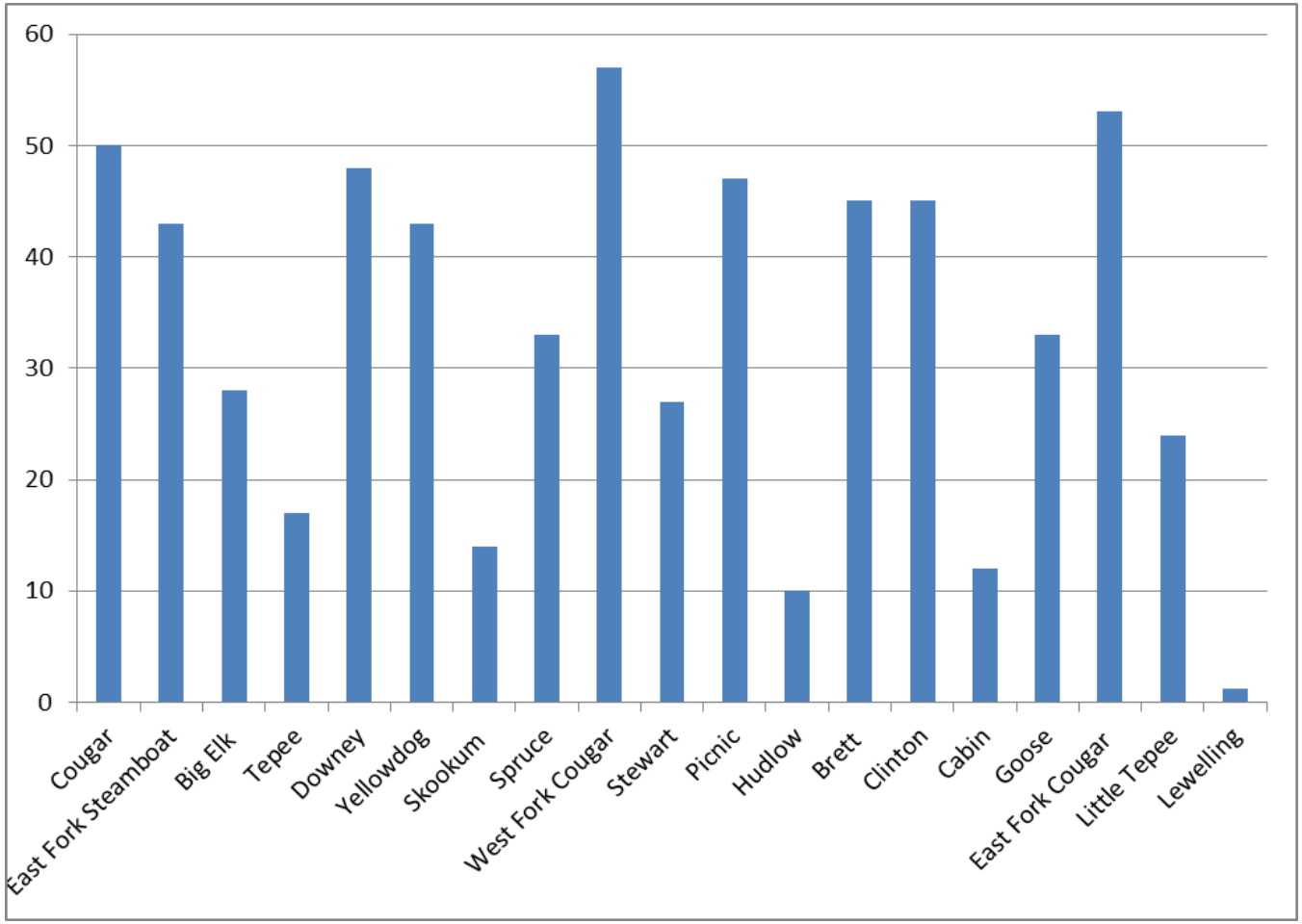


Figure 5. Estimated percent reductions in sediment loads due to watershed restoration.

Discussion

The sediment TMDL evaluation model closely approximated the original sediment TMDL model. Estimates of pre-restoration sediment loads were close to sediment TMDL estimates of existing loads, but could not exactly replicate the original estimates. The differences were due to the inability to reproduce the same data for the GIS model as used in the original analysis and potential differences in GIS processing. The model approximation was considered adequate since estimates were close to the original, the TMDL evaluation model utilized current sediment model techniques and GIS tools, and the relative comparisons to natural background remain appropriate.

The largest sediment load estimates were found in Cougar Gulch where annual sediment loads in one subwatershed dropped nearly 470 tons. Even after such a dramatic reduction of 50 percent, the post-restoration sediment loads were estimated as 34 tons over the estimated TMDL target and 1.62 times natural background. However, reductions were also substantial (more than 50%) in the East Fork and West Fork Cougar Gulch subwatersheds and the entire Cougar Gulch watershed combined achieved a total estimated reduction of 645 tons (50% overall) and achieved nearly natural background annual sediment loads – 1.07 times natural background. The Cougar Gulch bioassessments were conducted at a downstream site to integrate upstream watershed conditions and indicated good cold water conditions. At the larger watershed scale, estimated sediment loads post-restoration are thought to be well within the assimilative capacity of the stream. Model results 1.6 or 1.7 times natural background in the subwatersheds might be assumed to be sediment-impaired; however, we observed no sign of sediment impairment in any part of the overall watershed. These results combined with field observations in tributaries suggest that assessments consider appropriate geographic scales and local ecological conditions, and should not rely on model results alone. For this subbasin, we recommend a 10-digit hydrologic unit code (HUC) watershed scale be evaluated along with the watershed's ecological context.

The location in relation to other watersheds, the size of waterbodies, connectivity, and range of stressors should all factor into assessments. Models provide an estimated sediment load in terms of an overall annual average. Very large hydrologic events may play a larger role than previously identified in this subbasin. Sediment loading and the associated biological and physical response may be much more episodic and stochastic than previously recognized in assessments. There was a very large flood event in February 1996. Many roads washed out and a significant amount of damage was observed throughout the subbasin. The period since then has consisted of moderate flows which, along with watershed restoration and improved BMPs, have resulted in substantial recovery. There is likely much greater resilience in current watershed conditions. Sampling, assessments, and development of TMDLs should consider the possible effects of climate cycles and hydrologic events.

The overall results may also help determine appropriate TMDL targets. Targets of 1.5 or 1.6 times natural background have been used in other north Idaho sediment TMDLs. These results

may suggest that higher estimated loads may be supported in some watersheds. The results may also suggest that there are uncertainties in the model to be resolved or improvements to be made in the modeling approach to reduce error.

Phase 2a. Forest Road Decommissioning Effectiveness Monitoring

Objectives

The objectives in Phase 2a of this study were to validate whether road restoration was effective at reducing sediment delivery at selected road restoration sites, and to determine the effectiveness of our designs and use of Best Management Practices (BMPs) at reducing localized sediment.

Even though significant restoration efforts had occurred in the last two decades, little quantitative monitoring of the effectiveness of these restoration efforts had been conducted. Monitoring was needed to evaluate the effectiveness of headwater road restoration BMPs and site recovery. Results could validate assumptions in the TMDL sediment model that existing and potential sources of road-related sediment were reduced or minimized throughout several subwatersheds. Monitoring data can be used to determine the effectiveness of restoration and if the implementation of the restoration techniques utilized have reduced sediment risks to meet TMDL load allocations without creating additional long-term sediment sources.

Methods

The assessment targeted sediment sources located in several parts of each watershed. These included individual stream crossing culvert removal sites, and samples along road segments. Sampling was stratified into three categories:

- Stream crossing culvert removal sites – located at sites where culverts were present prior to road decommission work. These sites were targeted since they represent the highest potential for active erosion. Samples included those from both the headwater and riparian road areas.
- Riparian corridor roads - defined as valley bottom roads and those parallel to streams for a significant portion of their length.
- Headwater roads - defined as roads generally higher on the hillslope that contour across the mountain face.

Half of the sampling effort was spent on channel crossing sites, 30% on riparian roads, and 20% on hillslope roads. All sites were randomly selected using a variety of random sampling methods to evaluate where major sediment loads are produced from forest roads. All monitoring surveys were located in the eight watersheds where PIBO and BURP surveys occurred: Big Elk, Cougar, East Fork Steamboat, Picnic, Tepee, Yellowdog, Skookum, and Stewart.

Stream Crossing Culvert Removal Site Surveys

Every inventoried stream crossing site was split into three units (Figure 6) described as follows:

1) Control - the area above the treatment area (channel removal)

2) Direct impact area - the area where the culvert and/or fill removal occurred

3) Indirect impact area - the area below the direct impact area where no excavation or site disturbance occurred during restoration work. The indirect impact area could have been affected by sediment moving off the direct impact area.

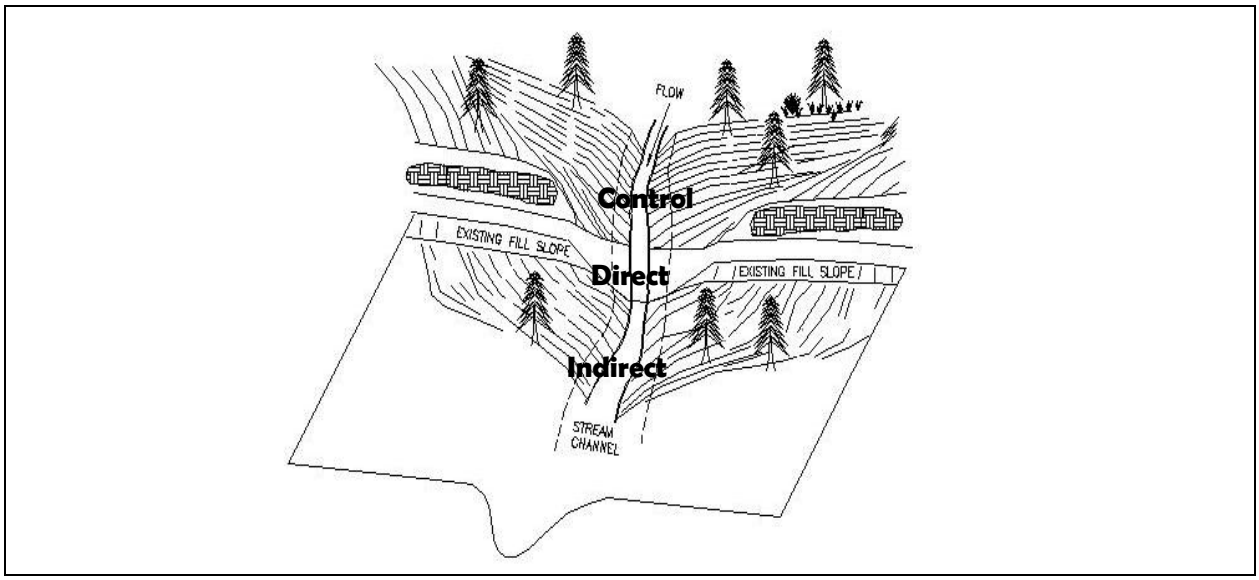


Figure 6. The assessment evaluated conditions in control, direct impact, and indirect impact study areas. Flow is from control downstream to indirect.

The direct impact area is the culvert removal site itself, i.e., where the road used to be. The control and indirect impact areas are the areas of channel immediately above and below the direct impact area, respectively. The length of the control and indirect impact areas was determined based on the length of the direct impact area; the control and indirect impact areas were at least the same length as the direct impact area but could be up to 3 times that length if significant upstream or downstream effects were observed. The control site was only evaluated in relation to the direct effects area despite the fact that impacts from past activities could have affected the control site (e.g., stacked roads above or harvest adjacent to the site).

Upslope condition assessments consisted of systematic sampling of effective ground cover, systematic sampling of bank slope and length, and inventories of erosion. Both the left and right banks were assessed in the same manner in the direct impact areas only.

A metric measuring tape was placed on the ground 1.5 meters up from the channel bed along the entire length of the stream crossing from the top end of the channel to the bottom within

the restored site. If there were no apparent channel bed indicators, then the tape was placed 1.5 meters up from the toe of the slope.

Effective ground cover (EGC) type was recorded every 0.2 meters along the measuring tape with the first reading at 0.0 meters. "Effective ground cover is defined as living or dead material within 30 cm of the ground surface" (USFS, 2009). At each measuring point, the observer recorded the dominant ground cover (> 51%) of a 2 cm circle using the dot-tally method. The individual locations of ground cover evaluations along the measuring tape were not recorded. Ground cover designations recorded were bare ground, rock, litter, moss, grass, forbs, shrub, and wood. If erosion control material was used and could be identified (e.g., straw) it was recorded.

Erosion information was recorded along the same transects as the upslope ground cover inventories. The observer noted type, width, depth, and height of erosion features. Erosion types inventoried were rills, ruts, gullies, slumps, and mass wasting. The width of erosion was measured along the measuring tape and recorded to the nearest centimeter. Depth of erosion was defined as the depth of the void of the erosion feature perpendicular to the slope of the bank at the transect tape. Height of erosion was the slope distance from the bottom of the feature to its highest point on the bank.

At four evenly spaced intervals along the bank's transect, bank slope and length on both the left and right banks were measured. Bank slope was measured with a clinometer and length with a tape from bankfull (toe of slope if there were no bankfull indicators) straight uphill to the top of the hydrologically contributing area, but not further than the top of the recontoured road (Figure 7).



Figure 7. The slope and length of the hydrologically contributing area of the sideslope was measured in direct impact areas at four equally spaced intervals. In this example picture, along the red lines.

Channel condition assessments consisted of a systematic sampling of ground cover and/or substrate materials, an inventory of grade control features, and a systematic sampling of channel dimensions including active channel width and bank height. This assessment was conducted in the control, direct and indirect impact areas of the culvert removal site.

A metric measuring tape was placed on the ground in the center of the channel along the entire length of the assessment unit (control, direct or indirect impact area). Stream channel gradient was measured with a clinometer. Observers determined whether a defined stream channel exists at the crossing. A defined channel was a persistent feature in a topographically convergent area where surface runoff is sufficiently concentrated to cause scour and measurably distinct banks (MacDonald and Coe 2007, Dietrich and Dunne 1993, Montgomery and Dietrich 1989).

Substrate composition, active channel widths, and bank heights were systematically sampled at each site. Substrate composition sampling utilized a Wolman Pebble Count (Wolman 1954); observers measured the median diameter of substrate particles throughout the length of the channel. Every 1.0 meter of the transect, the observer measured the active channel width and bank height (Figure 8). We then measured three particles, one each from 0.25, 0.5, and 0.75 of the active width of the channel.

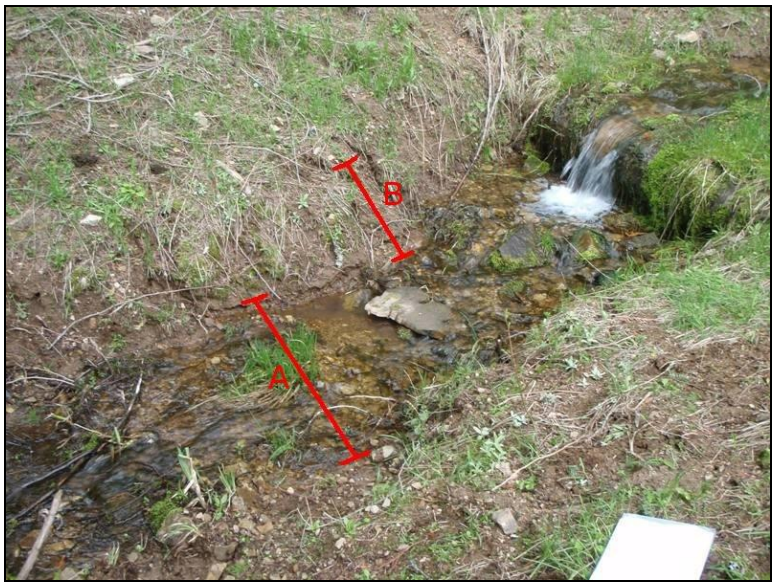


Figure 8. Active channel width (A) and bank height (B) were determined in the field.

Natural and artificial grade control features were inventoried. This assessment consisted of locating these features, determining their spacing, and assessing their functional condition with respect to sediment retention. Grade control features are meant to retain sediment within the channel (as opposed to transporting sediment) and prevent downcutting or gully formation within the channel. A natural grade control feature was usually large woody debris that fell into

the channel from the riparian zone or was composed of stick aggregates or rocks. Artificial grade control features were rock or log structures placed at culvert removal sites during restoration. A structure's functional condition was noted as to whether it was intact as constructed, being undermined or cut around, holding back sediment, etc. A score was assigned to each structure (Table 2). The location of each grade control structure according to the transect tape was recorded as well as its functional condition (score).

Table 2. Scores, functional conditions, and indicators of functional conditions for grade control structures.

Score	*Functional Condition*	*Indicators*
1	Excellent	Structure keys intact, sediment retention 90-100% of structure height
2	Good	Some scour occurring at keys and sediment not filling structure, 50-90% full
3	Failing	One of the keys failing with sediment moving around or under structure, but holding back some sediment, 25-50% full
4	Failed	One or both keys failed or structure undercut, structure holding back less than 25% height of structure

Headwater and Riparian Road Condition Surveys

Hillslope and riparian road survey sites were located 200-300 meters away from approximately channel crossing sites and were outside of any riparian or channel influence. The road condition surveys consisted of systematic sampling of ground cover, an inventory of erosion, and retrieval of soil samples for bulk density testing along a 100 meter transect of decommissioned road. The apparent prescription as well as slope, aspect, elevation, and GPS coordinates were also noted.

