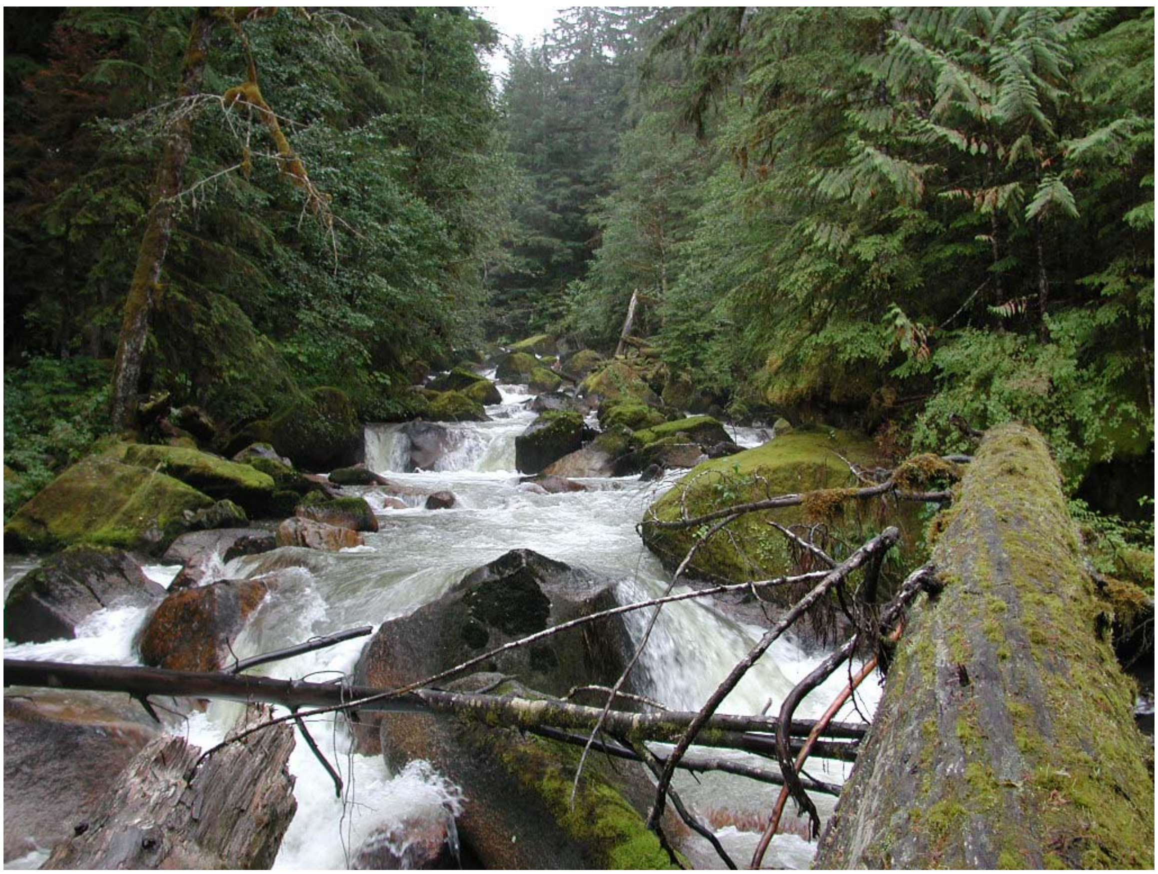
Northwest Forest Plan
Aquatic and Riparian Effectiveness-Monitoring Program

FY2000 pre-Pilot Summary Report



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Summary

The aquatic and riparian module was developed to monitor the effectiveness of the Northwest Forest Plan's (the Plan) aquatic conservation strategy across the Plan's entire geographic area. A "pre-pilot" effort was initiated in fiscal year 2000 on five 6th-field hydrologic unit code (HUC) subwatersheds to assess the feasibility of implementing the monitoring plan before its final approval in 2001. Specifically, we wanted to develop and evaluate the organizational structure needed to operate the module; test and compare procedures and sampling designs with subwatersheds as recommended by our interagency expert teams; and develop cost estimates for implementation.

For the pre-pilot, subwatersheds were selected to examine aspects of implementing the module across the broad spectrum of climatic, ecological, and geomorphic conditions present in the Plan area. Our sampling program was divided into a basin-scale assessment of important watershed features and an intensive site-scale survey consisting of quantitative channel cross-sectional and longitudinal surveys, substrate measurements, large-wood tallies, water chemistry, and water-quality bioassessments based on aquatic macroinvertebrates and benthic periphyton. An extensive basin-wide survey was conducted in one subwatershed, in addition to the intensive-reach-scale surveys. Our analysis of these data will provide an information base for further evaluating and refining of the protocols before the full-scale pilot effort in 2001.

The insight gained from this exercise was invaluable. Major lessons learned are outlined here, and all are described in detail in the discussion section. Key Findings and Recommendations:

- Intensive and extensive survey data were remarkably similar. The only significant difference was that more pools were identified during the intensive survey. However, frequency of large pools was the same using the two methods, therefore the disparity between the two methods for total pools apparently arose due to inclusion of shallow pools.
- Reconnaissance of the subwatersheds prior to sampling improved crew efficiency tremendously.
- Considerable effort needs to be focused on bankfull identification in training because the bulk of the physical data hinges on identification of bankfull stage.
- The large woody material protocol was inadequate, as we did not collect data on wood volume or location in the stream. Further, basing the minimum length criteria on channel width does not allow for consistency in data across subwatersheds.
- Several unexpected delays were encountered for the remote-sensing and GIS-based portion of AREMP, due to the disparate availability and accuracy of GIS layers.
- A quality assurance/quality control (QA/QC) program needs to be implemented in the future to examine observer bias, temporal variance, and adequacy of sampling protocols.
- The cost estimate for collecting indicator data for each watershed is $18.6K for fieldwork and $11.9K for the map-based portions, plus an additional $11.9K to include aquatic vertebrates (as recommended by several of the Plan agencies), for a total of $42.4K/watershed.

Introduction

Background

The Record of Decision for the Northwest Forest Plan (the Plan) was approved in April of 1994. The Plan included an aquatic conservation strategy (the Strategy) requiring the protection and rehabilitation of watersheds and aquatic ecosystems under the Plan's jurisdiction and with subsequent monitoring of these areas (USDA-USDI 1994). The Record of Decision also called for developing new monitoring protocols with consistent criteria, goals, and reporting methods to address watershed condition at spatial scales ranging from specific reaches to ecological provinces encompassed by the Plan. In response to this directive, a team of resource management experts and scientists from several federal agencies (Reeves et al. 2000) developed the framework for the aquatic-riparian effectiveness monitoring plan (the monitoring plan).

The primary goal of the monitoring plan is to evaluate the success of the management and restoration efforts on aquatic and riparian ecosystems at the subwatershed scale, including detecting trends and characterizing ecological status. Monitoring conducted under monitoring plan guidelines should detect any changes in watershed condition that result from implemention of the Plan. The monitoring plan's specific objectives, as determined by Reeves et al. (2000, p. 9) include annually assessing the condition of aquatic and riparian ecosystems by estimating the regional distribution of watershed conditions; developing and validating ecosystem management decision-support models to refine indicator interpretation; developing predictive models to improve use of monitoring data, anticipate trends, and reduce long-term monitoring costs; providing information for adaptive management by analyzing trends in watershed condition and identifying elements that result in lowering watershed condition; and providing a framework for adaptive monitoring at the regional scale.

Pre-pilot monitoring effort

A monitoring plan pre-pilot project was completed in August 2000 to assess the feasibility of implementing the Plan. This effort included developing, testing, comparing, and refining field protocols for collecting specific subwatershed monitoring data, developing and evaluating organizational structure needed to operate the AREMP, exploring opportunities for interagency cooperation and coordination, and developing cost estimates for the Plan.

Collected data will be summarized and put into a decision-support model that calculates a general indicator of subwatershed health. A decision-support model is a knowledge base or meta database that describes subwatershed patterns and processes derived from field data (Reynolds et al. 2000). The model's framework can be applied to any geographic scale. Data collected during the 2000 field season and in subsequent years will be put into the model to help define the condition of subwatersheds in the Plan area. The monitoring document calls for revisiting subwatersheds every five years to monitor trends in the health of aquatic ecosystems Plan subwatersheds.

Here, we summarize the aquatic riparian 2000 pre-pilot effort in five subwatersheds. Included are descriptions of the sampling protocols, data summary techniques, and the problems encountered. The data from the field exercises represent about half the variables listed in the monitoring document. Data for the balance of the variables will come from nonfield sources such as remote sensing, aerial photographic interpretation, or Geographic Information Systems (GIS). The decision-support model will be developed in coordination with local experts to build the fuzzy-logic models for each of the variables.

Site Descriptions

Lobster Creek Subwatershed

Lobster Creek is a tributary to the Five Rivers, which in turn flows into the Alsea River in Oregon. The creek is in the Plan's Coast Range Province (Table 1). Sites selected for sampling were in the upper mainstem, the East Fork, and the South Fork of Lobster Creek (Figure 1). An original set of 80 sites was drawn in what were later determined to be two sixth-field hydrologic unit codes making up the Lobster Creek watershed. Only those sample sites in the upper sixth-field hydrologic unit codes were considered for surveying.

The upper subwatershed is mostly managed by the Salem District of the Bureau of Land Management (BLM) with a few scattered private in-holdings in the uppermost portion of the subwatershed. The entire lower mainstem is privately owned. Land-use activity in upper Lobster Creek historically focused on producing timber, but small farms and ranches in the valley bottom and timber harvest on the upslopes predominates in the lower subwatershed. The upper subwatershed consists of a mix of constrained and unconstrained reaches, with some bedrock-constrained gorges. The lower subwatershed consists mostly of unconstrained reaches. Elevation ranges from about 60m near the mouth of the subwatershed to 1040 m on the highest peak. Average annual precipitation ranges from 203 to 254 cm and is predominantly in the form of rain (Daly and Weisburg 1997). Geologic features are primarily older Cenozoic marine and estuarine sedimentary rock with minor amounts of volcanic rock (Walker and King 1969). Common streamside and upslope trees and shrubs were Douglas-fir (*Pseudotsuga menziesii*), western redcedar

(*Thuja plicata*), bigleaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), salal (*Gautheria shallon*), salmonberry (*Rubus spectabilis*), stink currant (*Ribes bracteosum*), and vine maple (*Acer circinatum*). Coho and chinook salmon (*Oncorhynchus kisutch* and *O. tshawytscha*), steelhead (*O. mykiss*), and coastal cutthroat trout (*O. clarkii*) are the salmonid species known to live in the upper subwatershed.

Illabot and Arrow Creek Subwatersheds

Illabot and Arrow Creeks, in the Plan's Western Cascades Province, are tributaries of the Skagit River (Table 1). Eighty sample sites were randomly selected for the entire Illabot Creek fifth-field HUC (because of the inconsistent definitions of 5^{th} - and 6^{th} -field HUCs).