Prescriptions for decommissioning a road varied and may have included full recontouring, partial recontouring, ripping, end-hauling, or abandonment. The transect tape was placed parallel in the middle of the road for 100 meters.

Effective ground cover was recorded every 2 meters along the measuring tape. At each measuring point, the observer recorded the dominant ground cover (> 51%) of a 2 cm circle. Ground cover designations recorded were bare ground, rock, litter, moss, grass, forb, shrub and wood. At least four evenly spaced hillside slope measurements above the road were taken with a clinometer.

Erosion information was recorded along transects as inventories. The direction of erosion was also noted. Erosion direction was downslope (perpendicular tothe transect tape) or down road (roughly parallel to the transect tape). For downslope erosion, the observer noted type, width,

length, and depth of erosion features. Erosion types were rills, ruts, gullies, slumps, and mass wasting. Width of erosion features was measured along the tape. Length of erosion was the slope distance from the bottom of the feature to its highest point on the slope. Depth of erosion is the depth of the void of the erosion feature perpendicular to the road surface at the transect tape.

For downslope road erosion, the observer noted type, length (within limits of the extent of the tape), width and depth of the erosion feature. Erosion types were rills, ruts, and gullies. Length of erosion was measured parallel to the transect tape. Width of erosion was the width of the erosion feature perpendicular to the transect tape. Depth of erosion was the depth of the void created by the feature. If multiple, concurrent erosion features were present in down road erosion (e.g., two parallel tire ruts), these were inventoried as independent features.

At least four digital photos were taken at every selected culvert removal site. Photos depicted the general condition of the site including such elements as the left and right banks and upstream/downstream views of the stream channel. At least two photos were taken at each decommissioned road survey site. The photographer was allowed some "artistic license" in order to capture the general condition of the road, channel, significant erosion features, etc. However, the photographer noted on the field form for every picture the filename of the photo, the date/time, and a description of the picture which include, at a minimum, what the picture is of and the location of the photographer. A meter board was utilized to show scale in the photos (Hall 2002).

Data analysis and graphics were conducted using Windows 7 Excel spreadsheets. We used the size class pebble analyzer -2001 to evaluate pebble counts. The program calculated a P- test to test for differences in treatment type (Sokal and Rohlf 1969). The student T-test was used to evaluate differences in ground cover metrics. Transformations and statistical test, such as Correlation coefficients (Sokal and Rohlf 1969) were used from the Windows 7 Excel package.

Results

Site recovery was evaluated using the following categories: vegetation, active erosion, maintenance of channel stability, and sediment transport and retention.

Site Recovery – Vegetation

Average effective ground cover (EGC) approached 90% for all inventory types (Figure 5). Across all sites and watersheds, average EGC on disturbed sites (road and direct impact) was only 4% to 8% less than undisturbed sites (control and indirect impact) or undisturbed forest (background) (Figure 9). No significant differences were detected between any of the three undisturbed sites, or the two disturbed sites ($p=0.3$). Our analysis also found no significant difference between the undisturbed and the disturbed sites ($p=0.3$).

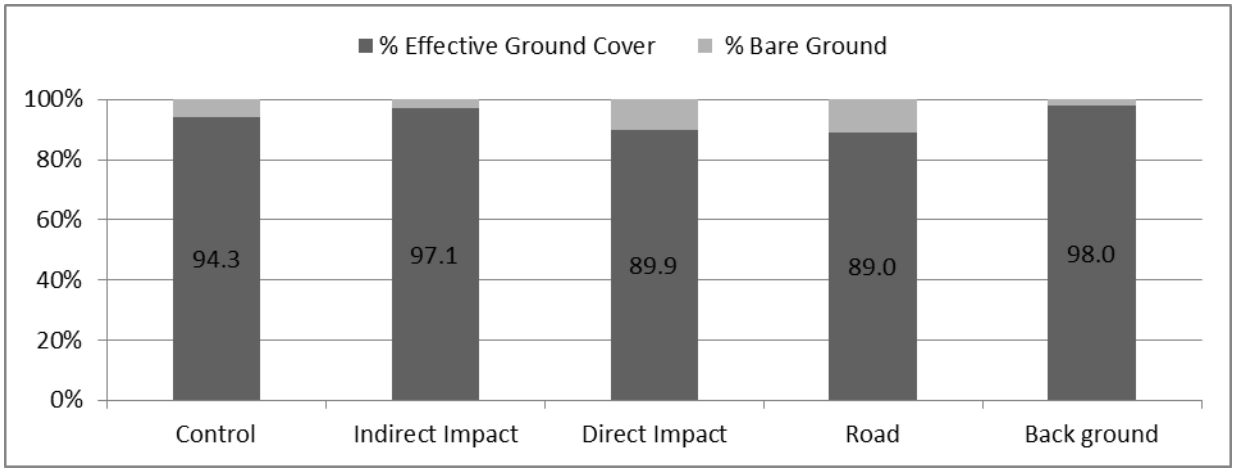


Figure 9. Percent effective ground cover and percent bare ground at all sites. The data is the average of all sites and watersheds by survey type. Data shows undisturbed areas (control and indirect impact) and disturbed sites (direct impact and road). Background data was collected at undisturbed forest sites in the Priest Lake Experimental Forest (Glaza, Unpublished).

Effective ground cover (EGC) at disturbed channel sites (direct impact) was very high in all watersheds, ranging from 82% to 94% (Table 3). We found undisturbed sites (control and indirect impact) had a similar range, ranging from 80% to 100% (Table 3). Effective ground cover is comprised of rock, wood, forest litter, and vegetation. Vegetative recovery in all watersheds ranged from 50% to 86% for direct impacted channels. At the undisturbed channel areas percent vegetation ranged from 46% to 69%, with average vegetation about 10% lower than disturbed sites (58%) (Table 3), no data was collected in Skookum or Yellow Dog watersheds at undisturbed sites. This lower vegetative cover appeared to be influenced by overstory vegetation, both brush and conifers that did not meet the ground cover criteria and were not tabulated as ground cover. This over story provided significant shading at many of the sites and reduced the amount of ground cover vegetation. The vegetative component of EGC is comprised of grass, forbs, shrubs, moss, and small conifers. Conifers over three meters tall were not counted as EGC. We found a trend that forbs dominated in the disturbed areas and litter and wood were higher in the undisturbed areas, but none of these difference were significant ($p=0.4$). The results were not unexpected as they follow a progression of natural succession. More open bare ground and early successional stages such as forbs dominated the disturbed sites. Forbs made up the largest proportion of EGC ranging from about 25% to as much as 50% ground cover at all the disturbed sites. Within the undisturbed site forbs comprised from 13% to 32% (Table 3).

Woody debris was most often placed on the bank and upper contributing areas at the time of restoration, but our data shows that wood contributed a greater percentage in the undisturbed sites (20%) than in the disturbed sites (7%) (Table 3). During restoration large wood is placed at disturbed sites to slow overland flow and catch sediment. The wood inventoried in the undisturbed site was a combination of large wood and small branches that fell from overstory.

Litter also was found to occur twice as often in the undisturbed sites as compared to the disturbed sites. Again this was not unexpected as the undisturbed sites had been in a vegetative state much longer that the disturbed areas, allowing for a greater contribution of litter for ground cover. From our data it appears that effective ground cover is high at all sites, but the composition of the effective ground cover varies between the undisturbed and disturbed sites.

Table 3. Percent effective ground cover (%EGC), percent vegetation (% Veg), percent rock, litter, wood, forbs, grass (%Gra), shrubs, moss (% Mo), small conifer (% con) and percent bare ground (%BG) by watershed and treatment, disturbed equals impact to channel and banks (direct areas), and undisturbed equals no impacts to streambed or banks (control and indirect areas).

Watershed	Treatment	% Rock	% Litter	% Wood	% Forbs	% Gra	% Shrub	% Mo	% Con	% Veg	% EGC	% BG
Big Elk	Disturbed	7.5	6.4	9.9	39.5	7.2	13.3	0.7	0.0	70.7	84.6	15.4
Cougar	Disturbed	3.3	15.7	6.5	37.9	10.9	13.8	3.4	1.2	73.7	92.7	7.3
EF Steamboat	Disturbed	14.3	13.7	5.5	32.5	14.7	7.8	2.9	0.8	64.2	92.2	7.8
Picnic	Disturbed	16.2	17.7	7.0	37.6	2.3	8.0	1.7	0.3	57.0	90.8	9.2
Skookum	Disturbed	2.9	4.8	6.9	69.7	5.6	3.4	0.7	0.0	86.3	94.0	6.0
Stewart	Disturbed	6.8	19.6	10.8	36.1	5.2	3.8	2.6	4.1	62.6	89.1	10.9
Upper Tepee	Disturbed	3.0	11.3	8.0	47.3	10.3	5.1	5.1	0.0	75.8	90.1	9.9
Yellow Dog	Disturbed	9.0	23.8	1.2	28.0	1.7	2.2	16.4	0.6	50.1	82.8	17.2
Average	**Disturbed**	**7.9**	**14.1**	**7.0**	**42.1**	**7.2**	**7.2**	**4.2**	**0.9**	**67.5**	**89.5**	**10.5**
Big Elk	Undisturbed	7.1	42.6	34.6	12.7	0.0	0.2	0.3	0.0	47.7	97.4	2.6
Cougar	Undisturbed	7.3	24.1	14.7	30.2	1.7	18.1	1.7	0.1	66.5	97.9	2.1
EF Steamboat	Undisturbed	2.4	30.9	7.9	22.7	1.7	13.3	0.8	0.0	46.4	79.7	20.3
Picnic	Undisturbed	1.8	36.4	23.5	29.5	0.4	4.4	1.3	0.0	59.2	97.4	2.6
Stewart	Undisturbed	5.8	31.1	28.2	32.0	0.0	1.0	1.9	0.0	63.1	100	0.0
Upper Tepee	Undisturbed	0.0	38.4	12.9	12.9	0.9	42.4	0.0	0.0	69.0	97.4	2.6
Average	**Undisturbed**	**4.4**	**33.3**	**20.2**	**23.6**	**0.9**	**10.8**	**1.0**	**0.0**	**58.0**	**93.3**	**6.1**

Effective ground cover on road segments was slightly less than channel crossings, but nonetheless, still very high. Upper Tepee Creek roads had the lowest percent EGC at 77%. The sites surveyed were on a western aspect with one of the sites in the middle of an old clear cut timber sale unit. Cougar Gulch road sites had the highest percent EGC at 93%. The average over

all watersheds was 89% (Table 4). The overall composition of ECG on roads differed from that of stream crossings. Notably, the forb component is high on roads, but did not consistently take up the majority of ground cover in all watersheds. Forbs were still a major component on headwater and riparian roads in East Fork Steamboat Creek and Stewart Creeks and on riparian roads in Picnic creek. In other watersheds wood, forest litter, rock, and shrubs made up a more significant portion of EGC. Upper Tepee Creek's low vegetative cover may be explained by the fact that the road site that was surveyed was a southwest-facing site with low soil-moisture content and poor soils. Low vegetative cover in Yellowdog Creek may be the result of being a very recent restoration project; these roads were decommissioned in 2006. The Yellowdog site also had a very high percent rock (21%) in the EGC. This riparian road had significant rock placed along the entire road in an attempt to protect the road during high flows. Most of this rock was used in stream restoration work when the road was removed, but smaller pieces were spread along the banks, it appears this high rock could have affected vegetative recovery. Similar trends were observed on the Picnic and Upper Tepee headwater roads with high rock content and lower percent vegetation (Table 4).

Table 4. Percent effective ground cover (%EGC), percent vegetation (% Veg), percent rock, litter, wood, forbs, grass (%Gra), shrubs, moss (% Mo), small conifer (% con) and percent bare ground (%BG) by watershed on treated headwater roads (HW Road) and riparian roads (RP road).

Watershed	Treatment	% Rock	% Litter	% Wood	% Forbs	% Gra	% Shrub	% Mo	% Con	% Veg	% EGC	% BG
Big Elk	HW Road	3.0	20.0	27.3	24.2	6.0	6.0	1.0	0.5	37.7	88.0	12.0
Cougar	HW Road	8.9	12.9	20.8	19.3	8.9	16.8	5.5	0.0	50.5	93.1	6.9
East Fork Steamboat	HW Road	3.9	17.6	1.0	54.9	5.9	1.0	4.9	2.9	69.6	92.2	7.8
Picnic	HW Road	15.7	31.4	7.8	13.7	2.0	15.7	0.0	2.0	33.3	88.2	11.8
Stewart	HW Road	0.0	23.5	2.0	64.7	0.0	0.0	7.8	2.0	74.5	100	0.0
Upper Tepee	HW Road	12.0	21.0	6.0	22.0	0.0	7.0	9.0	0.0	38.0	77.0	23.0
Average	**HW Road**	**7.3**	**21.1**	**10.8**	**33.2**	**3.8**	**7.8**	**4.7**	**1.2**	**50.6**	**89.9**	**10.2**
East Fork Steamboat	RP Road	7.5	13.2	3.6	35.5	8.6	0.8	11.8	0.4	58.8	89.0	11.0
Picnic	RP Road	9.0	15.7	3.7	41.7	2.2	5.8	7.0	4.8	61.4	89.9	10.1
Stewart	RP Road	2.4	6.2	6.0	38.6	17.1	4.7	8.4	6.5	75.4	90.0	10.0
Yellowdog	RP Road	21.2	18.4	10.6	20.8	8.2	1.2	5.1	0.0	35.8	85.5	14.5
Average	**RP Road**	**10.0**	**14.9**	**6.0**	**34.2**	**9.4**	**3.1**	**8.1**	**2.9**	**57.7**	**88.6**	**11.4**

Site Recovery – Active Erosion

Of the five erosion types surveyed, only three occurred; rills and gullies were not tallied (Figure 10). Upon examination of the field data, the two ruts were not caused by machinery or tires. It appears they were seeps where water had concentrated and formed a small channel. These two sites could have been classified as a rill. Mass wasting accounted for the greatest volume of sediment (38.8 cubic meters), but only eight occurrences were inventoried. 24 slumps were inventoried accounting for 29.2 cubic meters and two ruts/rills were measured with less than 3.5 cubic meters. We found a total of 34 erosion sites and 33 of these were associated with channel crossings.

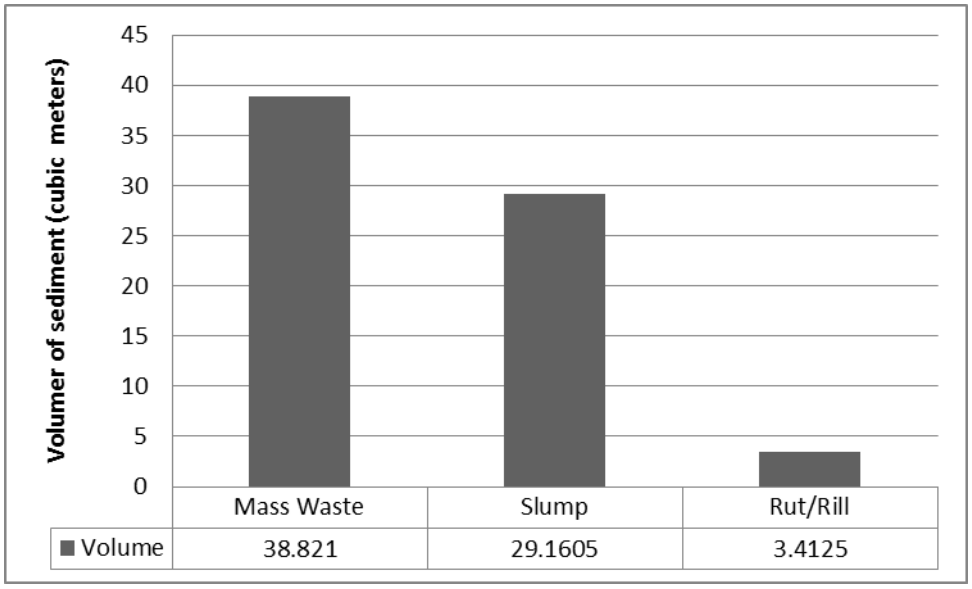


Figure 10. Erosion types and total volume (cubic meters) of sediment measured at all sites in all watersheds.

Only one erosion site was found on a headwater road within Big Elk creek (Figure 11). No erosion sites were inventoried on riparian roads. The site, a slump, accounted for four cubic meters of sediment, less than 6% of the total sediment volume inventoried. The site was well vegetated with no connection to any water course, so movement of sediment was retained on the hill slope and did not enter a stream channel.



Figure 11. Site where road erosion slump was inventoried in Big Elk Creek watershed. Slump is located just above the meter board to the right indicated by red arrow.

As presented earlier, the majority of erosion sites were associated with channel crossings and all were within direct impact areas. Overall, bank erosion at channel crossings was low. Of the sites surveyed, five out of the eight watersheds had very low bank erosion on a per site basis. However, three sites in three different watersheds can be accounted for by large singular erosion events at each specific site (Figure 12).

Big Elk Creek had the highest calculated erosion volume of 3.56 cubic meters per crossing, but two large mass wasting events located at the same crossing accounted for 61% of the detected erosion in the watershed. This channel crossing, decommissioned in 1999, is characterized by failing grade control structures. Field crews also noted that not enough fill material had been excavated from the banks; very steep banks made up of loose, unconsolidated soil eroded at the toe-slope resulting in mass failures.

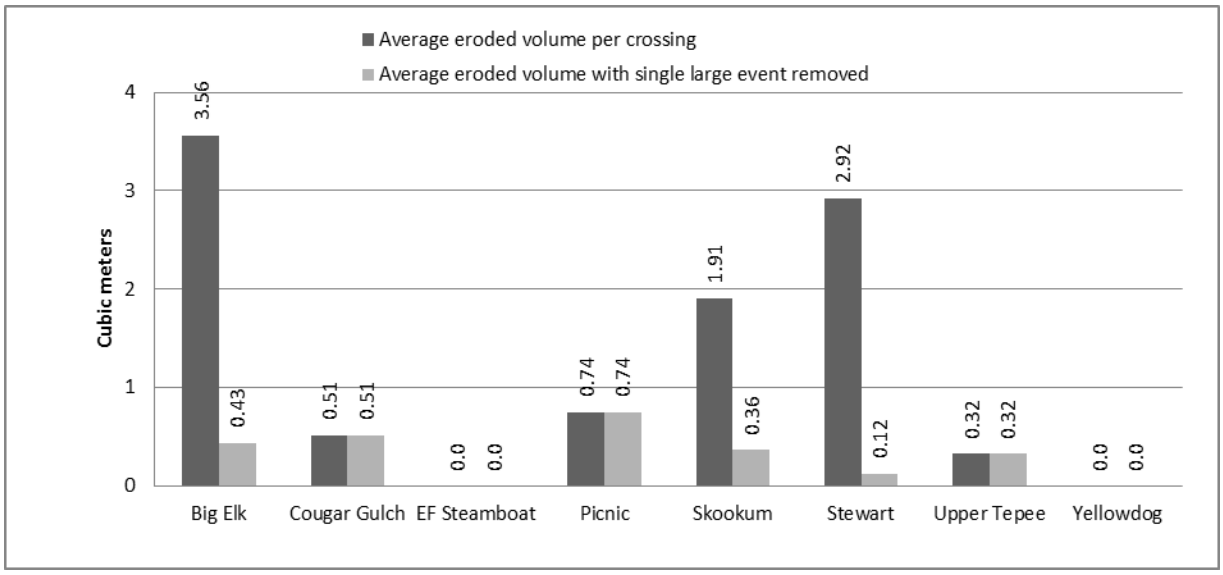


Figure 12. Volume of eroded material at channel banks per crossing. Large singular events accounted for a significant portion of material eroded in Big Elk, Skookum, and Stewart. To show perspective of how these events influence the data, the largest erosion events in Big Elk, Skookum, and Stewart Creeks were removed.

Stewart Creek, with an eroded volume of 2.92 cubic meters per crossing, had a single mass wasting event on the right bank that accounted for 99% of the eroded volume in the watershed. A large amount of fill material was left on the right bank leaving it with steep banks and exposed to erosion at the toe (Figure 13). The crossing was decommissioned in 1997. The left bank did not erode and had a very mild bank slope.



Figure 13. Stewart Creek erosion site. Note the mild slope and heavy vegetation on the left bank and steep banks on the right. A mass failure is present on the right bank behind the meter board.

Skookum Creek, with an eroded volume of 1.91 cubic meters per crossing, had a single slump that accounted for 90% of that volume. The slump in Skookum Creek was caused by not excavating enough fill out of the flood plain and channel; the stream was down cutting through fill material, and undercutting grade control structures (Figure 14). It was difficult to determine whether the slump has stabilized or will develop further into a mass wasting event.

These figures may be artificially high because the vast majority of erosion types noted were slumps. Slumps on channel banks may contribute some sediment to the stream network by eroding at their toe, but they are generally much more benign than ruts, gullies, or mass wasting. Our data indicated a large percentage of the slumps did not interact with the channel. Slumps on stream banks may require a coefficient for sediment delivery. This could be achieved by having field technicians estimating the percentage of the slump that was delivering sediment to the stream.



Figure 14. Downcutting and slumping banks at a decommissioned crossing in the headwaters of Skookum Creek.

Results indicate that rills on the excavated slopes were non-existent, or undetectable. It may be that the rock content, uneven ground left on site, and the cover (logs and brush) prevented the concentration of overland flow on restored sites. On average, the disturbed areas at the direct impacted channel sites averaged about 240 m^2 (range 143 - 480 m^2) and slopes averaged 46% (range 23% -60%).

Site Recovery – Maintenance of Channel Stability

Results suggest a significant correlation with watershed size and channel width in our study (Figure 15). This information could provide good modeling information to estimate channel widths in future projects. Watersheds with drainage areas less than 14 hectares had no defined

channel, and results may help in future planning efforts to determine buffer widths for many resource projects.

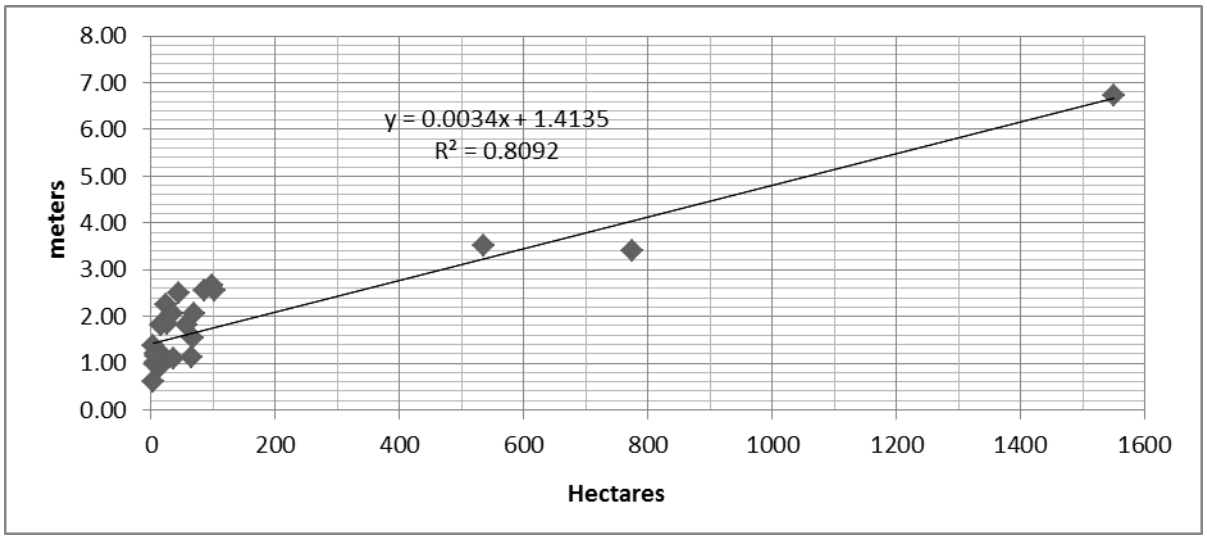


Figure 15. Relationship between watershed area (hectares) and channel width (meters) for headwater channels.

One of the key components of headwater channel restoration is to reestablish grade control at disturbed sites. As discussed in the erosion section of this report, the three sites that exhibited the highest sediment production appeared to not have sufficient fill removed resulting in down cutting and the failure of grade control structures. Monitoring efforts looked at both artificial grade control (constructed during restoration) and naturally occurring grade control structures (Figure 16). 82 artificial and 509 natural grade control structures were inventoried, and crews described 68 types of natural structures and only 8 that were artificially constructed. Diverse combinations of grade control materials were observed at natural sites. Results showed that grade control structures fit nicely into four major groups of material that formed grade control: wood, substrate, shrubs and a combination of materials (Figure 16).

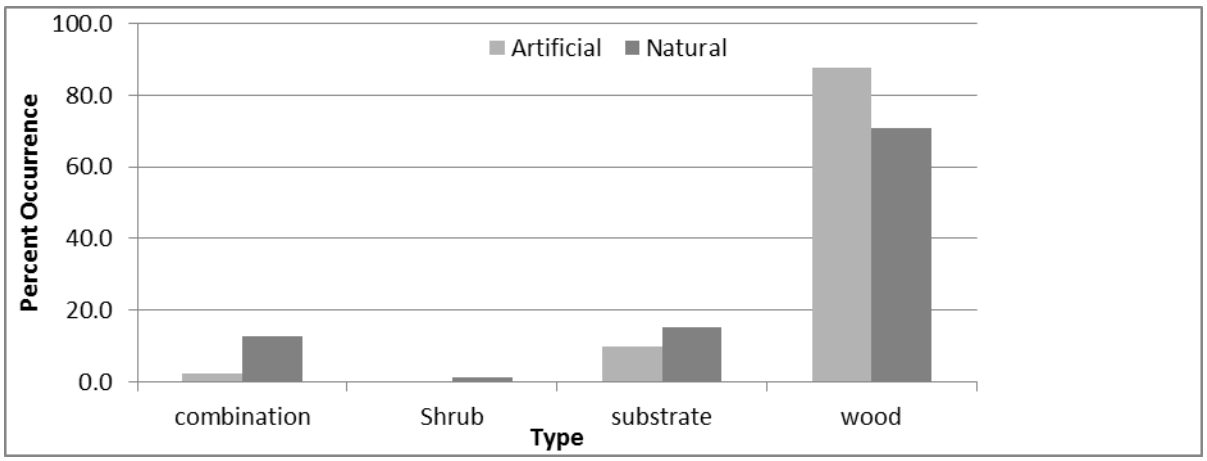


Figure 16. Percent occurrence by structure type for artificial and natural grade control structures combining all watersheds and channel types (direct impact, indirect impact and control.

Wood was the dominate structure type accounting for over 71% of the natural and 88% of the artificial structures. It was also noted that small wood (branches and twigs) occurred more often as natural structures. The next most common structure type was substrate for both artificial and natural. It was also noted that smaller cobbles were providing grade control in the natural structures as compared to artificial structures. Less than three percent of artificial structure had a combination of materials and no artificial grade control was formed by shrubs.

Both artificial and natural grade control structures were evaluated on their functional success. Results showed that over 90% of the naturally occurring grade control structures were in either the excellent or good functioning classes where as 81.8% of the artificial grade control structures were in these two classes (Figure 16). The artificial structures had almost twice the failure rates than naturally occurring structures, 18% to 10%, respectively. When the frequency of occurrence of structures over the length of inventoried channel was evaluated, data suggested that naturally occurring structures occurred almost 10 times more frequently than the artificial structures. This higher frequency of grade control provides more stability to the channel and associated structures.

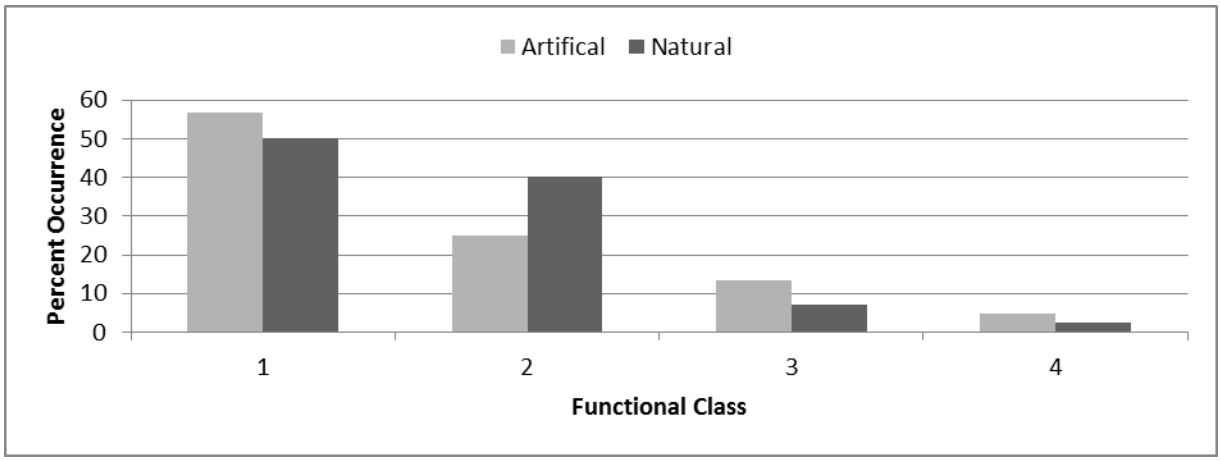


Figure 17. Percent occurrence by functional class for artificial and natural grade control structures combining all watersheds and study areas (direct impact, indirect impact and control). Functional Class 1 = Excellent, 2 = Good, 3 = Failing, 4 = Failed.

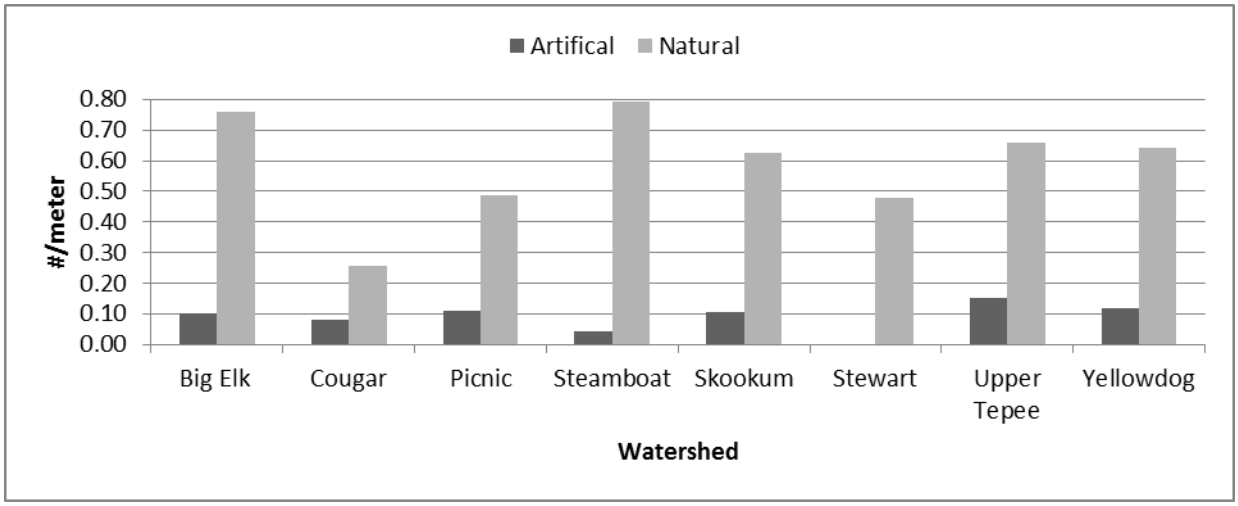


Figure 18. Frequency of grade control structures (#/meter) in each watershed comparing natural grade control (indirect impact and control) and artificial grade control (direct impact).

In individual watersheds with functional class 3 and 4 grade control structures, two of the watersheds with the highest failure rates were also two of the watershed with the highest erosion rates, Big Elk and Skookum Creeks (Figure 18). In Stewart Creek, no artificial structures were identified. However, some of the structures may not have been classified correctly. When we looked at failure rate of naturally occurring structures in Stewart Creek, 100% were in the good and excellent class (Functional class 1 and 2). The channel was very stable and excess erosion was attributed to not removing fill from the right bank. Cougar and Picnic creeks had the third and fourth highest structure failure rates and the 4th and 5th highest erosion rates.

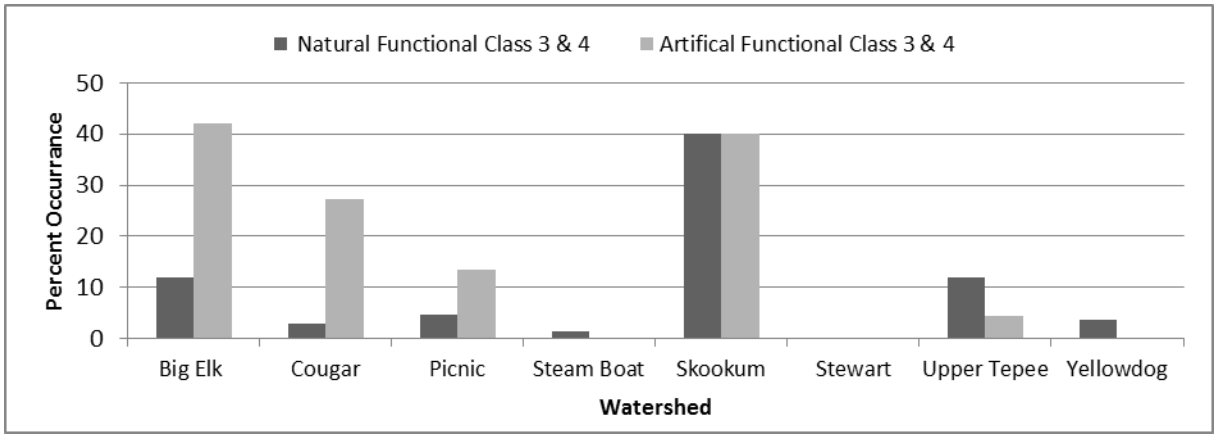


Figure 19. Percent occurrence of failed or failing grade control structures in each watershed comparing natural grade control (indirect impact and control) and artificial grade control (direct impact).

Site Recovery – Sediment Transport and Retention

Pebble counts were conducted in all watershed and all channel types, control (n = 28), direct impacts (n = 28), and indirect impacts (n = 25). We wanted to evaluate if we could detect any differences in sediment composition due to restoration effort and potential sediment production from restoration efforts. Each individual channel site was analyzed to test the difference between the direct impacted channels to the control channels and the direct impacted channels to the control and indirect channels. The size-class pebble count analyzer 2001 program allowed us to look at pebble sizes of course gravel (32 mm) and smaller. The program evaluated the 4mm and 8mm size classes (these could not be changed) and allowed the user to analyze one other size class. This study used 32 mm, which was the largest size class that could be tested statistically in the program. Although significant differences between pebble count size classes were found at a number of individual sites we found no trends between sites.