Sites were sampled only in Arrow Creek and Upper Illabot Creek, two adjacent sixth-field subwatersheds in the upper end of the Illabot Creek (Figure 2). The Mt. Baker – Snoqualamie National Forest manages both subwatersheds. Their headwaters are in the Glacier Peak Wilderness. Land-use activity in the subwatershed has historically focused on timber production and wilderness recreation. The headwaters of Illabot Creek originate on the steep glaciated peaks of Snowking Mountain and Mount Chavall. A few short, unconstrained reaches exist along the upper mainstem of Illabot Creek, with a larger unconstrained reach around Illabot Lake, a shallow wetland. The Arrow Creek subwatershed is primarily a high-gradient boulder cascade stream, with some small wetland ponds near the headwaters. Arrow Creek originates on Mount Chavall. Several unnamed, high-gradient tributaries enter the mainstem of both creeks. Elevations range from about 670 m at the mouth of Arrow Creek and 800 m at the mouth of the Illabot Creek sixth field to 2257 m on the highest peak. Average annual precipitation ranges from 229 to 305 cm and comes in the form of rain at low elevations and snow at high elevations (Daly and Weisburg 1997). Geologic features are primarily metamorphic rock from the pre-Cretaceous period (Tabor et al. 1987). Common streamside trees and shrubs were western hemlock *(Tsuga heterophylla*), Douglas-fir, western redcedar, silver fir *(Abies ambilis),* bigleaf maple, red alder, salal, Alaska huckleberry *(Vaccinium alaskaense),* cascara *(Rhamnus purshiana*) and devil's club *(Oplopanax horridum).* Bull trout *(Salvelinus confluentus*) and resident coastal cutthroat trout were also seen in these subwatersheds.

Beaver Creek Subwatershed

Beaver Creek, a tributary to the Middle Fork of the Eel River in Northern California, is in the Plan's Klamath Province (Table 1). Study sites were on the mainstem of Beaver Creek, Smokehouse Creek, and Buck Rock Creek (Figure 3). The Covelo Ranger District of the Medicino NF manages most of the subwatershed, with the exception of a few small private in-holdings. Land-use activity has primarily focused on timber production and light recreation. Almost all of the stream miles in the subwatershed were constrained, with large boulder and bedrock substrate. Landslides and recent flood activity were also apparent in the subwatershed. Many of the unnamed tributaries were dry or had flows too low for sampling (because of equipment constraints). Elevations range from about 760 m at the mouth of Beaver Creek to 2220 m on the highest peak. Average annual precipitation ranges from 162 to 203 cm and is primarily rain at low elevations and rain or snow at high elevations (Daly and Weisburg 1997). Geologic features are primarily sandstone and shale sedimentary rocks from the Jurassic and Cretaceous, with minor amounts of serpentine and metamorphic rocks, generally associated with unstable soils, landslides, slumps and erosion (USDA and USDI 1994). Common streamside trees and shrubs were Douglas-fir, incense cedar (*Calocedrus decurrens*), bigleaf maple, mountain alder (*Alnus incana*), Pacific madrone (*Arbutus menziesii*), white fir (*Abies concolor*), California red fir (*A. magnifica*), sugar pine (*Pinus lambertiana*), ponderosa pine (*P. ponderosa*), and several varieties of oak (*Quercus* spp.) and willow species (*Salix* spp.). Steelhead can access the lower 0.8 km of Beaver Creek up to a 6.1-m waterfall, above which resident rainbow trout are found almost everywhere that flow is perennial (Bob Faust, Mendocino N.F. Willows, CA, pers. comm.).

Glade Creek Subwatershed

Glade Creek, a tributary to the Little Applegate River, (a tributary of the Rogue River), is in the Plan's Klamath Mountains Province (Table 1). Sites were on the mainstem of Glade Creek, Garvin Gulch, and Wrangle Creek (Figure 4). The Ashland Ranger District of the Rogue River NF manages the subwatershed, with the exception of a few, small, private in-holdings. Land-use activity primarily focused around timber production, livestock grazing, placer mining, and light recreation. Most of the stream miles in the subwatershed were constrained. Boulders and bedrock were often present. Recent road failure and landslide activity were apparent in the subwatershed, mainly the result of the floods in of January 1997. Elevations range from about 790 m at the mouth to 2260 m on the highest peak. Average annual precipitation ranges from 102 to 152 cm, primarily rain at low elevations and snow at high elevations (Daly and Weisburg 1997). Geologic features are a mixture of ultramafic and gabbroic rock, chiefly of the Mesozoic, and sedimentary and volcanic rock strongly metamorphosed from the Permian and Triassic (Walker and King 1969). Common streamside trees and shrubs were Douglas-fir, western redcedar, bigleaf maple, red alder, white fir, several oak species, ponderosa pine, Pacific yew (*Taxus brevifolia*), and poison oak (*Toxicodendron diversilobum*). Steelhead can access the lower 0.3 km of Glade Creek up to a 4.6-m waterfall; above the falls, resident rainbow and a few coastal cutthroat trout are present.

Methods

Sampling protocols for obtaining the data needed for the model were developed primarily from existing agency protocols, but some modifications were needed to meet the exact specifications of the monitoring plan (Reeves et al. 2000). Repeatable protocols with quantitative rather than qualitative attributes were developed consistent with other agency methods and techniques, as often as possible. Source protocols included the US Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP) (Kaufmann et al. 1999), the USDA FS Region 6 stream inventory (USDA 1999), the ODFW habitat inventory (Moore et al. 1999), and the USDA FS Pacific Northwest Forestry Sciences Laboratory (PNW-FSL) Aquatic/Land Interactions Team terrestrial and aquatic vertebrate sampling protocols. Protocols were refined throughout the 2000 field season; later versions always allowed for integrating data with the earlier version. Changes to protocols typically fell under one of two categories: measurement technique or crew size and configuration. Each subwatershed was surveyed both intensively and extensively. The intensive survey was at 1 to 10 stream segments in each subwatershed. At each sampling segment, 11 cross-sections and a longitudinal profile were mapped by using a laser range finder that generated a three-dimensional map of the stream channel. Information was also collected on discharge, the number of pieces of large wood in certain size criteria, and substrate measurements (to generate both D_{50} and D_{84}). Water chemistry was evaluated by using both *in-situ* measurements and laboratory analysis, and bioassessed by using benthic periphyton and aquatic macroinvertebrates (Table 2). Finally, at some segments, fish and amphibian (terrestrial and aquatic) data were collected (Table 2). Work was always conducted from the downstream start of the site to its upstream end.

The extensive survey consisted of walking the length of the stream and tributaries included in the intensive survey. The surveyors documented major features in the stream channel such as deep pools, log jams, beaver dams, and landslides. During the 2000 pre-pilot, nearly 6 km of stream was sampled in the intensive survey in the five subwatersheds (Table 3). The extensive survey covered more than 60 km (Table 3), representing nearly 60% of the total stream length in the five subwatersheds.

Selecting Stream-Sampling Segments and Sampling Design

Subwatersheds were selected according to a set of criteria (such as accessibility and prior studies) distributed to local area managers, who in turn nominated subwatersheds for the pre-pilot effort. No attempts were made to select subwatersheds with a probability sample. Selection was stratified among the geographic provinces covered by the Plan.

Once subwatersheds were selected, random sampling segment starting points were generated by using a protocol developed by the EPA. The sampling scheme was spatially distributed to ensure that random starting points were about evenly spaced through the subwatershed. Segment starting points were selected by using the EPA's RF3 stream layer (a 1:100,000-scale GIS map) in each 6^{th}-field HUC, and printed onto

1:24,0000-scale US Geological Survey (USGS) quadrangle maps for field use (that is, on-the-ground site location). Before beginning the sampling session in a given subwatershed, field reconnaissance determine at which sites were feasible to sample. The criteria for reach exclusion include access, size and flow of the stream at that random starting point (too small, ≤0.3 m wide and ≤ 0.05 m deep, or too large, waters too deep or swift for crew safety), and non-Federal ownership.

Specific sample segment sites and starting points along the stream were found by using Global Positioning Systems (GPS). To ensure accuracy with the GPS unit, at least 2,400 points were averaged to obtain the final site position. After determining the starting point of the segment, five wetted-width measurements were taken near the first transect to obtain an average wetted width. The length of the sample segment was calculated as 40 times the average wetted width but, minimum length was 150m and maximum was 500 m (with one exception, a 510-m reach caused by a mistake in the field). Each site had 11 transects marked with plastic flagging (with Transect A the most downstream and Transect K the most upstream). Transects were spaced at an interval one-tenth of the segment length.

Longitudinal Profiles

Longitudinal profiles were mapped by using a laser range finder (line of sight mechanism; Laser Technologies Inc., model 200LR) and an electronic compass (Mapstar model, Laser Technologies Inc.), following the thalweg between each transect. Standard survey techniques were used to produce (X, Y, Z) coordinates of each measured point (relative to the initial origin of the range finder). In general, the increments between measurements were taken at one one-hundredth of the total segment length rounded to the nearest 0.5 m (for example, if reach length = 212 m, the measurement increment = 2.0 m). In Lobster Creek, however measurements were taken every 2 m regardless of segment length. Additional measurements were taken at pool tail crests, pool maximum depths, and pool heads. A pool was defined as being longer than the average wetted width and the habitat unit had to span the channel. Data points were labeled with both the longitudinal name and, if appropriate, the extra pool measurements names.

Longitudinal profile data were used to calculate pool frequency, residual pool depth, streambed gradient, and sinuosity. Pool frequency (number of pools/100 m) was determined by counting the pools documented in the reach longitudinal profile and dividing by the total length of the reach and multiplying by 100. Residual pool depth was calculated by subtracting the depth of the pool tail crest from the maximum pool depth (Table 4).

Stream gradient or slope percentage was calculated as the rise of the streambed divided by the length of the sampling segment. The following equation was used to determine gradient:

$$\% \text{ slope} = (Z_K - Z_A) / d_{A\text{-}K},$$

where Z_K is the thalweg depth at transect K and Z_A is the thalweg depth at transect A. The denominator, $d_{A\text{-}K}$, is the horizontal distance between the thalweg points at transects A and K and was calculated as:

$$d_{A\text{-}K} = \sqrt{(X_K - X_A)^2 + (Y_K - Y_A)^2}\ ,$$

where X and Y are the (X, Y) values of the thalweg points at transects K and A. Note that because thalweg depths were used, the gradient calculated is the slope of the stream bed, not the water surface:

Sinuosity was calculated as

$$\text{Sin} = \sum_{i=1}^{11} d_i \Big/ d_{AK}$$

where d_i is the distance between any two consecutive transect thalweg points and is calculated as:

$$d_i = \sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2} \,,$$

where (X_1, Y_1) and (X_2, Y_2) are the coordinates of those two consecutive thalweg points, and d_{AK} is the distance between the most upstream thalweg point (at Transect K) and the most downstream thalweg point (at Transect A), it was calculated as previously described for slope percentage.

Cross-Sectional Profiles (Transects)

At each transect, bankfull indicators were identified on both banks. A measuring tape was stretched across the bankfull channel and held securely in place with bank pins. If only one bank had good bankfull indicators, that side was used to level the tape (starting at Illabot Creek, the best bankfull stage as indicated by the environment was typically recorded with the transect data).

The laser rangefinder was used for cross-sectional point measurements. Measurements began on the left bank (looking downstream). At each transect, to begining and ending the profile well above the flood-prone height (two times the maximum bankfull depth) was attempted. In Lobster Creek, however, only the transects with the narrowest and widest floodplains were intentionally measured beyond flood-prone height. Outside the bankfull stage on each transect, adequate points were measured to capture major terraces and slope changes. Within bankfull width, an increment was used to place points along the transect. Increments were determined by dividing the bankfull width by 11 (10 in Lobster Creek), resulting in a minimum of 12 (11 in Lobster Creek) points measured within the bankfull channel. Additional data points were collected at each wetted edge and at the thalweg of the main channel. Notes were made of these features in the comments. If gravel bars were encountered, they were labeled in the comments, and wetted edges were recorded on both the main and secondary channels in addition to any points needed to capture slope changes. Side channels were also captured unless the terrain separating the channels was above flood-prone height. Then, the presence of the side channel was documented in notes or comments. An example list of codes that point along a transect might be labeled as follows: Left End, Left Bankfull, Left Wetted Edge, Thalweg, Right Wetted Edge, Gravel Bar, Left Wetted Edge, Right Wetted Edge, Right Bankfull, Best Bankfull Indicator, Right End.

Transect data were used to calculate bankfull width-to-depth ratios and entrenchment ratios. Width-to-depth ratios were calculated as bankfull width divided by mean bankfull depth. This ratio was calculated for each transect sampled (323 total in all five subwatersheds). Subwatershed averages were determined in two ways: as the average of the mean width-to-depth ratio in the sample segments, calculated as the average if the width-to-depths at each transect (thus, an average of averages); and as the average of all transects in the subwatershed (grand mean).

Entrenchment ratio was calculated as the flood-prone width divided by bankfull width. We attempted to get above the point where the flood-prone width intersected the transect, but points were not specifically taken at flood-prone widths.

Floodprone width (FPW) was calculated as:

$$FPW = D_R + D_L,$$

where D_R and D_L are the distances from the flood-prone center (FPC; (X_{FP}, Y_{FP}, Z_{FP})) to flood-prone intercept (FPI; $(X_{INT}, Y_{INT}, Z_{INT})$), the point at which the line from FPC intersects the transect (Figure 5). Each of these distances (d) are calculated as;

$$d = \sqrt{(X_{FP} - X_{INT})^2 + (Y_{FP} - Y_{INT})^2}.$$

Hereafter, the steps outlined will refer only to one side of the transect (from FPC to FPI right or left); that is, a second, duplicate set of calculations is needed for the other side. The FPC is calculated as:

$$X_{FP} = X_{TH},$$
$$Y_{FP} = Y_{TH}, \text{ and}$$
$$Z_{FP} = 2 * (Z_{BF} - Z_{TH}),$$

where X_{TH} and Y_{TH} are the X and Y coordinates for the thalweg field measurement (Figure 5). The average elevation for the two bankfull elevation measurements (Z_{BF}) is calculated as:

$$Z_{BF} = \text{mean(RB,LB)},$$

where RB is the right and LB and left bankfull points, and Z_{TH} is the elevation for the wetted channel thalweg taken from the field measurement (Figure 5).

The point $(X_{INT}, Y_{INT}, Z_{INT})$ is calculated as:

$$X_{INT} = X_1 * (X_{DIFF} * t),$$
$$Y_{INT} = Y_1 * (Y_{DIFF} * t), \text{ and}$$
$$Z_{INT} = Z_1 * (Z_{DIFF} * t),$$

where $(X_{DIFF}, Y_{DIFF}, Z_{DIFF})$ is the difference between the points (X_1, Y_1, Z_1) and (X_2, Y_2, Z_2)

$$X_{DIFF} = X_2 - X_1,$$
$$Y_{DIFF} = Y_2 - Y_1, \text{ and}$$
$$Z_{DIFF} = Z_2 - Z_1.$$

And t is the calculated as:

$$t = \frac{Z_{INT} - Z_1}{Z_2 - Z_1}$$

which is the proportional distance between (X_1, Y_1, Z_1) and (X_2, Y_2, Z_2): therefore, at (X_1, Y_1, Z_1) t = 0 and at (X_2, Y_2, Z_2) t = 1. Like the bankfull width-to-depth ratio, a mean and grand mean was calculated for each subwatershed entrenchment ratio. Several times, the survey failed to capture flood-prone width. Under these circumstances, entrenchment ratios were not calculated for those transects, and reach averages were calculated based on the number of entrenchment ratios available.

Substrate

Substrate measurements were taken at increments along each transect (same location as the cross-sectional measurements), using a modification of the procedure described by Wolman (1954). The modification is similar to one used by the EPA in their EMAP protocol, the monitoring plan procedure measures more substrate particles at each transect. The EMAP protocol calls for taking five substrate measurements at 21 transects, for a total of 105 measurements per sampled reach (Kaufmann et al. 1999). Our monitoring protocol calls for taking a substrate count at each measure increment along the 11 transects. Increment width was based on the bankfull width of the channel, as described for the cross-sectional data. In Illabot, Beaver, and Glade Creeks, 12 substrate particles were measured at each transect for a total of 132 at each reach. Eleven particles were measured at each transect on Lobster Creek for a total of 121. Standard substrate classes and pebble-count procedures were used for categorizing the data. Particles were counted at each transect regardless of habitat; used both pools and riffles were sampled, so a more representative sample of the substrate composition for the entire reach was collected, rather than in just one type of habitat.

The D_{50} and the D_{84} were calculated for each reach and for each subwatershed (Wolman 1954). Subwatershed means were calculated in two ways. First, a D_{50} and a D_{84} were calculated for each sample reach, and the average of the sites was calculated (an average of averages). In addition, the substrate measurements were pooled and a D_{50} and a D_{84} were calculated for the subwatershed (grand mean).

Large Wood

The number of pieces of large wood were tallied for the entire length of the sampling segment. A piece of large wood was counted if was longer than or equal to the bankfull width, and at least 0.3 m in diameter at breast height. On Lobster Creek, length was determined by the bankfull width at each transect in a reach; length was determined by the bankfull width at transect A for each reach in the remaining subwatersheds. A piece of large wood was counted only if some portion of the main bole was in the bankfull channel. Pieces that were suspended across the bankfull channel were also counted. No live trees still rooted and standing on the bank were counted even if their boles were in the bankfull channel.

Our criteria for measuring large wood came from a modification of a protocol used by Oregon Department of Fish and Wildlife. The diameter criterion is the same as that used by Oregon Department of Fish and Wildlife in their aquatic habitat inventory (Moore et al. 1999). However, the length criteria differ. The ODFW protocol uses several length classes, with 3 m as the minimum length (Moore et al. 1999). The length criteria developed for the pre-pilot was designed to record large wood pieces that would contribute to larger scale channel changes.

Ambient Discharge

Discharge was estimated at one point in each sample reach. Depending on the size of the stream, either a flow meter (Marsh-McBirney or Pigmy) or a neutral-buoyant object technique was used. Flow meters were preferred, but the stream was sometimes too small to accommodate the equipment and a neutral-buoyant object was used. Both methods are the same as those described in the EPA EMAP protocol (Kaufmann et al. 1999).

Velocity – Area (flow meter). An area in the sample reach suitable for measuring discharge was sought (a straight segment with uniform flow, a depth mostly greater than 15 cm, and free of boulders and other debris). A measuring tape was stretched across the wetted width of the segment, perpendicular to the flow. An increment was calculated that was one-twentieth of the wetted channel width. The top-setting rod was adjusted to the proper height (0.6 * depth) and water velocity was measured for 40 seconds. The distance from the starting bank (usually left, facing downstream) for cell width, depth, and velocity were recorded on a data sheet. Discharge for the stream was calculated by multiplying the area of the cell by the velocity, then summing these values across all cells.

Neutral-buoyant object. A neutral-buoyant object was used in streams too small to accommodate the flow meter (all of Beaver Creek and two sites at Glade Creek). A relatively straight segment of the reach was chosen with few boulders or other obstructions and constant flow. The length of the segment was recorded, as were the width at the upstream, middle, and downstream ends of the segment. Five depth measurements were taken at each width measurement. A stopwatch was used to determine the time the object (an apple or orange) took to float the length of the stream segment (time measurements were repeated three times). The average width and average depth were used to calculate the area of the stream segment. The area was then multiplied by the stream-segment length and average time for object to float through the stream segment to estimate discharge.

Water Chemistry

Water for total dissolved phosphorus, soluble reactive phosphorus, and dissolved nitrate and nitrite analyses were collected in an acid-washed Nalgene bottle. The bottle was rinsed 4 to 5 times with stream water before samples were collected for analysis. The bottle was immediately placed on ice in a soft-sided cooler and the sample was frozen on return to the laboratory. The Cooperative Chemical Analytical Laboratory at Oregon State University analyzed the water samples. Procedures for nitrogen and phosphorus analyses are modifications of the protocols described in Standard Methods (APHA 1980).

Daily water temperature, dissolved oxygen, conductivity, and pH were determined by using YSI-65 (pH) and YSI-80 (the other variables) meters. Meters were calibrated before taking each measurement according to the instructions in the instrument manual. The pH meter was calibrated by using 2 points, pH 4.0 and 7.0. Dissolved oxygen and alkalinity were determined by titration with a Hach kit.

Annual Water Temperature

Initially, annual water temperatures were to be collected by deploying two calibrated electronic thermographs before June at the mouth of each surveyed subwatershed. Because of the time of the field efforts, however, we were unable to begin then. For the summer 2000 field season, temperature data were acquired from local National Forest Ranger Districts. Daily water temperature was recorded at the time of sampling, however, by using a Yellow Springs Instrument model 85.

Benthic Periphyton

Field sampling. The periphyton protocol used for both field collection and lab analysis is the same as that outlined by the EPA EMAP (Peck et al., in prep). Samples were collected at an assigned sampling site (left, center, or right bank), which alternated at each transect. A relatively smooth rock with adequate surface area exposed was chosen from each site. An area of 12 cm^2 was delineated by using a template made from polyvinyl chloride (PVC) pipe. All attached periphyton inside the area was removed with a toothbrush. About 30 to 45 seconds of scrubbing time was adequate to remove a sufficient amount of periphyton. Material clinging to the toothbrush was washed into a 125-ml wide-mouth bottle. We found potential sample contamination by fine particulate sediment in only one case. A large-bore syringe was used to vacuum the surface of the sediment in an area of 12cm^2.

All samples were pooled into one sample jar for the reach. During sampling, the jar was placed out of direct sunlight as much as possible to reduce chlorophyll degradation. On completion of the sampling, the volume of the sample was determined and recorded. The sample was vigorously shaken and 50 ml placed in a separate vial, with 1 ml of 37% formalin solution (a preservative).

Laboratory analysis. Samples were analyzed by Loren Bahls, in Helena, Montana. Each sample was placed on a slide and at least 300 individual organisms were identified and enumerated for relative-abundance assessments. All non-diatom taxa were identified to genus; diatoms were identified to species. The voucher slide was permanently fixed, and will be retained by the monitoring-plan module.