No significant trends were detected in in d16, d50 and d84 particle size class distributions. General trends in median particle size varied between sites with finer material observed in Big Elk, Upper Tepee, and Yellowdog sites (Figure 20). In some cases the direct impacted channels had lower d16, d50 and d84 values, than those observed in the control or indirect channel sub-units.

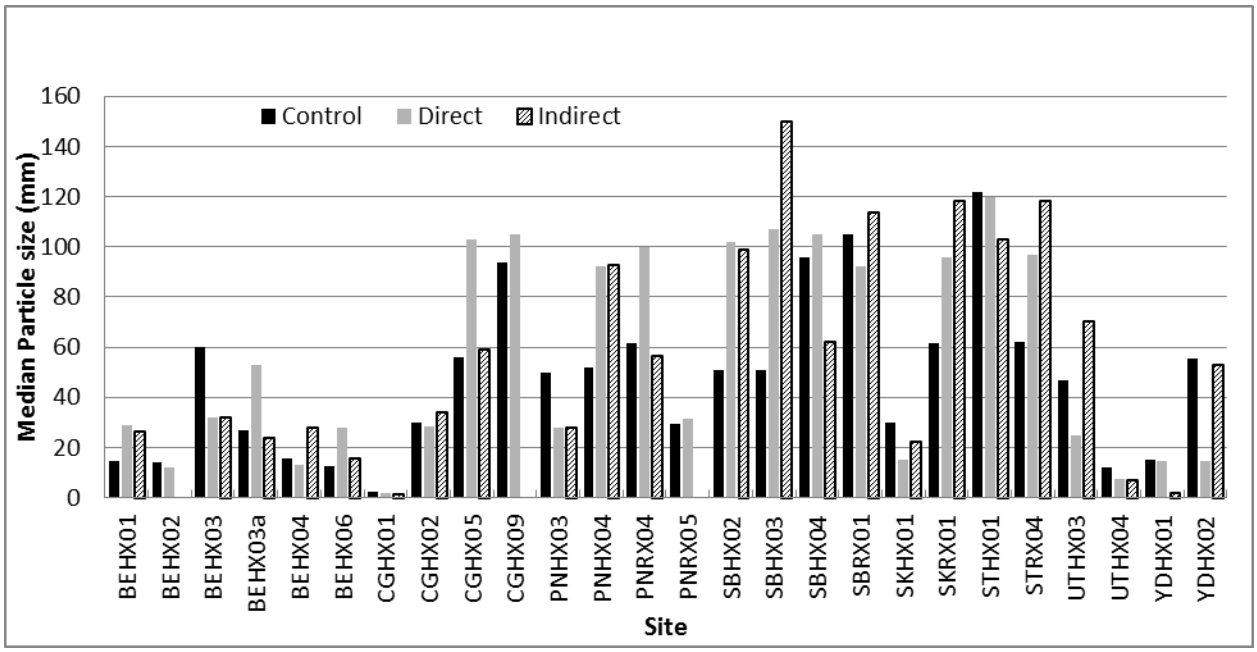


Figure 20. Median particle size (d50) for twenty six channel sites comparing the control, direct impact and indirect impact channels. HX = headwater road channel, RX = riparian road channel. BE = Big Elk, CG = Cougar Gulch, PN = Picnic, SB = Steamboat, SK = Skookum, ST = Stewart, UT = Upper Tepee, YD = Yellowdog.

Table 5. Sample size, range of gradients (%) and range of watershed areas (hectares) for each watershed above the monitoring sites for the three channel types sampled.

Watershed	*Control*			*Direct Impact*			*Indirect Impact*		
	N	Range Gradient (%)	Range Area (hectare)	N	Range Gradient (%)	Range Area (hectare)	N	Range Gradient (%)	Range Area (hectare)
Big Elk	6	8-55	5-103	7	7-52	5-103	6	12-52	5-103
Cougar	4	4-56	15-41	4	4-56	17-40	3	4-56	13-45
Picnic	4	3-44	8-775	4	5.5-43	8-775	3	5-48	8-775
Steamboat	4	8-65	9-535	4	5-35	9-535	4	5-45	9-535
Skookum	2	4-20	12-1550	2	3.5-25	12-1550	2	4.5-20	12-1550
Stewart	3	3-20	7-70	2	5-22	7-70	2	4-25	7-70
Upper Tepee	3	21-50	4-17	3	18-30	4-17	3	17-29	4-17
Yellowdog	2	20-20	7-15	2	20-22	7-15	2	26-35	7-15

A wide range of stream gradients and watershed areas were observed, and this likely accounted for much of the particle size variability between sites (Table 5, Figure 20). Stream gradients varied between the three channel types at each site, whereas watershed area was much more consistent at each site (Table 5). Variability in the frequency and type of grade control structures present at each site further complicated particle size distribution analysis.

Discussion

Legacy road restoration has been ongoing in the North Fork Coeur d'Alene River Subbasin for over 25 years, from 1984 to present. Little quantitative data had been collected to investigate the success or failure of road and channel restoration work. The assessment quantified localized erosion from past road decommission work, and assessed the effectiveness of road restoration work, the stability of the road restoration sites, and evaluated the effectiveness of several BMPs used to minimize future erosion from treated sites.

The results of the assessment suggest that erosion from road restoration work in the North Fork Coeur d'Alene River Subbasin contributes little to annual sediment only in the context of overall sediment loads within each of the subwatersheds evaluated. Furthermore, channels remained stable, and resilient to a wide range of hydrological conditions following treatment. These findings were similar to those reported by Cook and Dresser (1999), Madej (2001) and Sirucek (1999) where they found sediment delivery from restored roads was much less than roads where no restoration activity had occurred. Road surveys on closed roads on the Coeur d'Alene River Ranger District in the late 1980s found that of 118 sites inventoried 69% were failed or failing (Lider, unpublished). The average volume eroded at these sites was 32.6 cubic meters. The average volume of all sites inventoried in this study for all erosion sites was 2.32 cubic meters of sediment. Sediment movement and delivery was 26.0 times higher at road failure sites as compared to restored sites.

Aside from the three larger erosion sites in Big Elk, Skookum and Stewart Creeks, the volume of sediment delivered to streams was low. An average of 2.32 cubic meters per crossing was noted for all watersheds; discounting the large singular events noted above that figure drops to 0.44 cubic meters per crossing. When we pro rate the sediment load over time we find very low annual contribution of sediment to these headwater channel crossings. Our data is very similar to that found in preliminary surveys conducted in 1996 on restored roads within Cougar Gulch and the West Fork of Steamboat watersheds. The inventory did not collect measured data at the sites, but did visual estimates of failure types and reasons. The data found no erosion sites on the running surface of headwater roads. All erosion was associated with channel crossing removal. (Lider, unpublished). These findings are also similar to those of Cook and Dresser (1999), who reported the average amount of erosion for stream crossings was 21 cubic meters, and attributed most of the erosion to sites in unstable and erosive geology.

Relationships with precipitation and storm event variables and their correlation to erosion at specific sites were not measured. However, the project did reveal that these variables did not

greatly result in large or chronic sources of sediment delivered to streams. Average annual precipitation was only 38.8 cm, but treated watersheds and inventoried sites experienced a wide range of flow events. Restoration activity had occurred in six of the eight watersheds when the North Fork Coeur d'Alene Subbasin experienced its second highest flow on record, 36,000 cfs on February 9, 1996. Furthermore, a high percentage of the sites inventoried were within the sensitive snow zone. These sites would have been subject highly variable precipitation and flows. If the sites were not stable, one would expect higher levels of erosion than those observed. Based on the results, the assessment suggests that restoration efforts have established watersheds that are stable and more resilient to rain on snow events and other flood events and disturbance. These watersheds now meet the goals and objectives of the TMDL to reduce sediment loads.

Based on results it appears that the use of seeding and other forms of post-treatment vegetation treatments are an effective BMP at reducing long-term surface erosion at both stream crossing and road decommission sites. Mean EGC at all sites was nearly 90% for all sites. However, other local observations suggest that the effectiveness of vegetation treatments may not be realized for 3 to 5 years after road restoration efforts. Data collected in 1995 in Cougar and Steamboat Creeks, on the year of treatment, found no rilling or rutting at channel sites despite little ground cover. The next season vegetative cover was still low, averaging about 12% (range 0% to 35%), showing an obvious progression in the effectiveness of the seeding and other vegetation treatments. Similar responses were also noted in Yellowdog, Short, and Riley Creeks where EGC progressed to 75-80% within 3 to 5 years of treatment.

Grade control structures were a common design criteria used at many of the stream crossing restoration sites to established channel stability and decrease channel down cutting. Grade control structures were either secured in the channel by contractors or existing wood was left in place to control stream grade. Logs were the primarily structure used, and grade control structures tended to remain in place following restoration work. However, we could find no real trends or relationships for grade control failures, other than watershed erosion rates. Two watersheds with the highest failure rates were also two of the watershed with the highest erosion rates, Big Elk and Skookum Creeks. Results suggest that construction or retention of existing grade control structures may be useful design criteria for stabilizing stream channels following stream crossing fill removal, and should continue to be employed in future road decommission work.

The assessment was unable to gain any effective interpretive power from the pebble counts. Results found significant variation in the d16, d50 and d84 where control sites were compared to direct and indirect sites. One could assume that d50 or d84 calculations that are not statistically different from the control can be assumed to be "recovered" in the context of substrate composition. Collectively, if the d50 from the control sites are significantly different (especially finer) than the direct and indirect sites, then perhaps the sites are still contributing sediment to the stream or impacts have not been routed out of the disturbed sites. Also the

frequency and effectiveness of grade control and variation in gradient between the treatment types could explain differences in substrate composition at any given site.

Large variability in site design and contract administration procedures was observed since 1990. During the early periods of road restoration, activities were primarily administered by the engineering or timber sale administration department under traditional road construction or timber sale contract authorities. Consequently, site specific design criteria to reduce short and long-term erosion at each site were not well incorporated in rigid contract specifications. Furthermore, skills to minimize this erosion were not full developed. For example, the Skookum Creek crossing was decommissioned in 2004. The decommission contract was performed by a timber sale purchaser, who may not have had much experience in road restoration and inspected by a timber sale administrator, again with limited experience. This inexperience resulted in excess fill material left in the channel, and over steepened fill slopes left in place. Consequently, additional sediment from the site was delivered to the stream.

However, since 2004, road decommissioning has become a much more common purchaser requirement and the Forest Service has gained experience in this type of work. Improvements in contract development, design criteria, experience, and contractor education over the last 10 years have further reduced the volume of sediment eroding in the larger channels, such as Big Elk, Stewart and Skookum Creeks. Evidence of this progress can be seen in more recent road restoration work in Yellowdog Creek where no active erosion sites were found.

Monitoring results suggest that while there is a short-term risk of increased erosion and sedimentation at road decommissioning sites, the amount of erosion is minor and road-decommissioning treatments are effective in reducing long-term sedimentation risks. Recommendations for future work include assessing the extent and duration of sedimentation effects from decommissioning treatments on local aquatic life, as well as assessing the magnitude of changes to the local hydrology of affected streams.

In summary, the study validates that Forest Service watershed restoration efforts, site specific design criteria, and use of BMPs were effective at stabilizing stream channels and reducing sources of sediment and surface erosion. Furthermore, post treatment sediment sources identified in the study contributed little to the predicted annual sediment loads for each of the study subwatersheds. Post-treatment road restoration monitoring suggests that while there is a short-term risk of increased erosion and sedimentation, the amount of erosion is minor when compared to the volume of material removed, and that road-decommissioning treatments are effective in reducing long-term sedimentation risks.

BURP assessments conducted after restoration activities appear to validate our findings since reaches originally assessed as not meeting beneficial uses have now been found to support beneficial uses (see Phase 2b of this report). Additional trend analysis on adult westslope cutthroat trout on the North Fork Coeur d'Alene River appears to support this finding. Dupont et

al. (2008) studied movement, migration, and habitat use for westslope cutthroat trout in the North Fork Coeur d'Alene River and identified several factors that may be responsible for suppression of the larger cutthroat trout. They concluded that non-compliance with fishing regulations, and degraded or loss of coldwater refugia, overwinter habitat, and summer rearing habitat, were limiting factors to the density of larger westslope cutthroat trout. The authors recommended that improvements to correct these problems should lead to improvements in this fishery. Recent IDFG snorkel data suggests that densities of larger westslope cutthroat trout > 300 m continues to improve with the current "catch and release" fishing regulations in place. However, improvements in overwinter and summer rearing habitat remain a limiting factor for the production of larger westslope cutthroat trout in the North Fork Coeur d'Alene River. Continued watershed restoration efforts in key westslope cutthroat trout tributaries such as Little North Fork Coeur d'Alene River, and Shoshone, Tepee, and Beaver Creeks will be important management tools for improving fish habitat in the North Fork Coeur d'Alene River.

Phase 2b. Bioassessments

The United States Department of Agriculture Forest Service (USFS) Coeur d'Alene River Ranger District and Idaho Department of Environmental Quality (DEQ) Coeur d'Alene Regional Office performed wadeable streams rapid bioassessments following DEQ's Beneficial Use Reconnaissance Program (BURP) protocols on eight streams in the Upper (North Fork) Coeur d'Alene River Subbasin during 2009 (Figure 21). These eight streams were selected based on extensive watershed restoration and preliminary model results. Watersheds varied in range of years for restoration, and time since restoration was completed (Table 6). Sites were selected in or near the most downstream reach of each assessment unit being evaluated to coincide with sites evaluated by USFS crews for the Pacific and Inland Fisheries Biological Opinion (PIBO) effectiveness monitoring program (Figure 21). All sampled sites are on 2nd or 3rd order streams and represent forested watersheds small to moderate in size and predominantly managed by USFS (Table 7).

Table 6. Restoration timing in the eight watersheds sampled for bioassessment monitoring.

Watershed	*First Year Restoration*	*Last Year Restoration*
Big Elk	1988	1999
Cougar Gulch	1994	1995
East Fork Steamboat	1989	2002
Picnic	1993	1994
Skookum	2002	2004
Stewart	1988	2001
Upper Tepee	1993	2009
Yellowdog	2000	2006

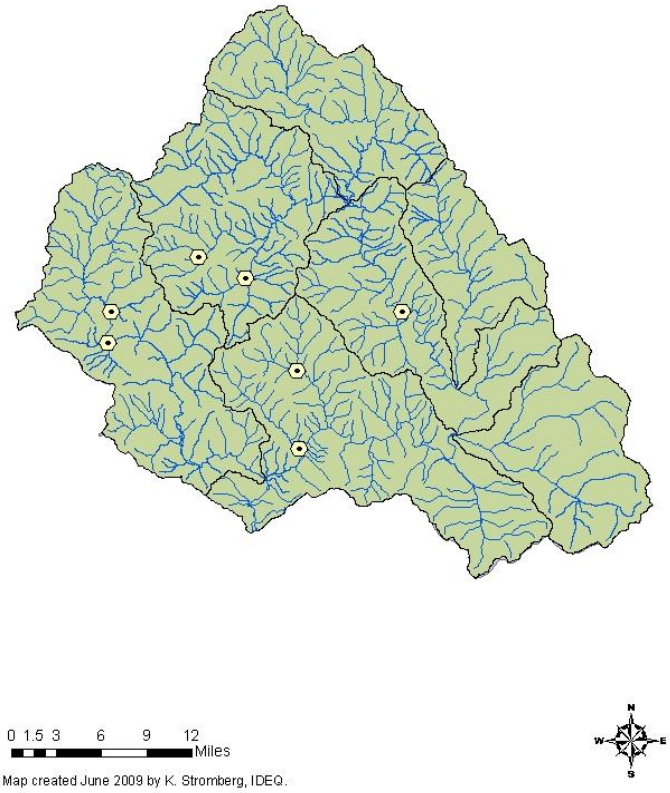


Figure 21. Site locations in the North Fork Coeur d'Alene River Subbasin for rapid bioassessment monitoring following BURP and PIBO protocols.

Table 7. Characteristics of North Fork Coeur d'Alene River Subbasin streams selected for BURP and PIBO wadeable streams bioassessment in 2009.

	Big Elk	*Cougar*	*EF Steamboat*	*Picnic*	*Tepee*	*Yellowdog*	*Skookum*	*Stewart*
Stream Order	3	3	2	2	3	3	3	2
Gradient (%) BURP	1.0	1.5	2.0	1.5	1.0	3.0	6.0	4.5
Elevation (m) BURP	951	682	780	853	951	804	853	1,030
Gradient (%) PIBO	0.667	1.044	2.013	1.924	0.959	3.270	2.457	1.207
Elevation (m) PIBO	950	688	781	862	956	798	839	997
Watershed Area (km^2)	29	49	28	13	26	20	16	15
BURP ID #	2009SCDAA001	2009SCDAA002	2009SCDAA003	2009SCDAA004	2009SCDAA005	2009SCDAA006	2009SCDAA007	2009SCDAA008
DEQ Assessment Unit #	PN020_02	PN029_03	PN028_02	PN030_02c	PN020_03	PN024_02	PN038_03	PN019_02
PIBO ID #	2853-5241	2850-5239	2851-5240	2852-5242	2732-5125	2730-5123	2731-5124	2199-5126
PIBO Reach Name	521-01-I-M2-09	521-02-I-M2-09	521-03-I-M2-09	521-04-I-M2-09	521-05-I-M3-09	521-06-I-M3-09	521-07-I-M3-09	521-08-I-M3-09

Following BURP protocols and the Idaho Small Stream Ecological Assessment Framework, physical habitat, macroinvertebrates, and fisheries data were collected and used to calculate three multimetric index scores: the Stream Habitat Index (SHI), Stream Macroinvertebrates Index (SMI) and the Stream Fisheries Index (SFI) (DEQ 2002, DEQ 2007). Data for individual metrics are converted into metric scores, combined into a multimetric index score and then compared to reference conditions for an overall condition rating as described in the Water Body Assessment Guidance (Grafe et al., 2002). The Stream Habitat Index is made up of 10 individual habitat measures (or metrics, the Stream Macroinvertebrates Index (SMI) is comprised of 9 individual metrics, and the Stream Fisheries Index (SFI) is made up of 6 metrics plus a consideration for amphibians. The three index scores can then be compared to reference conditions to obtain condition ratings for habitat, macroinvertebrates, and fish. These are used for water quality status assessments of cold water aquatic life use support.