Aquatic Benthic Macroinvertebrates

Field sampling. The protocol used for collecting and analyzing macroinvertebrates is the same as that used for the reach-wide macroinvertebrate sampling outlined by the EPA EMAP (Peck et al. 2000), with one minor exception. The EMAP protocol describes subsampling pool and riffle habitats and placing subsamples from both habitats into a single jar. In the monitoring-plan protocol, subsamples were taken in both pool and riffle habitats, but subsamples were collected into separate sample jars for each habitat.

One macroinvertebrate subsample was taken at each transect (11 total subsamples) by using a 504-µm mesh kick net (a Surber sampler was used in Lobster Creek). Subsamples were taken as close as possible to the transect, without regard to habitat. Although subsamples were combined in jars, pool and riffle habitats were kept separate. If possible, subsamples were taken from an assigned sampling point (left, center, or right bank). If the assigned sampling point was unsuitable, however, then the nearest suitable point was used. An area was considered suitable if it had adequate space among the rocks for the net and adequate flow to wash organisms into it. The net was placed in the stream so that water ran straight into its mouth. The area sampled was about 0.3 x 0.6 m or 0.18 m^2. All rocks inside the sample area larger than a golf ball were scrubbed with a brush to remove attached organisms and then placed outside the sampling area. Only the exposed areas of embedded rocks were brushed. When all rocks were scrubbed, kicking the substrate for about 30 seconds disturbed the entire sampling area. The net was then rinsed and inspected; all additional insects were removed and placed in the sample jar. Large organic debris was inspected for clinging organisms and removed from the sample. Samples were then washed in the 504-µm mesh to remove fine particles and excess water. Ethanol (95%) was added to preserve samples.

Laboratory analyses. Samples were analyzed at the BLM Buglab (National Aquatic Monitoring Center) at Utah State University. Each sample was spread evenly into a 250-µm sieve and divided into equal portions. Small amounts of material were placed in a petri dish and all organisms removed by using a dissecting scope at 10 to 60 power. Subsamples were taken until at least 500 organisms were included in the analyses and each individual with identified and counted. All insects were identified to genus (except the chironomids, identified just to subfamily). Non-insects were identified to the lowest possible taxonomic level. The remainder of the sample was searched for additional taxa not included in the analyses. Voucher specimens were retained for all taxa by the monitoring plan's module.

Aquatic Vertebrates

Fish and aquatic amphibians. Data on fish and aquatic amphibians were collected at all sampling sites in the Glade Creek subwatershed and at six of nine segments on Lobster Creek; however, electrofishing was only done in riffles (Table 3). A single-pass technique with an electrofisher was used between transects at each reach. The goal was to obtain a complete list of taxa and species composition at different sites in the subwatershed. Data collected between each transect included species, number captured, length (fork length for fish, snout-vent length for amphibians), shocker settings, water temperature, effort (time in seconds), and comments (such as weather, fish condition, water clarity, and number of fish seen but not captured).

Terrestrial amphibians

Terrestrial amphibian searches were conducted at every site in the Glade Creek subwatershed and at six of nine sites in the Lobster Creek subwatershed (Table 3). At each transect in a reach, two people would start at the wetted edge and search their way up the bank on either side of the stream for five minutes. During this time, searchers rolled over rocks, broke apart logs, and dug through leaves and soil. Any amphibians found were identified and measured from snout to vent. Other data collected include estimates of search area, the type of habitat searched, and the air temperature. If an amphibian was captured, the searcher recorded which bank it was on, what habitat it was in, and how far it was from the waters edge. The protocol used was adopted from Aquatic/Land Interaction Team at the PNW-FSL (Dede Olson, PNW Research Station, Corvallis, Oregon).

Basin Stream-Walk Extensive Inventory

The stream-walk inventory determined the frequency of important features in the subwatershed. The stream walk was along the entire stream length in the subwatershed (on public land), beginning at the mouth and ending at the headwaters. An initial GPS point and digital photograph was taken as close to the confluence of the stream as possible. The stream-walk crew then proceeded upstream documenting (with a GPS waypoint, written description, and photograph) all features encountered that were on the monitoring plan's stream-walk protocol code list (Appendix 1). The feature code list was modified from of the comment codes in the ODFW stream survey protocol (Moore et al. 1999). Care was taken to choose photos that best represented the feature, and a person was included in all pictures for perspective.

The surveyors walked in the stream channel only when absolutely necessary, to avoid disturbing the stream because of potential future sampling of water chemistry and macroinvertebrates by the habitat crew. In certain subwatersheds, walking in the stream channel was avoided as much as possible because endangered, threatened, or sensitive species were present.

Basin-Wide Habitat Inventory (Glade Creek)

A customized version of the Hankin and Reeves (1988) stream-survey protocol was developed for collecting habitat data on the mainstem of Glade Creek. The objectives of this survey were to collect pool frequency data, large wood counts, bankfull widths, and flood-prone widths for the entire basin. These data could then be compared with the values collected at the eight mainstem segments included in the intensive survey.

The survey began at the mouth of Glade Creek and continued to slightly upstream of the uppermost surveyed reach on the mainstem. Habitat was classified as either pool or riffle. A length and an average width were estimated for each habitat unit; maximum depth and pool tail crest were measured with a stadia rod (for pools only). The pool habitat definition was the same as that used for the monitoring plan's intensive survey. Every tenth pool and riffle unit was measured to obtain a calibration ratio that was later used to correct the lengths and widths of all estimated units. At each measured pool and riffle unit, a measuring tape was stretched across the bankfull channel and three equally spaced depth measurements were taken along the tape, with an additional measurement taken at the thalweg. The maximum bankfull depth was doubled to obtain the maximum flood-prone depth. The tape was then stretched out to both banks at this height to obtain flood-prone width.

Large wood was tallied by using the same diameter and length criteria previously described. The last bankfull measurement was used to determine the minimum length until the next bankfull measurement was taken. Comments were made on major landmarks, habitat calls, and the intensively surveyed sites. Habitat units began and ended at the downstream and upstream ends of each monitoring plan's sampling segment. Length and width data were corrected according to Hankin and Reeves (1988). Width-to-depth ratios, entrenchment ratios, pool frequency, wood frequency, and residual pool depth were calculated as previously described from the data for the entire section of stream surveyed.

GIS, Remote Sensing, and Air Photo Watershed-Condition Indicators

Geospatial data collecting began in mid-October 2000 and is expected to continue throughout the monitoring effort. To date, GIS coverages were obtained from numerous agencies including the EPA, Regional Ecosystem Office, BLM, USGS, ODFW, California Department of Fish and Game and several National Forests. Efforts to collect GIS data have primarily been concentrated on the five subwatersheds sampled during the 2000 pre-pilot. The GIS data collected so far include: digital elevation model (DEM) lattices, national hydrography dataset streams, transportation, land ownership, water bodies, 4th-, 5th-, and 6th-field HUC boundaries. These data have primarily been used for reference and for display maps producing thus far. All GIS data acquired are converted and used in Universal Transverse Mercator projection, zone 10 (units: meters, spheroid: Clarke 1866).

The current availability and quality of geospatial data for vegetation and upslope processes (landslide) are unknown for the geographic provinces covered by the Plan. If still unavailable, such necessary data will be transposed from aerial photos or possibly classified by using remotely sensed images where feasible. Riparian zones and upslope areas will be administered according to stream class by the definitions provided in the Plan.

Results

The initial goal was to sample 10 randomly selected stream segments in each subwatershed, but that goal was achieved only in Glade Creek (Table 3). In the remaining streams, nine sites were sampled in Lobster, eight in Beaver, four in Illabot, and one in Arrow Creeks. On average, one day was needed for a three-person crew to sample a segment 250 m or less in length. About 40 days were spent in the field during the 2000 season, and 32 sites were sampled (Table 3).

The results from the 2000 summer field season are presented below. The results for Glade Creek include additional stream inventory information.

Lobster Creek

Lobster Creek was likely the most productive subwatershed, as evidenced by the high nitrate concentrations, ranging from 0.10 – 0.28 $mg \cdot l^{-1}$ (Table 5). Nitrate concentrations appeared to decline from the mouth to the headwaters in the mainstem of Lobster Creek (Figure 7; the first four data points from the left of the figure). Nitrate concentration in East Fork Lobster (points five through seven, Figure 7) was much higher than the South Fork Lobster (points eight and nine, Figure 7). Both total dissolved and soluble reactive phosphorus were much less variable than nitrate, and do not appear to change dramatically from the mouth to the headwaters (Figure 7).

Dissolved oxygen in Lobster Creek was highly variable (Figure 7). Dissolved oxygen data were collected during both morning and afternoon, so variability in oxygen from temperature was likely maximized. Water temperatures were warm in Lobster Creek, ranging between 11.4 and 15.8 °C (Table 5). Conductivity data were variable as well as incomplete. Apparently, conductivity is most variable in East Fork Lobster, though the reasons are not clear. The conductivity data are incomplete because the field season began before all of our sampling equipment arrived; we did not have a conductivity meter until the end of the first week of the field season. In contrast to conductivity, pH was relatively stable and appeared to decline slightly from the mouth to the headwaters of the subwatershed (Figure 7). Water chemistry data for each subwatershed are summarized in Appendix 2.

Thermograph temperature data were collected by ODFW on the main stem of Lobster Creek annually between 1995 and 1999, and on the East Fork of Lobster Creek during 1992, 1997, and 1998 (Table 6). In 1996, temperatures exceeded the Oregon Department of Environmental Quality's (2000) state temperature standard (17.7°C) for salmonid spawning and rearing on the mainstem.

Discharge was calculated at each site in Lobster Creek. Values ranged from 0.004 – 0.04 $m^3 \cdot s^{-1}$ (Table 7). Stream gradient (% slope) varied little in Lobster Creek and remained fairly constant from the mouth to the headwaters (Figure 7). Gradient ranged from 1.3 – 4.1% in the sample reaches, with an average of 2.3% (Table 7). Width-to-depth ratio ranged from 8.1 to 47.3 in Lobster Creek, with a mean of 24.2 for the eight sample segments (Table 7). Entrenchment ratios ranged from 1.3 to 3.9, with an average of 1.9 (Figure 7, Table 7). The two values (mean of the reach means and the grand mean) calculated for both the width-to-depth and entrenchment ratios were nearly identical (Figure 8C, Table 7); however, the estimates of variance around the grand mean was much higher than that calculated for the mean.

Large wood counts ranged between 0.5 and 15.5 pieces $\cdot 100\ m^{-1}$, with an average of 6.9 pieces $\cdot 100\ m^{-1}$ (Figure 9A, Table 7). Substrate D_{50} was about 51mm and D_{84} was about 299 mm for the Lobster Creek subwatershed (Figure 9B,C; Table 7). The grand means were about 45 mm for D-50 and 199 mm for D-84 (Figure 9, Table 7). Pool frequency was slightly less variable, ranging from 3.0 to 10.6 pools $\cdot$ 100 m^{-1}. Mean pool frequency in Lobster Creek was 5.1 100 m^{-1} (Figure 9D, Table 7). Residual pool depth averaged 0.4 m and varied only slightly (Table 7).

Lobster Creek had fairly diverse species assemblages of both fish and amphibians (Table 8). The fish captured in Lobster Creek were either sculpin or young-of-the-year trout, both difficult to identify to species in the field. At the time of sampling in Lobster Creek, our primary focus was on amphibians, so fish specimens were not collected for positive identification. The numbers of fish and the effort expended to capture them were recorded to generate a catch per unit effort at each reach sampled for aquatic vertebrates. Three salamander species were found in Lobster Creek in addition to rough-skinned newts and tailed frogs, a state sensitive species (Table 8). *Plethodon* salamanders were far more abundant than *Dicamptodon* or Pacific giant salamanders (Table 8).

Illabot Creek

Nitrate concentrations in Illabot Creek were among the lowest in all the subwatersheds (Figure 6, Appendix 2). Nitrate was very low at the sampling segment nearest the mouth of the subwatershed, increased at the next site upstream, and declined at the sites farther upstream (Figure 10). These changes were likely the result of a rainstorm the day before site seven was sampled; it was the first site sampled in Illabot Creek (second point from the left in the top panel of Figure 10). After site 7, the remaining points upstream were sampled, followed by the most downstream site (2), which was sampled on the last day. Nitrate concentrations continued to decline during that time (Table 9, Figure 10). Phosphorus concentrations were also very low at the first sample site, but they increased at the upstream sites and then leveled off (Figure 10).

Concentrations of both total dissolved phosphorus and soluble reactive phosphorus were near those detected at all reaches in Illabot Creek.

Dissolved oxygen showed a pattern similar to phosphorus (Figure 10). Water temperatures remained fairly constant, with the coolest temperature--taken in the morning--recorded at site 7 (Table 9). The water temperatures of the remaining sites—taken in the afternoon--were higher. In Illabot Creek, pH levels were fairly constant (Figure 10). Conductivity was moderate to low relative to the other watersheds (Figure 6, Appendix 2). Conductivity was generally higher in the upstream sites then in the downstream sites (Figure 10).

Discharge varied little in Illabot Creek, ranging from 1.3 – 1.6 $m^3 \cdot s^{-1}$ (Table 10). Sinuosity was lower upstream than in the downstream sites (Figure 10). Bankfull width-to-depth ratio, however, was lowest at the most downstream segment and increased farther upstream (Figure 10). These results were partly because the most downstream sampling segment began in a canyon, and only the first four transects were measured because of technical difficulties. The mean width-to-depth ratio in Illabot Creek was the largest for the subwatersheds sampled in 2000 (Figure 8C). Entrenchment ratios in Illabot ranged from 1.5-2.2, with an average ratio of 1.7 (Table 10). Gradient was fairly consistent between reaches in Illabot Creek (Table 10, Figure 10).

In contrast to Lobster Creek, large wood frequency in Illabot was relatively constant, and ranged from 2.6 – 9.9 pieces $\cdot 100\ m^{-1}$ (Figure 9A, Table 10). The D_{50} and D_{84} values in Illabot Creek were intermediate with other watersheds (Figure 9 B,C), with means of 86.7 D-50 and 724.9 mm for D_{84}. Pool frequency ranged from 0.9 – 3.5 pools $\cdot 100\ m^{-1}$ (Table 10). Mean residual pool depth was 0.5 m (Table 10).

Arrow Creek

Only one site was sampled in Arrow Creek, so estimates of variance are not available for any of the data. The nitrate concentration of 0.04 mg · l^{-1} (Figure 11, Table 11) was similar to that in Illabot Creek (Figure 6). The concentrations of soluble reactive phosphorus in Arrow Creek were about the same as those in Illabot at 0.001 mg · l^{-1}, but the total dissolved phosphorus, 0.003 mg · l^{-1} in Arrow Creek were higher than in Illabot Creek (Figure 6). The remaining water-chemistry variables, dissolved oxygen, and pH were similar to those found in Illabot Creek; however, conductivity was considerably higher in Arrow Creek than in Illabot Creek (Figure 7, Table 11).

Arrow Creek discharge was 0.71 $m^3 \cdot s^{-1}$ in the single sampling site (Table 12). Gradient in Arrow Creek was 7%, and sinuosity was fairly low at 1.1 (Figure 11, Table 12). Width-to-depth ratio was 22.3 in Arrow Creek, and the entrenchment ratio was the lowest in any of the subwatersheds at 1.2 (Figure 8D, Appendix 3). Large wood counts in Arrow Creek were the highest in any of the subwatersheds; pool frequency was the lowest, with only one pool ·100 m^{-1} (Figure 9D). Mean residual pool depth in Arrow Creek was consistent with the other subwatersheds at 0.5 m depth (Appendix 3). The D_{50} was the highest of any subwatershed at 180 mm, but the D_{84} was 510 mm, intermediate among the other subwatersheds (Figure 9B,C; Appendix 3).

Beaver Creek

Although both nitrogen and phosphorus concentrations showed a generally decreasing trend from the mouth upstream, the data appear erratic (Figure 12), in spite of being collected in mainstem Beaver Creek and two tributaries. Mean nitrate concentrations were the lowest in Beaver Creek compared with the other subwatersheds, but both total dissolved phosphorus (0.008 mg $\cdot$ l^{-1}) and soluble reactive phosphorus (0.005 mg $\cdot$ l^{-1}) were high (Figure 6, Table 13). Dissolved oxygen concentrations were also highly variable (Figure 12), possibly because they were measured in both the morning and afternoon, maximizing variability from diel temperature fluctuations. Water temperature was the most variable in Beaver Creek, ranging from 8.5 to 14.1 °C (Table 13). In contrast, pH and conductivity were fairly consistent throughout the Beaver Creek subwatershed (Figure 12, Table 13).

Sinuosity and slope were fairly consistent in Beaver Creek, and they do not appear to change between the reaches near the mouth and those upstream (Figure 12). The width-to-depth ratios are typically lower in the upstream reaches compared to those near the mouth, but the data are variable (Figure 12). These ratios are among the lowest of all watersheds (Figure 8C). Entrenchment ratios ranged from 1.2 to1.8, with an average of 1.5 (Figure 12, Table 14). Discharge in Beaver Creek varied by an order of magnitude, with an average of 0.4m^3 $\cdot$ s^{-1} (Table 14).

Large wood counts were lowest in Beaver Creek, with a mean value of 3.4 pieces $\cdot$100 m^{-1}, compared with the other subwatersheds, but in contrast, pool frequency was highest in all the subwatersheds (Figure 9). Residual pool depth averaged 0.6 m, the highest in any watershed (Appendix 3). The D_{50} and D_{84} values were intermediate in Beaver Creek compared with the other subwatersheds; the substrate data were also the most variable (Figure 9 B,C).

Glade Creek

Nitrate concentrations increased from the downstream sites to the headwater reaches (Figure 13), but phosphorus concentrations declined from the mouth to the headwaters of the creek (Figure 13). Temperature and dissolved oxygen varied little among the sampling segments in Glade Creek, in contrast to the other subwatersheds (Figure 13, Table 15). All sample sites in Glade Creek was surveyed in a single day, so all chemical data were collected at roughly the same time each day to minimize variability from diel temperature fluctuations. Glade Creek was also the last subwatershed sampled; the diel temperature fluctuations were presumably less dramatic than they would have been earlier in the summer. Conductivity in Glade Creek was among the highest in the subwatersheds, and also the most variable (Figure 6). The timing of the data collection may have increased the data variability, however, because the meter was left behind, conductivity was later measured in the laboratory by using water samples collected and frozen. Rogue River NF personnel collected thermograph temperature data on the main stem of Glade Creek from 1997 through 1999 (Table 16). Temperatures exceeded the Oregon DEQ (2000) state temperature standard (17.7 °C) for salmonid spawning and rearing in 1999.

Discharge in Glade Creek averaged 0.3 $m^3 \cdot s^{-1}$ over the 10 sample sites (Table 17). Bankfull width-to-depth ratios ranged from 11.0 to 21.4 in Glade Creek, with a mean of 16.0 for the ten sampling segments (Table 17). Width-to-depth ratios were lower in the reaches nearer the headwaters compared to sites near the mouth (Figure 13). Entrenchment ratios varied little, with a range of 1.5 – 1.8 (mean = 1.6; Table 17). Sinuosity was relatively constant throughout the Glade Creek reaches, with an average of

1.1 over all reaches (range = about 1.0 – 1.3; Figure 13, Table 17). Stream gradient increased from the mouth to the headwaters of Glade Creek (Figure 13). The mean percentage slope was about 9.4 over all the sampling sites (Figure 13, Table 17). The highest gradient was found in the most upstream segment, which had 19% slope (Table 17).

Average large-wood frequency was $7.2 \cdot 100m^{-1}$ and pool frequency was $4.1 \cdot 100m^{-1}$ (Figure 9). Mean residual pool depth was 0.3m, the shallowest of all subwatersheds (Appendix 3). Substrate values were intermediate among the other watersheds, with values of 58 mm for D_{50} and 650 mm for D_{84} (Figure 9B,C).

Glade Creek had abundant fish, primarily rainbow trout. Only two of several hundred trout captured were identified as cutthroat (Table 18). Amphibians were sparse at best; only seven were captured. Three of the amphibians caught were tailed frogs, a state sensitive species; the others were three tree frogs and a Pacific giant salamander (Table 18). The weather was not conducive amphibian activity: the fall was unusually dry, so soils were very dry and relative humidity was low. On the final day of amphibian sampling, a storm deposited about 7 cm of snow, making conditions less than optimal for amphibians.

The existence of monumented cross sections in the Glade Creek subwatershed was one of the reasons it was chosen for the pre-pilot effort. The results of intensive surveys during the summer of 2000 were compared, where appropriate, to the data gathered at the monumented cross sections. The results and a discussion are included in Appendix 4.

Summary data were compared from the eight monitoring plan sites on the mainstem of Glade Creek and the basin stream inventory that encompassed a length of stream from the mouth up to about 200 m above the last site. Considerably more stream miles were covered in the stream inventory but more than twice the number of cross sections were measured at the eight intensive-survey segments. The width-to-depth ratios were very similar between the two methods even though the range was wider at the intensive survey reaches (Table 19). Entrenchment ratios were also very similar for the two surveys, but the range was lower for the intensively surveyed reaches. Both number of pools >1 m deep and large wood frequencies were similar (Table 19). The number of pools · 100 m^{-1} was slightly different between the two techniques. This difference might be attributed to different interpretations of pool definition (indicated by smaller average residual pool depths at most of the intensive survey sites; Figure 14). This difference in residual pool depth suggests that the intensive survey included marginal pools, and the basin survey excluded them. Amounts of large wood tallied varied widely between sites (Figure 14). Differences might be attributed to the bankfull-width measurement each crew used to determine minimum piece size.

Extensive Surveys -- Basin Stream Walk

The basin stream walk surveyed about 56.8 km in all five subwatersheds, accounting for about 75% of the length of stream on public lands. The highest percentage of stream kilometers surveyed was in Lobster Creek, with 89%(Table 20). More than 500 features were documented in the five subwatersheds surveyed (Table 21). Deep pools, log jams, and tributary junctions were the only features recorded in all five subwatersheds surveyed.