According to the DEQ Water Body Assessment Guidance, 2nd edition (Grafe et al., 2002), rapid bioassessment data collected following BURP protocols can be integrated and used during water quality status assessments of beneficial use support. If at least two index scores are available, the average of the SHI, SMI, and SFI condition ratings can be used to indicate water quality support of cold water aquatic life. The full assessment can also use other available data to support or modify these assessment interpretations. The full assessments for these eight streams utilized SHI, SMI, and SFI ratings, component metrics, and additional data. This report summarizes only the data collected following BURP protocols, the associated multimetric index results, and 5 additional physical habitat measurements: bank stability, residual pool volume, width/depth ratio, pool frequency, and six-month average effective shade.

Field data collection was performed by DEQ and USFS staff during August and September 2009. The sampling effort was not part of DEQ's typical BURP sampling program since the program was not funded during 2009. Sampling followed the BURP Field Manual (DEQ 2007) with slight modifications noted in the text below. In addition to information normally gathered during BURP monitoring, estimates of stream shade were made using a Solar Pathfinder at six of the eight sites. Metric scores and index scores were calculated following the Idaho Small Stream Ecological Assessment Framework (DEQ 2002). Typically, index scores and ratings are calculated from BURP program data in the Biological Assessment Tool (BAT) component of the Idaho Assessment Database Supplemental Application (IDASA) database. This effort attempted to independently calculate the metrics and index scores and found this could not be done accurately and reliably for the SMI and SFI, so those metrics and scores are considered estimates. However, the independently calculated values and BAT-calculated values are very close and the weight of evidence approach is used to interpret all the data for water body assessment purposes. Condition ratings for SHI, SMI and SFI were calculated according to the Water Body Assessment Guidance 2nd edition (Grafe et al., 2002). Additional reference information is compiled from the 2001 Subbasin Assessment and Total Maximum Daily Loads of the North Fork Coeur d'Alene River (DEQ 2001) and the Inland Native Fish Strategy (USFS 1995). Photographs from each site are included in Appendices C and D.

Objectives

1. Conduct DEQ BURP and USFS/BLM PIBO bioassessments of physical and biological stream conditions post-restoration to assess biological response and attainment of TMDL goals.

2. Evaluate how USFS/BLM PIBO bioassessment frameworks can be used to assess beneficial use support.

Methods

BURP Stream Habitat Assessment

The Stream Habitat Index is made up of 10 individual habitat measures (or metrics):

- Instream cover
- Large organic debris
- Percent fine sediment
- Riffle embeddedness
- Wolman size classes
- Channel shape
- Percent bank cover
- Percent canopy cover
- Disruptive pressures
- Zone of influence

As described in the introduction physical habitat data are converted to metric scores ranging from 0 to 10 and then integrated into a multimetric index that can be compared to reference conditions for an overall condition rating. Condition ratings are determined by a comparison of sample data to ecoregional reference conditions, and range from 1 to 3.

The instream cover habitat measure is a numeric rating of instream cover for fish. Instream cover consists of areas with structure in a stream channel that provide aquatic organisms with shelter or protection from predators, competitors, sunlight, and high water velocities. Instream cover may include living vegetation, clumps of organic material, logs, boulders, surface turbulence, and root wads. Instream cover for the entire stream reach is rated from 0 to 20 according to the estimated percent instream cover and the mix of stable fish cover.

The large organic debris habitat measure is a quantitative count of large organic debris (LOD) within the BURP sampling reach. Large organic debris is defined as organic debris with a diameter greater than 10 centimeters (4 inches) and a length greater than one meter (39 inches). The term LOD is synonymous with large woody debris (LWD) described in other literature. These structures add important complexity to stream habitats, provide instream cover, retain sediment, and increase stream stability. Normally, crews count each piece of naturally recruited LOD within the bankfull channel of the stream reach. In this case, our crews also counted LOD placed intentionally during stream restoration efforts.

The percent fine sediment habitat measure is a quantitative estimate of percent fine sediment within the wetted width based on Wolman pebble count data from three riffle sites. Surface fine sediments are defined as material less than 2.5 mm in diameter. These include the silt and sand size classes of the Wolman pebble count. Excessive fine sediment can be detrimental to salmonid spawning success since it may limit the quality and quantity of intergravel spaces needed for egg incubation. Crews measured and recorded substrate sizes as a pebble count at three riffles. The percent fine sediment metric used in the Stream Habitat Index uses the number of fine particles (0-2.5 mm) within the wetted width divided by the total number of particles within the wetted width multiplied by 100.

The riffle embeddedness habitat measure is a numeric rating of the degree to which larger substrate particles (cobbles and boulders) in riffles are surrounded or covered by fine sediment. Embeddedness in riffles is visually estimated and rated from 0 to 20 in the Habitat Assessment Summary for the stream reach.

The Wolman size classes habitat measure is the number of Wolman pebble count size categories in which particles were recorded for that site. This measure illustrates the range of particle sizes observed within the three riffle sites. The BURP program uses a modified Wolman pebble count. Particles are measured in transects across the bankfull width, and observers record the particle size class and whether the particle was selected from within or outside of the wetted stream width. A minimum of 50 particles are recorded at each of three riffles. Substrate particles are measured at three riffle sites and recorded as one of 11 size classes ranging from silt/clay to large boulder.

The channel shape habitat measure is a numeric rating of overall bank angle and predominant channel shape. Bank angles are measured at a minimum of four representative locations using a clinometer. The channel shape is then rated from 1 to 15 in the Habitat Assessment Summary for the stream reach.

The percent bank cover habitat measure is a numeric estimate of the overall percent of streambank cover and stability as visually estimated for the entire stream reach. Bank cover refers to the percent surface protection when the following are true:

- Perennial vegetation ground cover is greater than 50%.
- Roots of vegetation cover greater than 50% of the bank.
- At least 50% of the bank surfaces are protected by rocks of cobble size (150 mm) or larger.
- At least 50% of the bank surfaces are protected by logs with 10 centimeter (4 inch) or larger diameter.
- At least 50% of the bank surfaces are protected by a combination of the above.

The percent canopy cover habitat measure is a quantitative estimate of the amount of stream shaded by nearby vegetation. A spherical densiometer is used that has been modified to show only 17 grid intersections. Densiometer readings are obtained from the center of the stream at each of the three riffle transects and at each of the three width-depth transects. Readings are recorded facing upstream and downstream and towards each bank. The percent canopy cover habitat measure used in the Stream

Habitat Index uses the sum of densiometer readings for the three riffle sites divided by the total possible densiometer readings (204) and multiplied by 100. Densiometer readings at the width-depth sites are not used for this metric.

The disruptive pressures habitat measure is a numeric rating of the anthropogenic impacts to the riparian zone. Disruptive pressure is rated from 0 to 10 in the Habitat Assessment Summary for the stream reach. The rating is based on a visual estimate of riparian plant community vigor and the observation of anthropogenic disturbance to riparian vegetation.

The zone of influence habitat measure is a numeric rating of riparian zone width. The presence and condition of riparian vegetation is important to the overall ecological health of the stream and floodplain. This habitat measure also reflects the impact of human activities on the riparian zone. Visual observation of human disturbance is included and the width of riparian vegetation is estimated. Zone of influence is rated from 0 to 10 in the Habitat Assessment Summary for the stream reach.

BURP Stream Macroinvertebrates Assessment

Stream macroinvertebrates were sampled at each of the eight study streams following BURP protocols, using a Hess sampler at 3 riffles for each site. The samples were sorted, identified, and counted by Rhithron according to BURP protocols. Results were analyzed using the DEQ Biological Assessment Tool (BAT) to calculate metrics and the overall Stream Macroinvertebrates Index (SMI) score for each site. The SMI is calculated from 9 metrics and then compared to reference condition values to obtain a condition rating. Metric scores for each macroinvertebrate metric range from 0 to 100. Condition ratings are determined by a comparison of sample data to ecoregional reference conditions, and range from 0 to 3.

BURP Stream Fisheries Assessment

Fisheries data were collected from the eight study streams according to BURP protocols. This sampling includes 100-m single-pass backpack electrofishing with no block nets. Fish were collected, measured and identified, then released back into the stream. The presence of amphibians, especially tailed frogs, was also noted. From this information, the Stream Fisheries Index (SFI) is calculated based on six component metrics:

- Number of coldwater native species
- Percent coldwater individuals
- Percent sensitive native individuals
- Number of coldwater individuals per minute electrofishing
- Number of sculpin age classes
- Number of salmonid age classes

The SFI is calculated differently for forest or rangeland stream types based on bioregion, elevation and stream order. Condition ratings are determined by a comparison of sample data to ecoregional reference conditions, and range from 0 to 3. The SFI also includes a consideration for the presence of

tailed frogs or other native amphibians. These sites were from forest stream types in the Northern Rockies bioregion.

Additional BURP Data

Data collection according to BURP protocols also includes pool counts and measurements of channel dimensions that can be important indicators of physical habitat integrity but are not used in the Stream Habitat Index (Table 6). These analysis included estimates of bank stability, residual pool volume, width/depth ratio, and pool frequency. This information can be evaluated compared to interim Riparian Management Objectives (RMOs) under the Inland Native Fish Strategy (INFISH) (USFS 1995) and other reference information.

In addition to physical habitat measurements included in the BURP Field Manual, stream shade was assessed at six of the sites using Solar Pathfinder digital photograph analysis. Following standard DEQ recommendations, at least ten digital photographs were taken at the center of the stream within the sampling reach to assess effective shade to the stream (Shumar and de Varona 2009). The Solar Pathfinder Assistant software was then used to calculate a six-month average effective shade for each site for April to September.

PIBO Stream Habitat Assessment

Stream habitat data collection for the PIBO Effectiveness Monitoring program included 18 stream habitat variables collected according to program protocols (Heitke et al. 2007, *now Archer et al 2012 footnote?*) and then analyzed using a multimetric approach (Al-Chokhachy et al. 2010). The PIBO-EM field crew visited the same 8 streams sampled with DEQ BURP protocols and selected sites following PIBO-EM standard protocols. Sites were not necessarily in the exact same location on each stream, but were similarly located near the stream's mouth and overlapped in some cases. Stream habitat variables used in PIBO habitat indices included eight metrics: percent fine sediment (<6 mm), D_{50} (mm), percent pools (%), residual pool depth (cm), bank angle (degrees), LWD frequency (#/km), LWD volume (m^3/km), and percent undercut banks (%).

Percent fine sediment is a measure of sediments less than 6mm diameter on the substrate surface in a subset of pool tail-out areas. Measurements were recorded for the wetted, flowing portion of 10 pool tail-out areas using a grid sampling technique. The percent fine sediment was calculated for each pool tail-out and then averaged for the entire reach.

The median particle size, or D_{50} (mm), was determined using a modified Wolman pebble count at channel transects.

The percent of the reach that is comprised of pool habitat was calculated by dividing the length of "primary" pools by the overall reach length. Primary pools are defined as "concave depressions in the streambed bound by a head and tail crest where the thalweg runs through the pool" (Meredith et al. 2012). Further, primary pools must occupy more than half the wetted channel, have a maximum depth at least 1.5 times the tail-out depth, must be as long as it is wide. Pool length is measured along the thalweg.

Residual pool depth (cm) is calculated by subtracting the tail-out depth from the maximum depth of primary pools.

Bank angle (degrees) is determined using a clinometer and rod to measure streambank slope at channel transects. An average bank angle is calculated for the entire reach.

LWD frequency (#/km) is determined by counting the number of large wood pieces at least 1 m long and 0.1 m in diameter within the bankfull channel, then dividing this count by the overall reach length.

LWD volume (m^3/km) is the volume of large wood pieces per kilometer. Large wood pieces are at least 1 m long and 0.1 m in diameter within the bankfull channel.

Percent undercut banks is calculated as the number of transect locations with bank angles less than 90 degrees divided by the total number of transect bank measurements.

Each of these parameters is reported along with an index score and then are combined into an overall habitat index score (Al-Chokhachy et al. 2010, Meredith et al. 2012). In 2011, habitat index score calculation was reduced from eight variables to six with LWD volume and percent undercut banks excluded. This report uses the revised 6-variable index. Additional information needed for the overall PIBO habitat index calculation includes latitude and longitude, gradient, percent federal ownership, catchment area, annual precipitation, elevation, stream density, forested percent of stream segment, slope of stream segment, percent igneous, percent sedimentary, and percent metamorphic geology.

PIBO Stream Macroinvertebrates Assessment

Stream macroinvertebrates were sampled at all 8 streams following standard PIBO-EM protocols (Hawkins et al. 2003, Heitke et al. 2007). Collection methods are slightly different than DEQ BURP protocols, but are similar in the random quantitative sampling of riffle habitats (Table 8). Once samples are collected, they are delivered to a laboratory for sorting and identification. Samples were analyzed and summarized by the BLM/USU National Aquatic Monitoring Center using ten metrics (Karr and Chu 1997). The River Invertebrate Prediction and Classification System (RIVPACS) summary attribute was calculated to provide an index of biological condition (Clarke et al. 1996, Clarke et al. 2003, Moss et al. 1987, Wright et al. 1993 and 2000, Hawkins et al. 2000, Hawkins and Carlisle 2001). This index is based on a predictive model that compares the observed macroinvertebrates at the sample reach to the macroinvertebrates expected at a reference site.

Additional PIBO Data

The PIBO program collects additional data including stream temperature and riparian vegetation information. These are not reported or analyzed in detail in this report because they are not as easily translatable to DEQ's water body assessment guidance based on BURP.

Table 8. Comparison of PIBO and BURP macroinvertebrate sampling.

	PIBO	BURP
Habitat Sampled	Four riffles are sampled beginning with the first riffle (or "fast-water habitat unit") encountered and continuing upstream to the next 3 riffles. If there are less than 4 fast-water habitats, samples may be collected from shallow, slow-water habitat units.	Three separate riffle habitat units are sampled spread evenly through the reach. If there are less than three riffles available for sampling, another habitat type may be sampled. Habitat type is then noted on field forms and labels.
Selection of Sample Location within Habitat	Random	Random
Sample Collection	Two separate 0.09 m^2 fixed-area kick net samples are collected from each unit for a total of 8 samples and 0.74 m^2 per site. Net mesh size is 500 µm.	One sample per riffle is collected using a Hess or Surber sampler. Net mesh size is 500 µm. Hess sampler collects area of 0.086 m^2. Total area sampled per site is 0.26 m^2.
Effort	Careful inspection and cleaning of each stone and disturbance of substrate to depth of about 10 cm until no additional organisms or organic matter are washed into net.	Careful inspection and cleaning of each stone and disturbance of substrate to depth of about 10 cm for 3 to 5 minutes.
Field Processing	Yes (Decanting, filtering, etc.)	No
Sample Preservation	Composite or multiple jars preserved with 95% EtOH.	Composite or multiple jars preserved with 95% EtOH.

Results

BURP Stream Habitat Assessment

Instream cover was rated lowest at East Fork Steamboat Creek and Big Elk Creek as 6 and 9 respectively, corresponding to "10-30% mix of cobble, gravel or other stable fish cover. Cover availability is less than desirable." The remaining six sites ranged from 11 (Skookum Creek and Cougar Gulch) to 14 (Stewart Creek), all corresponding to "30-50% mix of cobble, gravel or other stable fish cover. Adequate cover." The instream metric score was lowest for East Fork Steamboat Creek and highest for Picnic Creek and Stewart Creek; however, none of the sites were highly rated for instream cover. See Appendix F for more detailed summary results of BURP sampling.

The LOD count ranged from 7 at Big Elk Creek and Tepee Creek up to 122 at Yellowdog Creek. The LOD metric scores were low for Big Elk Creek, East Fork Steamboat, and Tepee Creek and were high for Yellowdog, Stewart and Skookum.

Percent fine sediment was relatively low for all eight sites (<11%). Percent fine sediment was lowest (<1%) for Skookum Creek, Yellowdog Creek, and Picnic Creek. Percent fine sediment was highest in Big Elk Creek, but was still well below threshold values often used to gauge sediment impairment. Big Elk Creek, East Fork Steamboat, and Stewart Creek had moderate percent fine sediment metric scores, while the remaining streams received high metric scores indicating very low deposition and accumulation of fine sediment.

Riffle embeddedness at Upper Tepee Creek was rated 10 or "gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment." Picnic Creek and Skookum Creek were rated as "gravel, cobble, or boulder particles are 25-50% surrounded by fine sediment." The remaining streams received high ratings of riffle embeddedness reporting that "gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment." Picnic Creek and Upper Tepee Creek received moderate metric scores for riffle embeddedness, while the remaining streams received high metric scores indicating low embeddedness by fine sediments in riffles.

The number of Wolman particle size classes ranged from 8 to 9 at all eight sites and all received high metric scores, showing a wide range of substrate sizes in riffles.

Channel shape ratings were lowest at 2 for Skookum Creek and Yellowdog Creek and were highest at 7 for Big Elk Creek. All sites had relatively low bank angles and most sites received low metric scores and only Big Elk Creek and Upper Tepee Creek received moderate scores. None were highly rated. In general, channel shape was the lowest scoring metric for this dataset.