A total of 167 features were recorded in Lobster Creek from 18 to 30 August 2000. Deep pools were the most abundant feature found in this system, accounting for 31% of the total (Figure 15). Lobster Creek was the only subwatershed in which active beaver dams and other beaver activity were discovered. Many logjams (23) were encountered in this system (Figure 15). This subwatershed was also the only basin where artificial habitat structures were recorded. Land movements upslope of the stream channel were non-existent (Figure 15).

Illabot Creek in Washington was surveyed from 6 to 9 September 2000. A total of 53 features were documented during the survey; deep pools accounted for nearly half of them (Figure 16). Four land movements were documented upslope of the active channel. In addition, one lake and one off-channel pond were encountered (Figure 16); these systems, along with one lake in Arrow Creek were the only lentic systems documented during the 2000 field season.

The survey in Arrow Creek, Washington, was conducted from 10 to 11 September 2000. Arrow Creek had the fewest features reported, with a total of 32 (Figure 17). Deep pools were the most abundant feature in Arrow Creek, comprising about 40% of the total. Special features were also abundant, primarily braided channels and cascades.

By far, the most features (194) were logged in Beaver Creek (Figure 18), during the survey conducted 22 to 26 September 2000; 93 deep pools were documented in this basin (Figure 18), which was the most found in any subwatershed surveyed. Active landslides were also fairly common (34) in Beaver Creek (Figure 18). Special features documented in Beaver Creek were primarily the presence of amphibians.

A total of 124 features was recorded in Glade Creek during the 12 to 18 October survey. Special features were the most abundant reported in this basin (Figure 19), most of which were places with bank instability. A few were special features marking the beginning and ending of public and private lands. Several land movements were also found in this subwatershed (Figure 19).

Deep pools, log jams, and tributary junctions were the only features common to all subwatersheds, but all features shown in Figure 20 were found in at least three of the five subwatersheds (see Appendix 5 for example photographs). In contrast to the previous summary information, data in Figure 20 were normalized for the length of the stream. In four of the five subwatersheds, deep pools were the most frequently encountered feature, but few deep pools were found in Glade Creek. Special features were documented in all subwatersheds except for Lobster Creek, which was surveyed before the special feature category was added to the protocol (Figure 20).

Most of the rare features (Figure 21) were recorded in only one subwatershed (see Appendix 5 for example photographs). Lakes were encountered in Arrow Creek and Illabot Creek during the stream walk. Lobster Creek was the only subwatershed where beaver activity and dams were documented. Glade Creek was the only subwatershed with mining activities and road fords. A total of 36 uncommon features were documented in the five subwatersheds surveyed (Figure 21).

Fifty-six land movements were found in the five subwatersheds, mostly in Beaver and Glade Creeks (Figure 22). Of the land-movement features, active landslides were the most common, found in four of the five subwatersheds surveyed. Inactive landslides were found in three of the five subwatersheds. For monitoring-plan purposes, landslides were defined as the failure of a hill slope in which upslope debris was moved into the stream channel. Landslides that contributed debris to the stream channel regularly through the year were classified as "active." Inactive landslides were those that contributed only in winter or during high flow.

GIS, Remote Sensing, and Air Photos – Upslope and Riparian Watershed Condition Indicators

The following values will be derived from riparian and upslope areas from GIS analysis to use in the decision-support model:

- Proportion in early-, mid-, and late-seral stages.
- Dominant overstory type (coniferous or deciduous).
- Density of road stream-crossings.
- Road density by maintenance category.
- Frequency and volume of active landslides.
- Number of management-caused landslides
- Areas of high landslide risk.

Currently, road density, stream crossing, and upslope vegetation are complete for Lobster Creek. Road density and crossings are also complete in Lobster and Arrow Creeks. Progress is being made in obtaining aerial photographs and other appropriate GIS layers for the data in the remaining subwatersheds.

Discussion

The monitoring plan's primary goal is to evaluate the success of management and restoration efforts on aquatic and riparian ecosystems at the watershed scale, as called for under the Northwest Forest Plan. The monitoring plan's specific objectives as determined by Reeves et al. (2000, p. 9) include

1. Estimate the regional distribution of watershed conditions determined by integrating information from the suite of biological and physical indicators;
2. Develop and validate ecosystem-management decision-support models to refine indicator interpretation;
3. Develop predictive models to improve use of monitoring data, anticipate trends, and reduce long-term monitoring costs;
4. Provide information for adaptive management by analyzing trends in watershed condition and identifying elements resulting in poor watershed condition.

To the extent an understanding of cause and effect in aquatic and riparian habitats is desired, additional information needs can be integrated into the monitoring plan or as supplements to the ongoing Forest Plan implementation-monitoring plan; and provide a framework for adaptive monitoring at the regional scale.

During the 2000 pre-pilot, we focused on meeting the first two goals. Upslope, riparian, and in-channel data from 5 subwatersheds were collected and analyzed, then incorporated into a decision support model. During these efforts, several important data-collection issues arose and are described here by indicator. If the indicator is not discussed, then data-collection or other issues were not encountered. Justifications for protocol modifications are presented as well.

Physical Habitat Survey

We used cross-sectional surveys as described by the EMAP protocol (Kaufmann et al. 1999, Peck et al., in press) with one exception: our crews measured more points within the bankfull channel at each transect. The EMAP protocol describes taking five measurements to describe the channel profile within the bankfull channel with additional measurements taken at each wetted edge and the thalweg: The monitoring plan protocol calls for 12 measurements. Several hydrologists were consulted in developing the monitoring plan, all of whom recommended taking more measurements at each cross section for finer data resolution.

To detect change, sampling sites and the transects within them must be monumented to allow future resampling at the same locations. Monumenting cross sections in unconstrained channels or response reaches and increasing our sampling effort should increase our ability to detect temporal changes. Because constrained sites are generally considered less likely to respond to disturbance, a cost and time savings is possible if only a representative portion of the constrained sites are monumented.. Monumenting site locations and taking additional measurements will increase the amount of time and money needed to complete each site, therefore either the number of sites within a watershed or the number of watersheds completed each year may decrease.

Bankfull stage identification

The single largest problem with any of the protocols was accurate and consistent identification of bankfull stage. We consulted several resources that describe the use of field indicators for identifying bankfull stage. However, even with an experienced crew and these additional tools, consistently identifying bankfull within or between sites was difficult. Misidentifying bankfull height results in an erroneous bankfull width, resulting in erroneous calculation of site length, and width-to-depth and entrenchment ratios. Large wood counts are also affected by inaccurate bankfull identification.

Currently, methods for consistently identifying bankfull height are being explored. One possible technique using data from gauging stations in or near the subwatershed on precipitation and geologic features may help to indicate the bankfull elevation. Bankfull-stage recurrence interval can be calculated from gauging-station data, and bankfull height at the gauging station is determined. Good bankfull indicators near the gauging station are then identified and sought out in the subwatershed. This technique is expected to provide a more consistent measure of bankfull height than the haphazard individual identification during the 2000 summer field exercises. The downside of using this technique is that many of the subwatersheds sampled will not have a gauging station.

Entrenchment ratio

Initially, we intended to capture flood-prone width only at the narrowest and widest transects at each survey reach. These data would provide the range of flood-prone widths in the reach; however, determining which transects had the narrowest and widest transects was difficult. We then attempted to survey all transects above flood-prone height, yet we sometimes missed flood-prone during the survey, particularly in wider areas. Surveying beyond flood-prone at wide transects is time- and labor- intensive because so much vegetation must be cleared to create a line of sight between the laser range finder and the prism. In our attempt to determine the average flood-prone width, we found that our data consisted of several of the narrower transects and a few wider transects. Thus, mean flood-prone width was underestimated.

Recommendation: Measure two randomly selected transects for flood-prone measurements.

Justification: Using a random-number table to select two transects for flood-prone measurements eliminates the need to identify the widest and narrowest transect. Further, because the selected transect is random, any judgment on the part of the field crew is eliminated and by chance, the widest and narrowest transects would eventually be selected.

Environmental Variables

Wood counts --Large-wood was counted as described by the ODFW habitat-inventory survey protocol (Moore et al. 1999). The monitoring plan criteria for length of large wood were slightly different than the criteria in the ODFW protocol, however. The ODFW protocol outlined size classes for large wood, but the monitoring plan's protocol outlined a length criterion based on bankfull width. The size classes used by ODFW included small pieces of large wood that may provide habitat for stream biota. The length criteria developed for the monitoring plan pre-pilot, however, was designed to record only the large pieces that would contribute to large-scale channel changes.

Recommendation: Use the length classes based on the ODFW protocol and cataloging location of each piece in the stream.

Justification: Ensures consistency with ODFW protocols, and still allows data to be compared to Forest Service Level II protocols (which counts the number of large woody material in different size categories).

Substrate measurements

Pebble-count protocols were also slightly modified from the EMAP protocol. The EMAP protocol describes taking five substrate measurements at each major transect (Kaufmann et al. 1999, Peck et al., in press). To have adequate substrate measurements, the EPA added five counts at intermediate transects, located between the major ones. In contrast, our crews took 11 substrate counts at each major transect, rather than using the intermediate transect approach. Because crews were already taking additional measurements at each transect, taking substrate counts at each measurement increment seemed logical. In addition, this modification more closely approximates the methods detailed by Wolman (1954).

A criticism of the Wolman (1954) pebble count is that the method tends to overestimate mean particle size; therefore fine sediments are not adequately characterized. For these reasons, additional fines sampling using a Klamath grid will be implemented in 2001, using the USFS Region 5 SCI protocol (1998).

Comparing the Basinwide Survey with Intensive and Extensive Results

The data collected by the stream-inventory survey and the monitoring plan's intensive survey were remarkably similar (Table 18). Mean bankfull width-to-depth ratios varied by less than 5%, and entrenchment ratios varied by about 16%. The range of entrenchment ratios between the two survey methods differed considerably in the wider reaches of the watershed, a not-surprising difference considering our difficulties in capturing flood-prone width in wide sites. Large-wood frequency results were also strikingly similar between the two methods. The largest difference was with pool frequency; we found three 3 pools · 100 m^{-1} during the stream survey compared with 4.7 in the monitoring plan's intensive survey (Table 18). Because the number of pools deeper than 1 m was essentially the same, we assume that discrepancies arise in consistently classifying the smaller pools or marginal habitats. Similar problems have been described by Roper and Scharnnechia (1995).

Extensive Surveys

Recommendation: Add tasks from the stream-walk protocol to a Forest Service Level II-type habitat survey. Data on the major features in the stream would be used as a supplement to the habitat-inventory data. During the 2000 field season, the stream-walk crew usually finished their survey in seven or eight days. The combination of the two surveys would likely take two weeks to complete.

Justification: Addition of the Level II-type habitat survey would provide a dataset on the use of sub-sampling (i.e., Intensive surveys) versus conducting a census (i.e., Level II surveys).

Comparing Fixed and Random Transects

Another modification of the protocol under consideration is completing a small number of monumented cross sections in the intensive survey rather than completing cross sections in a large number of randomly-selected transects, as currently described in the protocol. This change would significantly reduce sample size, however our ability to detect change in the stream should improve.

Recommendation: Complete a small number of monumented cross sections in the intensive survey rather than completing cross sections in a large number of randomly-selected transects.

Justification: This change would significantly reduce sample size and increase our ability to detect change in the stream.