There was a wide range in percent bank cover at these eight sites. Percent bank cover was lowest at 20% for Skookum Creek and was highest at 100% for East Fork Steamboat Creek. Bank cover at Skookum Creek was low enough to receive a metric score of 0. Scores for Stewart Creek and Cougar Gulch were also low. Upper Tepee Creek was moderately rated and the remaining streams were highly rated for percent bank cover.

Percent canopy cover ranged from 23% at Big Elk Creek to 88% at Picnic Creek. Stewart Creek, Skookum Creek, and Big Elk Creek received low metric scores while Picnic Creek received a high metric score. The remaining streams received moderate scores for percent canopy cover.

Disruptive pressures at Big Elk Creek and Yellowdog Creek received moderate ratings of 4 and 5 respectively, or "disruption obvious; some patches of bare soil or closely cropped vegetation present. 30-60% of potential plant biomass remains." Skookum Creek was also moderately rated, though slightly higher on the range. The remaining five streams were highly rated for disruptive pressures, indicating little disruption from human activities in the riparian zone. Metric scores are the same value as ratings for this metric.

Zone of influence had moderate ratings for Big Elk Creek, Yellowdog Creek, Stewart Creek and Skookum Creek with a "width of riparian vegetative zone (on each side)... at least twice the width of the stream. Human activities have caused minimal impact." The remaining streams had high ratings. Metric scores are the same value as ratings for this metric.

Individual SHI metric scores range from 1 to 10 with 10 representing the best water quality, and the multimetric Stream Habitat Index (SHI) score is generated from the sum of individual metric scores for each site. The SHI score for these eight sites ranged from 57 at Big Elk Creek to 73 at Picnic Creek (Table 9, Figure 22). These scores are compared to reference condition values to obtain a condition rating. Big Elk Creek was rated a value of 1 or below the 10th percentile of reference condition. Upper Tepee Creek, Yellowdog Creek, Stewart Creek, and Skookum Creek were rated 2 or 10th to 25th percentile of reference condition. The highest habitat quality was found in Cougar Gulch, East Fork Steamboat Creek, and Picnic Creek with ratings of 3 or above the 25th percentile of reference condition.

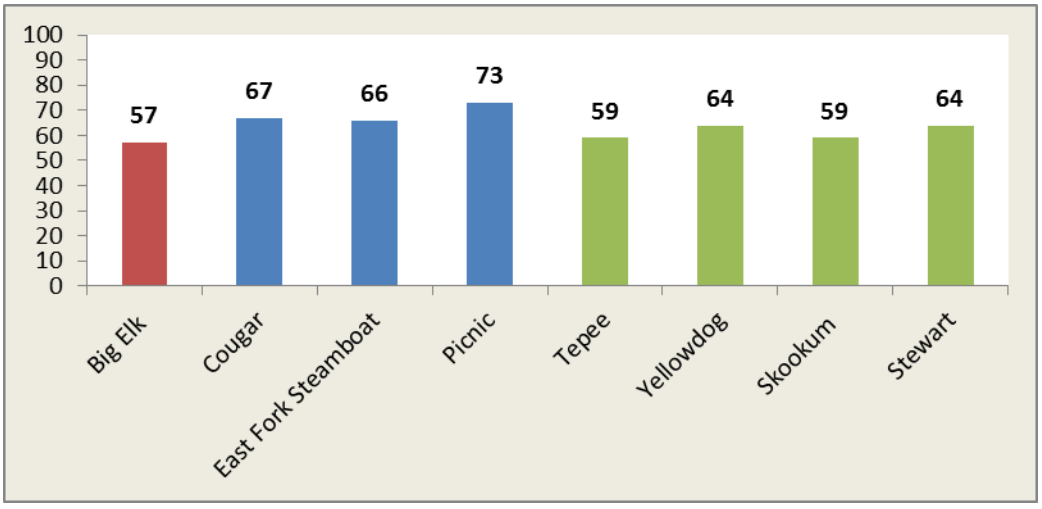


Figure 22. Stream habitat metric scores and DEQ Stream Habitat Index (SHI) ratings from North Fork Coeur d'Alene River Subbasin sites in 2009.

Table 9. Stream habitat metric scores and DEQ Stream Habitat Index (SHI) ratings from North Fork Coeur d'Alene River Subbasin sites in 2009.

Metric Scores	*Big Elk*	*Cougar*	*East Fork Steamboat*	*Picnic*	*Tepee*	*Yellowdog*	*Stewart*	*Skookum*
Instream Cover	5	6	3	7	6	6	7	6
Large Organic Debris	2	6	3	5	2	10	10	10
Percent Fine Sediment	6	9	7	10	8	10	7	10
Riffle Embeddedness	10	9	8	6	5	9	9	8
Wolman Size Classes	8	8	9	9	9	9	9	8
Channel Shape	5	1	2	1	4	1	3	1
Percent Bank Cover	8	3	10	8	5	8	1	0
Percent Canopy Cover	2	7	6	9	4	6	3	3
Disruptive Pressures	4	9	9	9	8	5	9	7
Zone of Influence	7	9	9	9	8	6	6	6
Overall SHI Score	**57**	**67**	**66**	**73**	**59**	**64**	**64**	**59**
Overall SHI Condition Rating	**1**	**3**	**3**	**3**	**2**	**2**	**2**	**2**

BURP Stream Macroinvertebrates Assessment

The SMI reported by BAT ranged from 74 at Upper Tepee Creek to 83 at Picnic Creek (Table 10, Figure 23). The SMI condition ratings for all eight sites were each 3 out of a possible 3, and were above the 25th percentile of reference conditions.

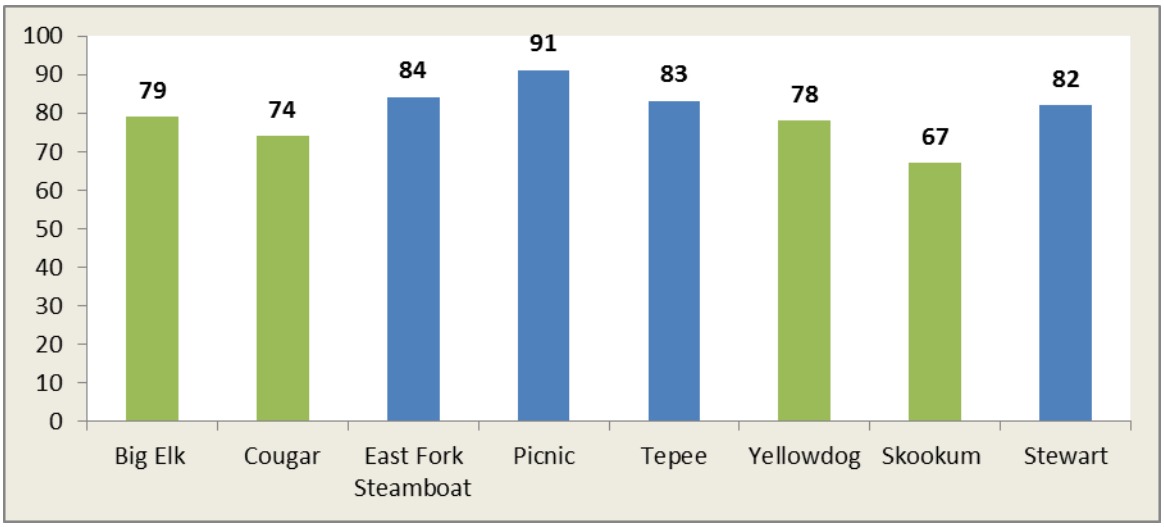


Figure 23. Stream macroinvertebrate metric scores and DEQ Stream Macroinvertebrate Index (SMI) ratings from North Fork Coeur d'Alene River Subbasin sites in 2009.

Table 10. Stream macroinvertebrate metrics and DEQ Stream Macroinvertebrate Index (SMI) scores from North Fork Coeur d'Alene River Subbasin sites in 2009.

Metric Scores	*Big Elk*	*Cougar*	*EF Steamboat*	*Picnic*	*Tepee*	*Yellowdog*	*Skookum*	*Stewart*
Total Taxa	100	95	100	100	95	85	100	87
Ephemeroptera Taxa	77	77	85	69	54	54	62	54
Plecoptera Taxa	60	70	70	100	80	70	70	60
Trichoptera Taxa	70	80	90	90	90	100	100	80
Percent Plecoptera	58	40	58	85	35	30	100	83
Hilsenhoff Biotic Index (HBI)	85	47	55	56	55	56	62	60
Percent 5 Dominant Taxa	100	88	96	81	71	100	67	85
Scraper Taxa	75	100	100	88	100	100	75	88
Clinger Taxa	96	100	100	100	100	100	100	96
Overall SMI Score (From BAT)	**76**	**76**	**82**	**83**	**74**	**75**	**79**	**75**
Overall SMI Condition Rating	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

Note: Metric values reported in Table 3 are based on hand calculations rather than BAT outputs since BAT does not report individual metrics. Because the SMI cannot be independently calculated, these scores must be considered estimates. The SMI score is from the BAT output.

BURP Stream Fisheries Assessment

Westslope cutthroat trout, sculpin, brook trout, rainbow trout, and longnose dace were collected (Table 11). The SFI ranged from 67 in Skookum Creek to 91 in Picnic Creek. Four streams were rated 2 or between the 25th percentile and median of reference condition, and four streams rated 3 or above the median of reference condition (Table 12, Figure 24).

Table 11. Electrofishing data for 8 North Fork Coeur d'Alene River Subbasin sites sampled in 2009.

	Big Elk	*Cougar*	*East Fork Steamboat*	*Picnic*	*Tepee*	*Yellowdog*	*Skookum*	*Stewart*
Effort (s)	1,731	2,433	1,074	771	1,298	1,387	4,568	3,082
Area (100 m^2)	3.5	5.8	5.6	2.4	4.7	3.9	5.5	4.3
Westslope Cutthroat Trout	12	0	5	26	31	9	1	20
Sculpin	202	243	237	149	40	60	386	175
Brook Trout	0	33	0	0	0	0	0	0
Rainbow Trout	0	0	1	0	0	0	0	0
Longnose Dace	0	0	1	0	0	3	0	0
Total Fish Collected	214	276	244	175	71	72	387	195

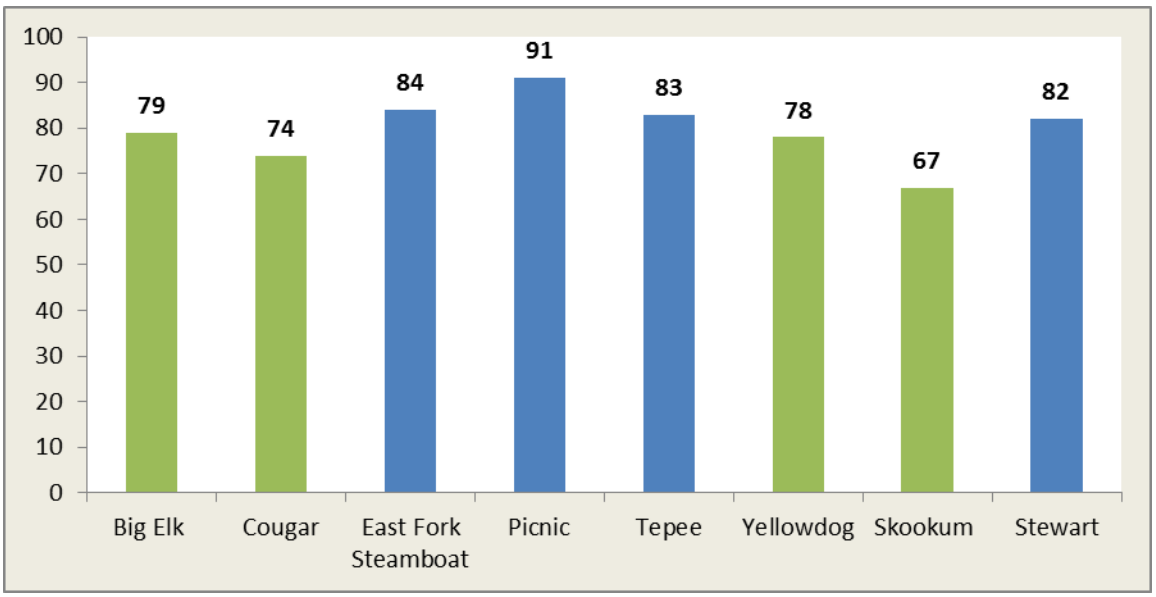


Figure 24. Stream fisheries metric scores and DEQ Stream Fisheries Index (SFI) ratings from North Fork Coeur d'Alene River Subbasin sites in 2009.

Table 12. Stream fisheries metric scores and DEQ Stream Fisheries Index (SFI) ratings from North Fork Coeur d'Alene River Subbasin sites in 2009.

Metric Scores	*Big Elk*	*Cougar*	*EF Steamboat*	*Picnic*	*Tepee*	*Yellowdog*	*Skookum*	*Stewart*
Number of Coldwater Native Species	100	50	100	100	100	100	100	100
Percent Coldwater Individuals	100	100	98.8	100	100	87.4	100	100
Percent Sensitive Native Individuals	22	1	11	49	90	42	3	36
Number of Coldwater Individuals per Minute	100	100	100	100	58	50	71	100
Number of Sculpin Age Classes	100	100	100	97.5	100	97.5	97.5	92.5
Number of Salmonid Age Classes	50	92.5	97.5	75	50	92.5	5	75
Overall SFI Score (From BAT)	**79**	**74**	**84**	**91**	**83**	**78**	**67**	**82**
Overall SFI Condition Rating	**2**	**2**	**3**	**3**	**3**	**2**	**2**	**3**

Note: Metric scores reported in Table 5 are based on hand calculations rather than BAT outputs because the SFI cannot be independently calculated. Therefore, these scores must be considered estimates. The SFI score is from the BAT output.

Additional BURP Habitat Data

Pools are a very important habitat feature for westslope cutthroat trout native to these streams. Pool frequency ranged from 41 pools per km at Cougar Gulch to 104 pools per km in Yellowdog Creek (Table 13). These values can be compared to minimum targets for pool frequency based on wetted width from the Inland Native Fish Strategy interim RMOs (USFS 1995). All streams exceeded those minimum targets for pool frequency except for Big Elk Creek and Stewart Creek which were 82% and 88% of the targets respectively.

Table 13. Summary of additional stream physical habitat information from North Fork Coeur d'Alene River Subbasin sites in 2009 with INFISH targets.

	Big Elk	*Cougar*	*EF Steamboat*	*Picnic*	*Tepee*	*Yellowdog*	*Skookum*	*Stewart*
Stable Banks (%)	74	98	98	91	42	93	75	50
Wetted Width (m)	3.5	5.8	5.6	2.4	4.7	3.9	5.5	4.3
Wetted Depth (m)	0.31	0.35	0.15	0.16	0.14	0.14	0.08	0.11
Actual Wetted Width/Depth	11	17	37	15	34	28	69	39
Target Wetted Width/Depth	<10	<10	<10	<10	<10	<10	<10	<10
Width/Depth Index	1	2	4	2	3	3	7	4
Actual Pool Frequency (#/km)	49	41	61	100	49	104	61	53
Target Pool Frequency (#/km)	60	35	35	60	35	60	35	60
Pool Frequency % of Target	82	116	173	167	139	174	173	88
Bankfull Width (m)	5.3	9.2	7.0	4.0	5.4	10.0	10.1	6.0
Residual Pool Volume (m^3/km)	1,400	3,443	322	222	486	3,086	225	942

Four representative pools were selected for further measurements of width, length, depth, substrate and cover characteristics. From these data, residual pool volume can be calculated. Residual pool volume is the volume of water held in pools if the stream were to reach zero discharge conditions. This can make a useful comparison to other streams and reference conditions as an indicator of habitat quality. Estimates of residual pool volume ranged from 222 m^3/km in Picnic Creek to 3,443 m^3/km in Cougar Gulch. Interestingly, Picnic Creek had relatively high pool frequency but relatively low residual pool volume while Cougar Gulch had relatively low pool frequency but relatively high residual pool volume. In other words, Picnic Creek had many small pools while Cougar Gulch had few and larger pools. These data can be compared to reference data contained in the 2001 Subbasin Assessment and Total Maximum Daily Loads of the North Fork Coeur d'Alene River Subbasin (DEQ 2001), but a small sample size of reference values makes meaningful comparisons difficult (Table 14).

Table 14. Estimated residual pool volume from North Fork Coeur d'Alene River Subbasin reference streams (DEQ 2001) for comparison to 2009 sample data.

	NF Coeur d'Alene	*Independence*	*Buckskin*	*Spruce*
Bankfull Width (m)	7.3	6.2	3.8	2.4
Residual Pool Volume (m^3/km)	722	1,402	428	336

Width to depth ratios are also an important measure of a stream's physical habitat integrity. High width to depth ratios are associated with overwidened streams associated with instability of the bed and banks and excessive sediment loading. Interim RMOs under the Inland Native Fish Strategy (USFS 1995) contain a minimum target for wetted width to depth ratio. The desired wetted width to depth ratio is less than 10. Wetted width to depth ratios ranged from 11 at Big Elk Creek to 69 at Skookum Creek. Big Elk Creek was the only stream to nearly meet the target. The remaining streams were approximately 2 to 7 times higher than the target. This can indicate overwidened channels. Despite the possibility of overwidened channels, bank stability was high for nearly every site. Only Upper Tepee Creek and Stewart Creek had 50% or less stable banks. The remaining sites had 74 to 98% stable banks.

Average stream shade results ranged from 27% at Big Elk Creek and Upper Tepee Creek to 84% at Picnic Creek (Table 15). These results were very similar to canopy cover estimates obtained during BURP monitoring with a spherical densiometer.

Table 15. Shade and canopy cover estimates for North Fork Coeur d'Alene River Subbasin sites in 2009.

	Big Elk	*Cougar*	*EF Steamboat*	*Picnic*	*Tepee*	*Yellowdog*	*Skookum*	*Stewart*
Six-Month Average Shade (%)	27	70	63	84	27	60	--	--
BURP Canopy Cover (%)	23	61	55	88	34	50	29	26

PIBO Stream Habitat Assessment

Stream habitat assessments by PIBO found LWD frequency ranged from 36 per km in Tepee Creek up to 342 per km in Stewart Creek. None of the streams were very high in LWD frequency. Percent fine sediment ranged from 5 percent in Tepee Creek to 16 percent in Cougar Gulch. Median particle size was 39 mm in Tepee Creek ranging up to 79 mm in East Fork Steamboat Creek. Nearly all streams were rated

relatively high for median particle size (Table 16). Average bank angle was highest in Yellowdog Creek (140 degrees) and lowest in Big Elk Creek (81 degrees). Yellowdog Creek was rated low for its high bank angle. Percent pools were only 6 percent in East Form Steamboat and as much as 80 percent in Big Elk Creek. Big Elk and Yellowdog Creek were rated high for percent pools. Cougar Gulch, East Fork Steamboat, Picnic and Skookum creeks all scored low for percent pools. East Fork Steamboat and Skookum creeks were both rated zero for percent pools. Residual pool depth was 0.25 m in Picnic Creek and up to .64 m in Cougar Gulch. Lowest metric scores for residual pool depth were found in Picnic Creek and Tepee Creek. When habitat metrics were integrated into the overall habitat index score, Skookum Creek was rated lowest (46) and Big Elk Creek was rated highest (85). Tepee Creek and Stewart Creek were also rated relatively highly (Figure 25).See Appendix G for more detailed summary of PIBO sampling results.

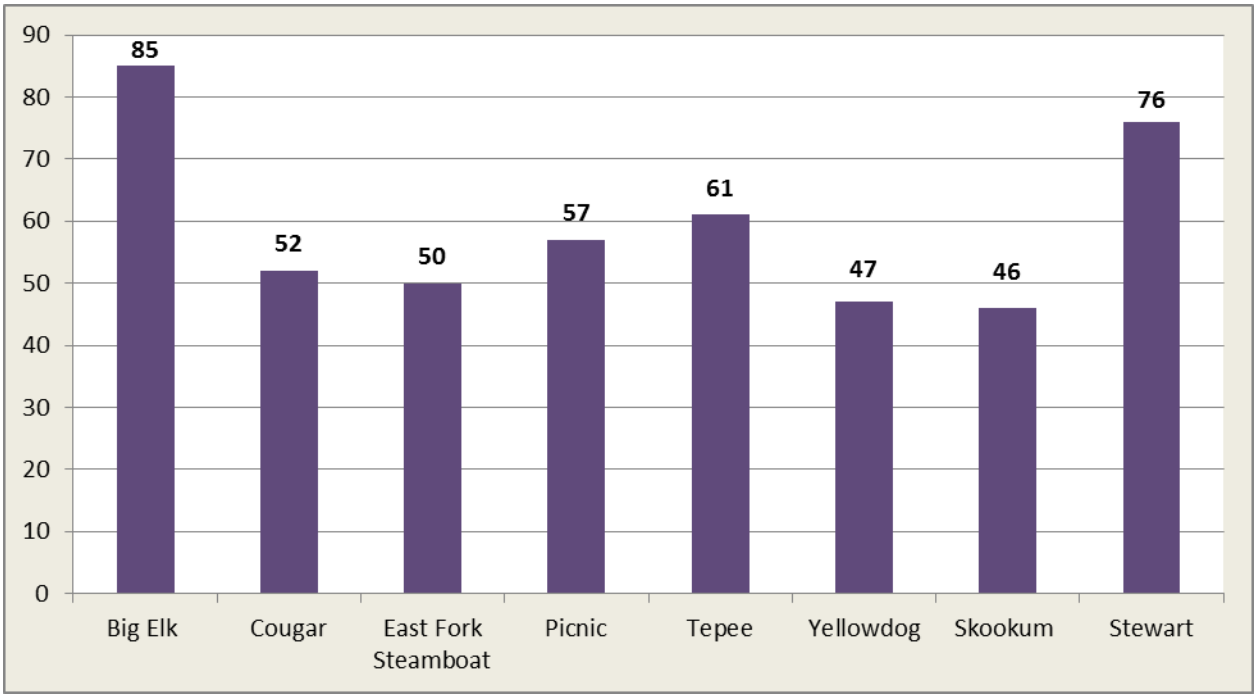


Figure 25. Stream habitat data and PIBO Stream Habitat Index (PHI) scores from North Fork Coeur d'Alene River Subbasin sites in 2009.

Table 16. Stream habitat metrics and PIBO Stream Habitat Index (PHI) scores from North Fork Coeur d'Alene River Subbasin sites in 2009.

Metric Scores	*Big Elk*	*Cougar*	*EF Steamboat*	*Picnic*	*Tepee*	*Yellowdog*	*Stewart*	*Skookum*
Large Woody Debris Frequency	7	4	5	7	2	6	7	6
Percent Fine Sediment	8	5	8	8	9	4	9	6
D50	10	9	9	7	9	4	9	8
Bank Angle	10	4	6	9	8	1	8	7
Percent Pools	8	3	0	2	7	10	4	0
Residual Pool Depth	5	8	5	3	3	7	5	5
Overall PHI Score	**85**	**52**	**50**	**57**	**61**	**47**	**76**	**46**

PIBO Stream Macroinvertebrates Assessment

We used the USFS PIBO observed/expected (O/E) index to assess biological condition of sampled sites. O/E models compare the macroinvertebrate taxa observed at sites of unknown biological condition (i.e., 'test sites') to the assemblages expected to be found in the absence of anthropogenic stressors (see Hawkins et al. 2000 for details). The PIBO O/E model is based on 201 reference sites (174 calibration and 27 randomly selected validation sites) grouped into ten distinct classes based on the similarity of macroinvertebrate assemblage composition among sites following the standard methods of Hawkins et al. (2000) and described in detail within the EMAP-West statistical summary (Stoddard et al. 2005). The expected class membership and subsequent reference macroinvertebrate assemblage (E) for comparison to test sites is predicted by linear discriminant function models using watershed area, 30-year average monthly maximum air temperature and the 30-year average precipitation for the 12 months prior to a standardized sample collection date of July, both derived from PRISM estimates. Prior to computing O/E scores, data for all test sites was standardized to the operational taxonomic units and re-sampled to a 300 fixed-count. Following the recommendations of Hawkins et al. (2000), O/E scores were calculated for taxa having a probability of capture ≥ 0.5 to increase the precision of O/E estimates and subsequent model sensitivity to stressors. Biological condition was subsequently assessed based on the precision of the 27 validation sites (mean =0.95, standard deviation (SD) = 0.16), with test sites scoring less than one SD below the mean of reference sites in "Good" biological condition (i.e. comparable to reference conditions); sites scoring between one SD and two SD in "Fair" biological condition; and sites scoring more than two SD below the mean of reference sites in "Poor" biological

condition. For the PIBO O/E model, the minimum count required for computing an O/E score is 200 individuals. Samples with less than 200 individuals are not given a condition rating.

Rating of "Good", "Fair", or "Poor" based on O/E score relative to the distribution of scores for reference sites (WMC, Hawkins et al 2000, Stoddard et al 2006). Samples with less than the required number of organisms are given an NA or "Null" rating because they did not meet model requirements. A "Poor" rating should receive additional analysis or sampling before classifying the sites as impaired. >Mean±2SD = "Poor", >Mean±1SD = "Fair", <Mean±1SD = "Good". This field indicates whether or not the site's habitat variables were within the range of experience of the model. A fail ("F") indicates the model had to extrapolate, rather than interpolate, to accommodate one or more of the habitat variables. O/E scores and condition ratings should be interpreted cautiously if a site failed the model.

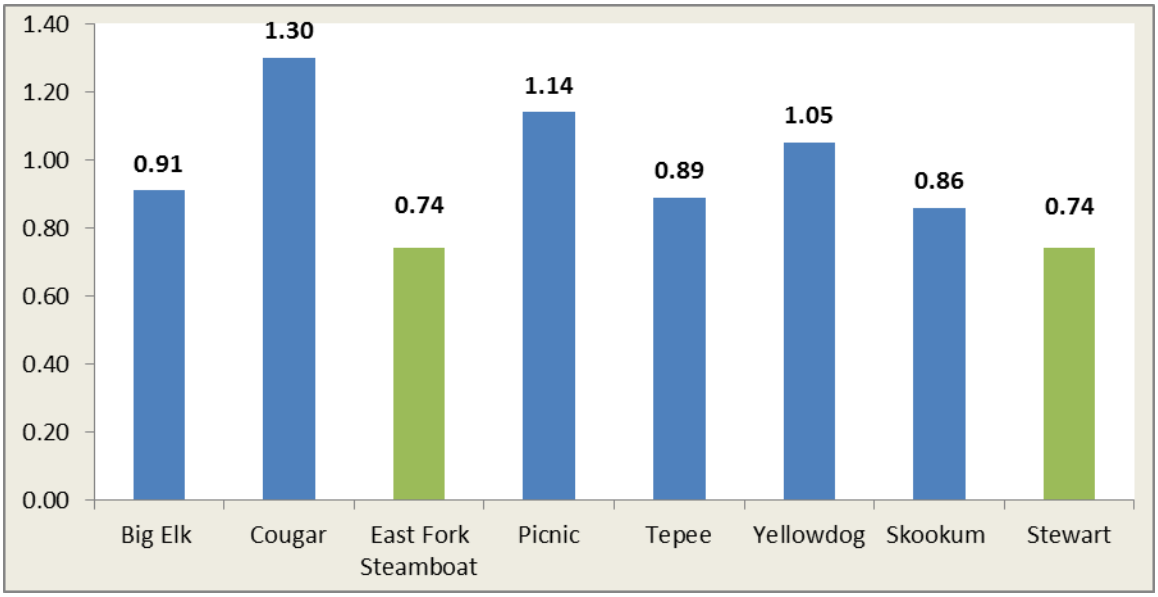


Figure 26. Stream macroinvertebrates O/E ratings from North Fork Coeur d'Alene River Subbasin sites in 2009. Blue columns indicate O/E greater than 0.8. Green columns indicate O/E less than 0.8.

Table 17. Stream macroinvertebrates metrics and O/E ratings from North Fork Coeur d'Alene River Subbasin sites in 2009.

Data	*Big Elk*	*Cougar*	*EF Steamboat*	*Picnic*	*Tepee*	*Yellowdog*	*Skookum*	*Stewart*
Total Taxa	39	60	53	50	30	27	40	49
Ephemeroptera Taxa	13	11	13	9	13	6	9	9
Plecoptera Taxa	6	10	8	11	4	2	9	9
Trichoptera Taxa	7	14	12	7	2	8	7	10
Percent Plecoptera								
Hilsenhoff Biotic Index (HBI)								
Percent 5 Dominant Taxa								
Scraper Taxa	7	8	7	5	8	5	5	8
Clinger Taxa	20	28	27	19	16	14	18	20
Long-lived Taxa	7	12	7	6	5	2	4	4
Community Tolerance Quotient								
Intolerant Taxa	15	22	21	18	11	11	17	18

	Big Elk	*Cougar*	*EF Steamboat*	*Picnic*	*Tepee*	*Yellowdog*	*Skookum*	*Stewart*
O/E	0.91	1.3	0.74	1.1	0.89	1.0	0.86	0.74
Rating	Good	Good	Fair	Good	Good	Good	Good	Fair

All 8 streams sampled had macroinvertebrates results within the range of experience for the model and did not need to be extrapolated. Therefore, an O/E value was reported with confidence. The macroinvertebrates O/E ratio ranged from 0.74 in East Fork Steamboat and Stewart creeks to 1.13 in Picnic Creek (Table 17). Six streams exceeded 0.8 and were rated "Good" compared to reference conditions while two streams had an O/E of 0.7 and were rated "Fair" (Figure 26). Typically, an O/E less

than 0.8 may indicate impaired conditions; however, East Fork Steamboat and Picnic creeks results were within one standard deviation of the mean and were rated fair.

Discussion

Extensive watershed restoration activities took place in these eight subwatersheds of the North Fork Coeur d'Alene River Subbasin. Modeling suggested sediment load reductions have been substantial, but field verification was needed to demonstrate the effectiveness of restoration BMPs and whether sediment load reductions resulted in streams attaining full support of cold water aquatic life. Bioassessment results from BURP and PIBO can be used to determine whether cold water aquatic life is fully supported in these streams (Table 18). Habitat, macroinvertebrate, and fish data from all eight streams indicate full support of cold water aquatic life. Following Idaho's Small Stream Ecological Assessment Framework and the Water Body Assessment Guidance, 2nd edition, three multimetric index scores are calculated from BURP data to assess support of cold water aquatic life (Grafe et al. 2002, DEQ 2002). Scores for stream habitat, macroinvertebrates, and fish calculated from BURP data in each of the eight streams were relatively high compared to reference conditions in the forested northern Rocky Mountains (Figure 27).

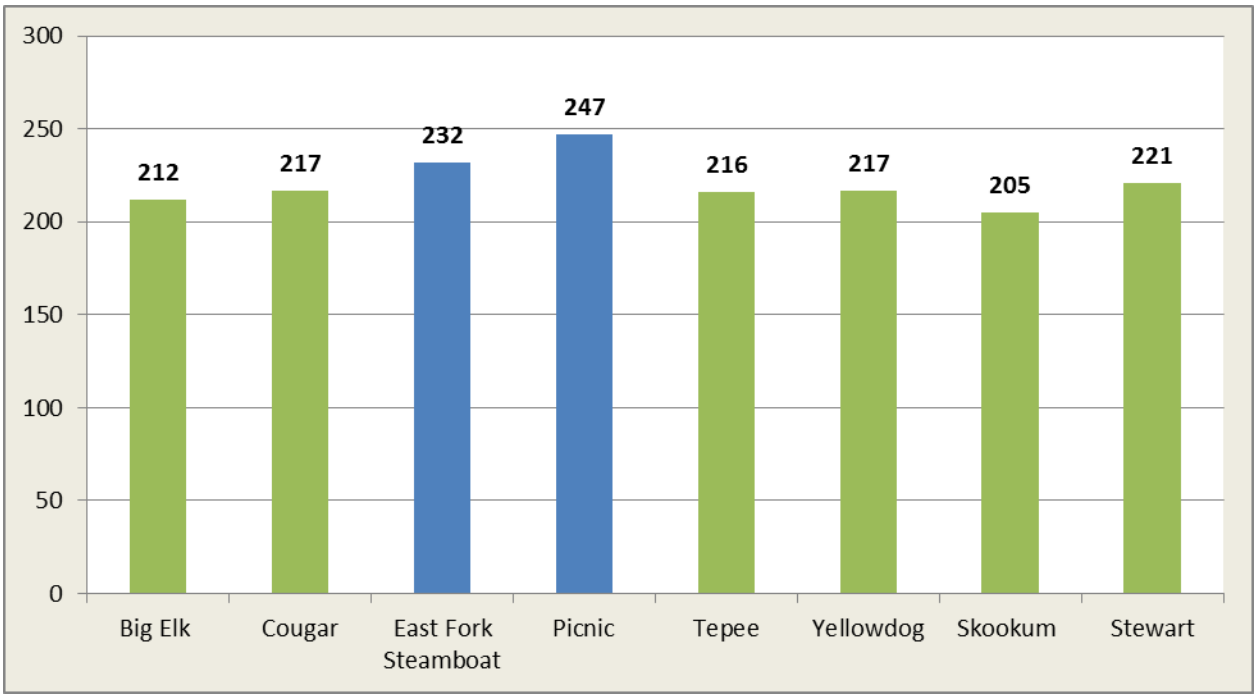


Figure 27. Combined bioassessment scores and overall ratings from 2009 BURP data. Blue columns indicate streams with combined average scores of 3. Green columns indicate streams with combined average scores between 2 and 3.

Table 18. Summary of BURP and PIBO bioassessment results for assessments.

	Big Elk	*Cougar*	*EF Steamboat*	*Picnic*	*Tepee*	*Yellowdog*	*Skookum*	*Stewart*
BURP Stream Habitat Index	57	67	66	73	59	64	64	59
BURP Stream Macroinvertebrates Index	76	76	82	83	74	75	79	75
BURP Stream Fisheries Index	79	74	84	91	83	78	67	82
PIBO Stream Habitat Index	85	52	50	57	61	47	46	76
PIBO Macroinvertebrates O/E	0.91	1.3	0.74	1.1	0.89	1.0	0.74	0.86

Evaluating PIBO Bioassessment Data for Water Body Assessments

This study also evaluated how USFS/BLM PIBO bioassessment frameworks can be used to assess beneficial use support. It appears that PIBO data can be used for assessment, but with difficulty and quite a bit of professional judgment. We determined that PIBO data were of sufficient data quality and scientific rigor according to the Idaho Water Body Assessment Guidance, 2nd edition. This was based on available quality assurance and quality control plans and protocols, the peer-reviewed publications produced from the data, and the use of these data to evaluate federal land management agencies' compliance with a major biological opinion.

Bioassessment data from the PIBO program contains more than one data type as recommended in DEQ guidance. Both macroinvertebrates and habitat data are available. Fisheries data could be obtained through supplementary electrofishing either by the PIBO field crews or local field crews through local coordination. These data would potentially strengthen water quality assessments.