Intensive – extensive survey comparison

We compared the data generated during the monitoring plan's intensive survey in Glade Creek with the survey of two monumented cross sections completed in 1996. The goal was to determine whether existing subwatershed data could be used by the plan.

Data were compared for five in-channel variables: substrate D_{50}, bankfull width-to-depth ratio, entrenchment ratio, sinuosity, and slope percentage. Sinuosity and D_{50} were similar between the two data sets, but bankfull width-to-depth ratio was significantly different in the comparisons. Entrenchment ratio was similar in one of the two reach comparisons.

Comparing the data sets was not valid for several reasons. Briefly the monumented sites were not surveyed in the intensive survey. Also, the data compared were means of the plan's sample reach-data to a single data point for the cross section. Finally, the monumented survey data were collected in fall 1996, before the 1997 New Year's flood. Further details of the comparison are included in Appendix 4.

GIS Topics

Available data layers are inconsistent in quality, scale, and extent. Few regional datasets are available, but they can likely be acquired at the state, county, NF, USGS quadrangle, or watershed scales. Often, boundaries do not match between coverages at different scales; for example, the 4th-field HUC boundaries drawn at 1:250,000 scale do not match 5th-field boundaries drawn at 1:24,000. In addition, boundaries and data attributes generally do not match between coverages collected from different sources such as different forests or the Forest Service and the Bureau of Land Management. Many geospatial datasets are under construction by the supporting agencies and are thus currently incomplete or unavailable. [list datasets w/date of completion if known]

Improving Efficiency and Lowering Cost

Recommendation: Field-operations personnel should conduct preliminary scouting of each watershed in the spring to improve the efficiency of survey crews.

Justification: During this reconnaissance visit, the field operations personnel would install electronic temperature thermographs, visit each selected site to determine whether it could be sampled, map the best roads and walk-in locations, and inspect bankfull recurrence heights at gauging stations to determine the best indicators.

Recommendation: Conduct analysis of the number of sample sites completed in a watershed and the number of measurements collected at each site (that is, cross-sectional profiles, macroinvertebrates, periphyton, substrate counts, and vertebrate sampling).

Justification: This would help determine whether we are oversampling them.
Reducing the number of measurements collected at each site would only be useful if it allowed us to sample two sites per day. Hiking back into a site to complete it was not cost effective because getting to another site and completing it in the same day was impossible.
Reconnaissance and determining sites to be sampled before the crew goes into the field would allow them to go on to the next-nearest site. This doubling-up might allow them to sample more than one site per day, but only if the number of measurements in several of the sampling activities is reduced.

Recommendation: Have the stream-walk crew start one to two weeks before the habitat-sampling crew.

Justification: The stream-walk crew could verify if a site could be sampled and, if so, they could locate it by GPS and mark the transects. This information would allow the habitat crew to start sampling immediately when they arrive at the site. If we choose to collect less and measure fewer variables at sites with constrained channels, either the stream-walk crew or the field-operations person could determine which sites were constrained before the habitat crew arrives.

Personnel and Costs Associated with Surveying Sub-Watersheds

The anticipated costs for future sub-watershed surveys (four different scenarios), based on "lessons learned" during the 2000 and 2001 field seasons, are presented in Table 22. There are six major categories of AREMP operation. They are 1) coordinating all field logistics (hiring, training, safety, payroll, travel, equipment purchases, etc) 2) handling the data (data processing; building, maintaining, and revising the decision support model used to analyze the data; and specialized analysis), 3) creating and updating fuzzy curves, 4) overhead costs (building space, phones, support personnel, training, equipment), 5) GIS support, 6) coordinating with state and federal land managers.

The total cost per sub-watershed is $58,000 and $40,000 for the pilot efforts of 16 or 32 sub-watersheds, respectively. For full implementation of the AREMP plan (50 sub-watersheds), the first year costs approximately $34,000 per sub-watershed and subsequent years cost approximately $30,000 per sub-watershed (based on 2001 prices, salary costs, etc.). While the salary component increases across all areas of operation as the number of sub-watersheds increase, base and equipment costs stay constant and decrease, respectively, as the number of sub-watersheds increase.

These costs are based on the need for a five-person crew, in order to finish one survey site each day, and 4-10 survey sites will be done per sub-watershed. Resurveying sub-watersheds for quality assurance also needs to be factored in. Generally speaking, two sites need to be resurveyed in each sub-watershed. Based on our 2000 and 2001 surveys we are adding another crewmember (the "block leader") to conduct reconnaissance of the sub-watersheds before field crews arrive on site. Scouting sub-watersheds involves, but is not limited to, tasks such as finding major access roads, camp sites, creek access points, determining which sample sites are suitable for survey, placement of water temperature probes, etc. The block leaders will also be responsible for general crew management tasks. Those tasks include checking the data for quality assurance, serving as the conduit for equipment repair and replacement, and serving as another check on to ensure to protocols are being followed correctly.

Conclusions

The 2000 pre-pilot taught us a tremendous amount about the adequacy of our protocols, efficiency of crews, and the time and financial requirements for sampling. We developed and refined data collection protocols that are repeatable and produce quantifiable data. Since the protocols are based on existing protocols, data sharing with other state and federal agencies will be possible. Problems such as the limitations of the substrate protocol to examine fine substrates were identified and corrected. The time in the field also gave us the opportunity to maximize crew efficiency and get a grasp on the logistical issues and time constraints that come from the implementation of such a large-scale monitoring program. For example, field reconnaissance is requisite for identification of areas in the watershed that can be sampled and for determining access routes, so we don't have entire crews wandering around lost or trying to access areas that are not suitable for sampling (e.g. dry).

In the office, we gained tremendous insight on our upslope and riparian analyses and our information management requirements. Several problems related to the GIS analysis of upslope and riparian vegetation and roads were identified. Many errors could potentially be introduced since many of the GIS layers are not consistent in quality or extent. For example, the roads layers may or may not have maintenance category, or they may have different definitions for the categories. Further, a roads layer across the NFP area currently does not exist; in fact, few region-wide coverages are available. A list of GIS data needs is included in Table 23.

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Tables

Table 1. Geographic information for the five subwatersheds sampled during the 2000 field season. Subwatershed is the common creek name, HUC is the 4th field Hydrologic Unit Code(5th and 6th HUC codes are not available as of this draft) as designated by the US Geological Survey, Province refers to the Northwest Forest Plan Province, Major River is the major river system into which the creek surveyed flows, and UTM is the Universal Transverse Mercator coordinate for the point at which the stream exist the 6th field HUC.

Subwatershed	HUC	Province	State	River Basin	UTM
Lobster	17100205	Coast Range	OR	Alsea	10T 0447731 4901852
Illabot	17110005	W. Cascades	WA	Skagit	10U 0617596 5364840
Arrow	17110005	W. Cascades	WA	Skagit	10U 0619046 5364260
Beaver	18010104	Klamath	CA	Mid Fork Eel	10S 0499769 4420375
Glade	17100309	Klamath Mtns.	OR	Little Applegate	10T 0511582 4665293

Table 2. Sampling information for each subwatershed. Subwatershed is the common creek name, Date is the dates of sampling for each subwatershed, and N is the number of surveyed sites. Length is the total length (in kilometers) of channel intensively surveyed, whereas % Length is the percentage that the intensive survey length comprises of the entire stream length on public lands. Walk is the total distance surveyed during the stream walk, whereas % Walk is the percentage that the stream walk length comprises of the entire stream length on public lands. Stream is the total distance (in kilometers) of stream channel on public lands. All stream lengths were taken from 1:100,000 scale maps except the Length values which is the actual surveyed distance.

Subwatershed	**Date**	**N**	**Length**	**% Length**	**Walk**	**% Walk**	**Stream**
Lobster	8/21 – 8/29	9	1.74	4	17.54	39	44.90
Illabot	9/9 – 9/16	4	1.29	5	8.37	33	25.43
Arrow	9/6	1	0.20	5	3.54	81	4.35
Beaver	9/23 – 10/1	8	1.22	5	15.29	62	24.62
Glade	10/12 – 10-20	10	1.51	8	15.45	83	18.68

Table 3. Data collected in each of the five subwatersheds. See the Methods for a description of the different parameters.

	Lobster	Illabot	Arrow	Beaver	Glade
Physical Habitat					
Width:depth	X	X	X	X	X
% Slope	X	X	X	X	X
Sinuosity	X	X	X	X	X
Entrenchment ratio	X	X	X	X	X
Substrate	X	X	X	X	X
Large wood	X	X	X	X	X
# Pools	X	X	X	X	X
Pool maximum depth	X	X	X	X	X
Pool residual depth	X	X	X	X	X
Water Chemistry					
Nitrate/nitrite	X	X	X	X	X
Total dissolved phosphorus	X	X	X	X	X
Soluble reactive phosphorus	X	X	X	X	X
Dissolved oxygen	X	X	X	X	X
Conductivity	X	X	X	X	X
pH	X	X	X	X	X
Temperature	X	X	X	X	X
Biological Sampling					
Periphyton	X	X	X	X	X
Macroinvertebrates	X	X	X	X	X
Amphibians	X*				X
Fish	X*				X

* Sampling was conducted at 6 of 9 sample sites

Table 4. Summary of methods used to collect data on AREMP subwatershed condition indicators. See the Methods for a description of the different parameters (Indicators). Collection refers to the method used to collect the data, where Calc. indicates values that were calculated after the field season, and Field indicates values that were measured on site. Methods briefly describes the technique used to generate the information.

Indicator	Collection	Method
Physical Habitat		
Width: depth	Calc.	= bankfull width / mean depth
% Slope	Calc.	= rise / run of the sample reach
Sinuosity	Calc.	= stream length / valley length
Entrenchment ratio	Calc.	= flood prone width / bankfull width
Substrate	Field	Modified Wolman pebble count
Large wood	Field	Tally of pieces in sample reach
# Pools	Field	Tally of pools in sample reach
Pool maximum depth	Field	Direct measurement
Pool residual depth	Calc.	= Pool max depth - pool tail crest depth
Water Chemistry		
Nitrate/nitrite	Field	Water collected for lab determination
Total dissolved phosphorus	Field	Water collected for lab determination
Soluble reactive phosphorus	Field	Water collected for lab determination
Dissolved oxygen	Field	YSI 85 meter
Conductivity	Field	YSI 85 meter
pH	Field	YSI 60 meter
Temperature	Field	YSI 85 meter
Biological Sampling		
Periphyton	Field	Removal from known substrate area
Macroinvertebrates	Field	Kicknet sampling at each transect
Amphibians	Field	Electroshocking and timed stream bank search
Fish	Field	Electroshocking

Table 5. Lobster Creek water chemistry data. The water chemistry parameters are water temperature (Temp.), dissolved oxygen (DO), conductivity (Cond.), pH, alkalinity (Alk.), total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), and nitrate/nitrite (NO_3) concentrations. Blank cells indicate missing data.