Despite their many similarities, BURP multimetric index scores cannot be calculated from PIBO data. This is partially because the PIBO program does not collect all of the information needed. BURP multimetric index scores cannot be calculated because descriptions are not detailed enough to facilitate calculating scores from outside data. It's not currently possible to calculate BURP multimetric index scores independently outside of DEQ database applications. As Idaho's bioassessment indices and assessment

guidance documents are revised, it would be helpful for many reasons to make it possible to independently calculate BURP multimetric index scores. This could enable collection of BURP-compatible data and calculation of multimetric index scores by others outside the agency, could enable collection of BURP compatible data by DEQ staff outside of the regular BURP program, and would provide important quality checks of the data and assessment process.

BURP protocols are well described in BURP manuals and workplans, but the steps between data collection and index score reporting are not well documented. The detailed information necessary to compare even simple macroinvertebrate data, such as taxa richness, is not available due to a lack of published taxonomic resolution used in the index. Other issues include a lack of standardized values for metrics such as the Hilsenhoff Biotic Index. If calculated consistently by a single laboratory using a standard set of pollution tolerance values, this is not a problem. However, different laboratories often apply different pollution tolerance values and may report significantly different values for HBI and can affect the assessment outcome. We recommend clearly documenting each step to enable standardized independent reproduction of multimetric index scores.

Several steps could be taken that would make water body assessments more simple and facilitate a more widespread use of PIBO data for assessments in Idaho. Having a set of guidance available for assessors would be helpful and would help ensure assessment decisions are objective and defensible. Additional information would be helpful wherever gaps occur between the two programs. For example, PIBO does not collect fisheries data directly, but this could be supplemented with electrofishing data. The two programs have a very similar definition of reference condition; however, it is not clear how to put the PIBO data into context with an appropriate reference condition similar to the approach used in Idaho's Small Stream Ecological Assessment Framework. It would be helpful, for example, to produce a range of PIBO habitat index scores for Idaho northern rocky mountain forested streams and to compare sample data to a percentile of reference condition.

Finally, it may be possible for USFS and/or BLM to perform water quality assessments on the PIBO data and report those assessment outcomes and conclusions to DEQ assessors. If these conclusions are well supported, current guidance allows DEQ assessors to consider using this information.

Conclusions

Restoration efforts in the North Fork Coeur d'Alene River Subbasin have established watersheds that are stable and more resilient to rain on snow flood events, and other land management disturbance. The restoration reduced sediment loads to streams previously considered impaired by sediment, and achieved the goals of the sediment TMDLs. Modeling and bioassessment results, combined with field evaluation of BMPs, demonstrate attainment of water quality goals. The eight pilot streams evaluated are not impaired by sediment and four were proposed for sediment delisting.

The attainment results are important to validate IPNF investments in watershed restoration activities where approximately $7 million was expended since 1990, excluding CERCLA-related funds. The techniques and strategies employed by the IPNF in the North Fork Coeur d'Alene River Subbasin have largely been successful. If these trends in restoration continue, and adequate data can be collected to demonstrate results, many more water bodies can be expected to attain water quality goals and full support of cold water aquatic life.

Additionally, there is great potential to use data from the PIBO Effectiveness Monitoring Program to increase the capability of DEQ water body assessments in Idaho. Though the PIBO data cannot be used to generate DEQ's standard set of multimetric indices, the extensive datasets are highly similar to DEQ's BURP program. Many of the same pieces of data are collected with slight variations and the PIBO program employs high scientific rigor. Currently, the PIBO data can be used for Idaho water body assessment with some difficulty and professional judgment. This could be made more straightforward by establishing a context of reference conditions for the outside data similar to DEQ's BURP program and assessment framework. The data could also be analyzed and assessment results reported to DEQ with supporting evidence and documentation.

Several recommendations came from this study. With regard to phase 1 modeling, the most important issue is reproducibility of models. The initial TMDL sediment model could not be reproduced due to missing data and lack of enough detail in model descriptions. The model used in this study cannot be easily reproduced because the Timber Stand Record Management System (TSRMS) database used in the model is no longer supported by the USFS. We recommend careful attention to data sources and detailed documentation of models to ensure reproducibility. Reproducibility is especially important for studies such as these that must demonstrate load reductions associated with management changes.

Our results can be used to consider appropriate targets for sediment TMDLs. The original sediment TMDLs for this subbasin were established at an estimated 1.5 times natural background. Field observations and bioassessments found full support in all 8 watersheds assessed although modeled sediment loads ranged from 1.41 to 2.42 times natural background. This could be due to difficulty accurately estimating sediment loads and local variability in site conditions. It could also be related to unusual weather and flow conditions. Large flow events (e.g., greater than a 25-yr flood event) tend to be associated with bioassessment findings of impairment. It could be that conditions with sediment loads modeled at 1.5 times natural background are more resilient to these events and recover more

quickly than watersheds with higher estimated sediment loads. If this is the case, 1.5 times natural background may remain an appropriate target and care should be taken to consider hydrologic regimes and timing of sampling.

Recommendations associated with BMPs evaluation of phase 2 include:

1. Measure floodplain widths in all road inventories before restoration. On all channels, remove fill in the floodplain, and require that construction and shaping of floodplains match areas above and below the channel structure removal site.
2. Install additional grade control structures with a recommended increase of up to 5 times. Require log or rock grade control, but allow for shrubs or a combination of materials between the more stable log or rock grade control structures.
3. Provide individuals trained in watershed restoration techniques to inspect road decommissioning activity associated with timber, mining or engineering projects.

Recommendations for bioassessment include interagency cooperation to improve water body assessments, availability of data, and enhance water body assessment guidance in Idaho. There may be opportunities to strengthen the DEQ habitat and fisheries indices. For example, pool quality and frequency are not part of BURP Habitat Index despite strong pool-salmonid density relationships. We also recommend interagency coordination to further develop procedures for the use of Tier 1 data in water body assessments in Idaho. This could facilitate DEQ's use of outside data and expand the datasets available for future water body assessments.

This project can serve as a template that can be used in the Idaho Panhandle and beyond to achieve and document tangible improvements to water quality. We hope to perform the same evaluation of two other sediment-impaired streams in this subbasin: Cub Creek and Calamity Creek. Collaboration was a key element to this project's success. Funding and staff support from the three lead agencies (EPA, USFS, and DEQ) was crucial for this project to happen and for the delisting proposals for our success stories. We hope these successes can be repeated widely as restoration is completed and water quality improves.

Acknowledgements

We appreciate the leadership and effort provided by Ed Lider throughout this project. We also appreciate the assistance and GIS expertise provided by Dave Funk in phase 1 of the project. Thanks are due to colleagues at DEQ, USFS, and EPA for supporting the project. We especially thank Don Martin, Leigh Woodruff, Jayne Carlin, and Eric Monschein of EPA; Dan Scaife, Dave Funk, Lisa Dosch, and Tom Burke of USFS-IPNF; and Tom Herron, Robert Steed, Tyson Clyne and Jason Pappani of DEQ. Staff from the PIBO Effectiveness Monitoring Program including Eric Archer and Brett Roper were important partners. Kary Phillips of TetraTech provided key assistance in preparation of Success Stories reports. Finally, we'd like to recognize the North Fork Coeur d'Alene Watershed Advisory Group (WAG) for initiating this effort, providing feedback all the way through, and for supporting water quality improvements in this important watershed.

References

Al-Chokhachy, R., B.B. Roper, and E.K. Archer. 2010. Evaluating the Status and Trends of Physical Stream Habitat in Headwater Streams within the Interior Columbia River and Upper Missouri River Basins Using an Index Approach. Transactions of the American Fisheries Society 139:1041-1059.

Archer, Eric K.; Scully, Rebecca A.; Henderson, Richard; Roper, Brett B. and Heitke, Jeremiah D. 2012. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. Unpublished paper on file at: http://www.fs.fed.us/biology/fishecology/emp.

Coles-Ritchie, M. 2006. Effectiveness Monitoring for Streams and Riparian Areas Within the Upper Columbia River Basin Sampling Protocol, Vegetation Parameters. U.S.D.A. Forest Service, PIBO Effectiveness Monitoring Program, Logan, UT.

Cook, C. and A. Dresser. 1999. Erosion and Channel Adjustments Following Forest Road Decommissioning, Six Rivers National Forest. *in* M Furniss, C Clifton, and K Ronnenberg, eds., 2007. Advancing the Fundamental Sciences: Proceedings of the Forest Service National Earth Sciences Conference, San Diego, CA, 18-22 October 2004, PNWGTR-689, Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Clarke, R.T., M.T. Furse, J.F. Wright, and D. Moss. 1996. Derivation of a biological quality index for river sites: comparison of the observed with the expected fauna. Journal of Applied Statistics 23:311-332.

Clarke, R.T., J.F. Wright, M.T. Furse. 2003. RIVPACS models for predicting the expected macroinvertebrate fauna and assessing the ecological quality of rivers. Ecological Modeling 160:219-233.

DEQ (Idaho Department of Environmental Quality). 2001. Subbasin Assessment and Total Maximum Daily Loads of the North Fork Coeur d'Alene River. Idaho Department of Environmental Quality, Boise, ID.

DEQ (Idaho Department of Environmental Quality). 2002a. Idaho Small Stream Ecological Assessment Framework. Idaho Department of Environmental Quality, Boise, ID.

DEQ (Idaho Department of Environmental Quality). 2002b. Idaho River Ecological Assessment Framework. Idaho Department of Environmental Quality, Boise, ID.

DEQ (Idaho Department of Environmental Quality). 2007. Beneficial Use Reconnaissance Program Field Manual for Streams. Prepared by Beneficial Use Reconnaissance Program Technical Advisory Committee. Idaho Department of Environmental Quality, Boise, ID.

DEQ (Idaho Department of Environmental Quality). 2008. Fish Creek Watershed Assessment and Total Maximum Daily Loads. . Idaho Department of Environmental Quality, Boise, ID.

Dietrich, W.E. and T. Dunne. 1993. The Channel Head. *in* Beven, K. and M.J. Kirkby (Eds), Channel Network Hydrology. Wiley, Chichester. Pp. 175-219.

Dupont, J., E. Lider, M. Davis, and N. Horner. 2008. Movement, Mortality, and Habitat Use of Coeur d'Alene River Cutthroat Trout, Panhandle Region, 2004. Idaho Department of Fish and Game Fishery Management Annual Report. IDFG 07-57.

Foltz, R.B., K.A. Yanosek, and T.M. Brown. 2008. Sediment Concentration and Turbidity Changes During Culvert Removals. Journal of Environmental Management. Vol. 87, No. 3, pp. 329-340.

Grafe, C.S., C.A. Mebane, M.J. McIntyre, D.A. Essig, S.H. Brandt, and D.T. Mosier. 2002. Water Body Assessment Guidance, 2nd Edition. Idaho Department of Environmental Quality, Boise, ID.

Hall, F.C. 2002. Photopoint monitoring handbook: Part A-Field procedures. USDA Forest Service, Pacific Northwest Research Station, PNW-GTR-526. Portland, OR.

Hawkins, C.P. and D.M. Carlisle. 2001. Use of predictive models for assessing the biological integrity of wetlands and other aquatic habitats. Pages 59-83 in R.B. Rader, D.P. Batzer, and S.A. Wissinger (eds.).

Hawkins, C. P., R. H. Norris, J. L. Hogue, and J. W. Feminella. 2000. Development and evaluation of predictive models for measuring the biological integrity of streams. Ecological Applications 10(5): 1456-1477.

Hawkins, C.P., J. Ostermiller, M. Vinson, R.J. Stevenson, and J. Olsen. 2003. Stream algae, invertebrate, and environmental sampling associated with biological water quality assessments: filed protocols. Department of Aquatic, Watershed, and Earth Resources, Utah State University, Logan, UT.

Heitke, Jeremiah D.; Archer, Erik J.; Dugaw, Dax D.; Bouwes, Boyd A.; Archer Eric A.; Henderson, Richard C.; Kershner, Jeffrey L. 2007. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. Unpublished paper on file at: http://www.fs.fed.us/biology/fishecology/emp. 75 p.

Idaho Department of Lands (IDL). 2000. Forest Practices Act Cumulative Watershed Effects Process for Idaho. Boise, ID.

Karr, J.R. and E.W. Chu. 1997. Biological Monitoring and Assessment: Using Multimetric Indexes Effectively. University of Washington, Seattle, Washington. EPA 235-R97-001.

Kolka, R. and M. Smidt. 2001. Revisiting Forest Road Retirement. Water Resources IMPACT. Vol. 3, No. 3, Pp. 15-18.

Lider, E.L. 1989. Unpublished. Road Structure Inventory Report. Idaho Panhandle National Forests, Fernan Ranger District. 20 p.

Luce, C.H. 1997, Effectiveness of Road Ripping in Restoring Infiltration Capacity of Forest Roads. Restoration Ecology. Vol. 5 No.3, pp. 265-270.

MacDonald, L.H. and D. Coe. 2007. Influence of Headwater Streams on Downstream Reaches in Forested Areas. Forest Science. Vol. 53, No. 2, pp. 148-168.

Madej, M.A. 2001. Erosion and Sediment Delivery Following Removal of Forest Roads. Earth Surface Processes and Landforms. Vol. 26, No. 2, pp. 175-190.

McCaffery, M., T.A. Switalski, and L. Eby. 2007. Effects of Road Decommissioning on Stream Habitat Characteristics in the South Fork Flathead River, Montana. Transactions of the American Fisheries Society. Vol. 136, No. 3, pp. 553-561.

Meredith, C., E.K. Archer, R. Scully, A. Van Wagenen, J. Ojala, N. Hough-Snee, and B.B. Roper. 2012. PIBO Effectiveness Monitoring Program for Streams and Riparian Areas 2011 Annual Summary Report. USDA Forest Service.

Montgomery, D.R. and W.E. Dietrich. 1989. Source Areas, Drainage Density, and Channel Initiation. Water Resources Research. Vol. 25, No. 8, pp. 1,907-1,918.

Moss, D., M.T. Furse, J.F. Wright, and P.D. Armitage. 1987. The prediction of the macroinvertebrate fauna of unpolluted running-water sites in Great Britain using environmental data. Freshwater Biology. 17:41-52.

Packer, P.E. 1967. Criteria for Designing and Locating Logging Roads to Control Sediment. Forest Science. Vol. 13, No. 1, pp. 2-18.

Ross, CP. 1963. The Belt Series in Montana. Professional Paper 346. United States Geological Survey, Helena, MT.

Shumar, M. and J. DeVarona. 2009. The Potential Natural Vegetation (PNV) Temperature Total Maximum Daily Load (TMDL) Procedures Manual. Idaho Department of Environmental Quality, Boise, Idaho.

Sirucek, D. 1999. Comparison of Eroded Soil Material from a Culvert Removal Site versus a Culvert Failure. 2 p.

Sokal, R.R. and F.J. Rohlf. 1969. BIOMETRY: The principles and practice of statistics in biological research. W.H. Freeman and Company. San Francisco. 776 p.

Stoddard, J. L., D.V. Peck, A.R. Olsen, D.P. Larsen, J. Van Sickle, C.P. Hawkins, R.M. Hughes, T.R. Whittier, G. Lomnicky, A.T. Herlihy, P.R. Kaufman, S.A. Peterson, P.L. Ringold, S.G. Paulsen, R. Blair. 2005. Environmental Monitoring and Assessment Program (EMAP): Western streams and rivers statistical summary. U.S. Environmental Protection Agency, Office of Research and Development, Western Ecology Division, EPA 620/R-05/006, Corvallis, Oregon.

Stoddard, J. L., D. P. Larsen, C. P. Hawkins, R. K. Johnson, and R. H. Norris. 2006. Setting expectations for the ecological condition of streams: the concept of reference condition. Ecological Applications 16:1267-1276.

Sugden, B.D. and S.W. Woods. 2007. Sediment Production from Forest Roads in Western Montana. Journal of the American Water Resources Association. Vol. 43, No. 1, pp. 193-206.

USDA Forest Service (USFS). 1991. Region 1 – WATSED Water Yield and Sediment Yield Model. USDA Forest Service, Northern Region, Missoula, MT.

USDA Forest Service (USFS). 1987. Forest Plan. Idaho Panhandle National Forests. United States Department of Agriculture, Forest Service, Northern Region.

USDA Forest Service (USFS). 1995. Inland Native Fish Strategy Environmental Assessment, Decision Notice and Finding of No Significant Impact. Interim Strategies for Managing Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana, and Portions of Nevada. United States Department of Agriculture, Forest Service.

USDA Forest Service (USFS). 1997. *Unpublished* Mass Failure Evaluation Report and Road Recontouring, Decompaction and Channel Crossing Removal Evaluation Report. United States Department of Agriculture, Forest Service, Fernan Ranger District, 11 p.

USDA Forest Service (USFS). 2009. *Unpublished* Draft R4 Soil Quality Monitoring Methods. United States Department of Agriculture, Forest Service, Region 4, Ogden, UT.

Wolman, M.G. 1954. A Method of Sampling Coarse River-Bed Material. Transactions of the American Geophysical Union. Vol. 35, No. 6, Pp. 951-956.

Wright, J.F, M.T. Furse, and P.D. Armitage. 1993. RIVPACS-a technique for evaluating the biological quality of rivers in the U.K.. European Water Pollution Control. 3:15-25.

Wright, J.F., D.W. Sutcliffe, and M.T. Furse. 2000. Assessing the biological quality of fresh waters: RIVPACS and other techniques. Freshwater Biological Association. Ambleside Cumbria, UK.