Site	**Date**	**Temp.** (°C)	**DO** (mg · l^{-1})	**Cond.** (μS · cm^{-1})	**pH**	**Alk.**	**TDP** (mg · l^{-1})	**SRP** (mg · l^{-1})	**NO_3** (mg · l^{-1})
6	08/28/2000				6.2	0.0	0.008	0.006	0.220
14	08/22/2000	12.8	10.1	47.0	7.3	0.0	0.008	0.004	0.100
18	08/29/2000	14.8	10.7	35.1	7.3	0.0	0.010	0.005	0.278
26	08/24/2000	14.9	6.6	25.2	6.6	0.0	0.007	0.005	0.201
30	08/29/2000	11.4	9.1	31.1	6.9	0.0	0.009	0.006	0.209
38	08/24/2000	12.3	9.7	36.1	6.5	0.0	0.014	0.009	0.135
46	08/21/2000	13.9	7.1		7.1	0.0	0.010	0.006	0.125
66	08/21/2000	11.8	8.5	36.5	7.1	0.0	0.011	0.005	0.209
78	08/22/2000	15.8	10.0	36.5	6.9	0.0	0.010	0.004	0.093
	Mean	13.46	9.0	35.4	6.9	0.0	0.010	0.006	0.174
	Var	2.62	2.2	43.3	0.1	0.0	0.000	0.000	0.004

Table 6. Seven-day average maximum summer temperatures from 1995-99 in the East Fork (E.F.) and mainstem of Lobster Creek, OR. Source: ODFW Tillamook district office.

Stream	Year	Date	7 d Average Max (°C)	Lat. Long. Location
Lobster Creek	1995	July 16-22	15.7	N 44.24651, W 123.64077
Lobster Creek	1996	July 23-29	18.0	N 44.24651, W 123.64077
Lobster Creek	1997	Aug. 11-17	14.4	N 44.24651, W 123.64077
Lobster Creek	1998	July 22-28	17.7	N 44.24651, W 123.64077
Lobster Creek	1999	Aug. 22-27	15.3	N 44.24651, W 123.64077
E.F. Lobster Cr	1992	Aug. 11-17	15.5	N 44.24871, W 123.63161
E.F. Lobster Cr	1997	Aug. 2-8	14.3	N 44.24871, W 123.63161
E.F. Lobster Cr	1997	Aug. 15-21	14.3	N 44.24871, W 123.63161
E.F. Lobster Cr	1998	July 22-28	15.6	N 44.24871, W 123.63161

Table 7. Summary of Lobster Creek in-channel and habitat data. Parameters include discharge (Q), % Slope (calculated from the bed surface), Sinuosity (Sin.), Entrenchment ratio (Ent.), bankfull width:depth (W:D), D_{50} and D_{84} substrate counts, large wood (Wood), pool frequency (Pool), and residual pool depth (P Dep). Numbers in parentheses with entrenchment ratios are the number of transects used to calculate site means. Slope, large wood, pool frequency, and pool depth are averages of data within the sample site. Site means (Mean), variance estimates (Var), and grand means (GM) are given at the bottom of the table. The number in parenthesis beneath the entrenchment grand mean is the estimate of variance around the grand mean. See text for explanation of grand mean calculation.

Site	**Q ($m^3 \cdot sec^{-1}$)**	**% Slope**	**Sin.**	**Ent.**	**W:D**	**D_{50}**	**D_{84}**	**Wood $\# \cdot 100m^{-1}$**	**Pool $\# \cdot 100m^{-1}$**	**P Dep (m)**
6	0.008	2.8	1.0	1.90 (6)	23.3	68.1	215.8	3.9	4.7	0.3
14	0.023	1.3	1.2	1.71 (4)	21.0	31.9	120.5	9.2	5.3	0.4
18	0.050	1.7	1.1	1.29 (7)	47.3	45.0	1024.0	0.5	3.2	0.5
26	0.010	1.4	1.3	1.51 (5)	29.9	90.0	180.0	1.9	4.5	0.4
30	0.004	4.1	1.1	1.41 (6)	27.6	65.6	432.1	13.5	4.1	0.3
38	0.008	3.2	1.1	3.77 (3)	8.1	50.5	119.4	4.6	10.6	0.2
46	0.028	1.8	1.1	2.11 (3)	22.9	39.0	160.5	15.5	3.0	0.5
66	0.044	2.0	1.2	1.28 (3)	14.4	45.0	362.0	3.9	4.7	0.6
78	0.012	2.1	1.1	1.66 (4)	22.9	22.0	76.2	5.8	5.8	0.4
Mean	0.022	2.2	1.1	1.85	24.2	50.8	299.0	6.9	5.1	0.4
Var	0.000	0.9	0.0	1.49	118.5	431.4	87664	29.3	5.7	0.0
GM				1.74 (210.6)	24.2	44.7	198.5	58.9	45.8	

Table 8. Lobster Creek fish and amphibian capture data for the six sites surveyed for aquatic and terrestrial amphibians and fish. N is the total number of animals caught. Catch per unit effort (CPUE; in seconds) data are the electrofishing data for aquatic species. Density data are for terrestrial amphibian species in numbers of animals captured per square meter.

Species	N	CPUE	Density
Fish			
Cottus sp.	190	0.79	
*(*Unidentified sculpin)		0.89	
Oncorhynchus sp.	89	0.31	
(Unidentified trout)		(0.03)	
Amphibians			
Dicamptodon tenebrosus	19	0.11	0.04
(Pacific giant salamander)		(0.01)	(0.00)
Plethodon dunni	55		0.07
(Dunn's salamander)			(0.00)
Plethodon vehiculum	46		0.08
(Western red-backed salamander)			(0.01)
Plethodon sp.	2		0.04
(Unidentified plethodon)			(0.01)
Taricha granulosa	2		0.09
(Rough-skinned newt)			(0.03)
Ascaphus truei	8	0.01	0.01
(Tailed frog)		(0.00)	(0.00)

Table 9. Illabot Creek water chemistry data. The water chemistry parameters are water temperature (Temp.), dissolved oxygen (DO), conductivity (Cond.), pH, alkalinity (Alk.), total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), and nitrate/nitrite (NO_3) concentrations. Blank cells indicate missing data.

Site	Date	Temp. (°C)	DO ($mg \cdot l^{-1}$)	Cond. ($\mu S \cdot cm^{-1}$)	pH	Alk.	TDP ($mg \cdot l^{-1}$)	SRP ($mg \cdot l^{-1}$)	NO_3 ($mg \cdot l^{-1}$)
2	09/16/2000	9.1	8.9	14.4	6.8	0.0	0.001	0.000	0.034
7	09/11/2000	5.8	11.9	10.8	7.3	0.0	0.001	0.001	0.060
31	09/12/2000	7.3	12.0	12.1	7.1	0.0	0.002	0.001	0.051
71	09/09/2000	8.9	12.9	19.0	7.0	0.0	0.002	0.001	0.048
Mean			11.4	14.1	7.1	0.0	0.002	0.001	0.048
Var			3.0	13.0	0.0	0.0	0.000	0.000	0.000

Table 10. Summary of Illabot Creek in-channel and habitat data. Parameters include discharge (Q), % Slope (calculated from the bed surface), Sinuosity (Sin.), Entrenchment ratio (Ent.), bankfull width:depth (W:D), D_{50} and D_{84} substrate counts, large wood (Wood), pool frequency (Pool), and residual pool depth (P Dep). Numbers in parentheses with entrenchment ratios are the number of transects used to calculate site means. Slope, large wood, pool frequency, and pool depth are averages of data within the sample site. Site means (Mean), variance estimates (Var), and grand means (GM) are given at the bottom of the table. The number in parenthesis beneath the entrenchment grand mean is the estimate of variance around the grand mean. See text for explanation of grand mean calculation.

Site	**Q ($m^3 \cdot sec^{-1}$)**	**% Slope**	**Sin.**	**Ent.**	**W:D**	**D_{50}**	**D_{84}**	**Wood $\# \cdot 100m^{-1}$**	**Pool $\# \cdot 100m^{-1}$**	**P Dep (m)**
2	1.5	3.6	1.7	2.2 (2)	19.7	214.7	2267.2	6.9	3.5	0.49
7	1.5	1.7	1.3	1.8 (2)	36.1	24.2	90.4	9.9	0.9	0.79
31	1.3	3.8	1.2	1.5 (3)	26.2	42.3	265.9	2.6	1.0	0.41
71	1.6	4.2	1.1	1.6 (8)	25.4	65.8	276.0	5.4	0.9	0.38
Mean	1.4	3.3	1.3	1.7	26.9	86.7	724.9	6.2	1.6	0.52
Var	0.1	1.2	0.1	0.3	46.4	7563	1064444	9.2	1.6	0.03
GM				1.7	28.2	40.8	239.8	24.8	6.3	

Table 11. Arrow Creek water chemistry data. The water chemistry parameters are water temperature (Temp.), dissolved oxygen (DO), conductivity (Cond.), pH, alkalinity (Alk.), total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), and nitrate/nitrite (NO_3) concentrations.

Site	**Date**	**Temp.** (°C)	**DO** ($mg \cdot l^{-1}$)	**Cond.** ($\mu S \cdot cm^{-1}$)	**pH**	**Alk.**	**TDP** ($mg \cdot l^{-1}$)	**SRP** ($mg \cdot l^{-1}$)	**NO_3** ($mg \cdot l^{-1}$)
22	09/66/2000	8.4	10.3	31.9	6.9	0.0	0.003	0.001	0.040

Table 12. Summary of Arrow Creek in-channel and habitat data. Parameters include discharge (Q), % Slope (calculated from the bed surface), Sinuosity (Sin.), Entrenchment ratio (Ent.), bankfull width:depth (W:D), D_{50} and D_{84} substrate counts, large wood (Wood), pool frequency (Pool), and residual pool depth (P Dep). Numbers in parentheses with entrenchment ratios are the number of transects used to calculate site means. Slope, large wood, pool frequency, and pool depth are averages of data within the sample site. Site means (Mean), variance estimates (Var), and grand means (GM) are given at the bottom of the table. The number in parenthesis beneath the entrenchment grand mean is the estimate of variance around the grand mean. See text for explanation of grand mean calculation.

Site	**Q ($m^3 \cdot sec^{-1}$)**	**% Slope**	**Sin.**	**Ent.**	**W:D**	**D_{50}**	**D_{84}**	**Wood # · $100m^{-1}$**	**Pool # · $100m^{-1}$**	**P Dep (m)**
22	0.71	7.0	1.07	1.2 (2)	22.3	180.0	510.4	14.8	0.96	0.50

Table 13. Beaver Creek water chemistry data. The water chemistry parameters are water temperature (Temp.), dissolved oxygen (DO), conductivity (Cond.), pH, alkalinity (Alk.), total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), and nitrate/nitrite (NO_3) concentrations. Blank cells indicate missing data.

Site	Date	Temp. (°C)	DO ($mg \cdot l^{-1}$)	Cond. ($\mu S \cdot cm^{-1}$)	pH	Alk.	TDP ($mg \cdot l^{-1}$)	SRP ($mg \cdot l^{-1}$)	NO_3 ($mg \cdot l^{-1}$)
6	09/26/2000	10.0	7.6	133.4	7.9	0.0	0.011	0.005	0.015
11	09/23/2000	14.1	8.2	136.2	7.8	0.0	0.008	0.005	0.044
12	09/29/2000	12.3	6.9	127.1	7.3	0.0	0.009	0.006	0.008
21	09/28/2000	8.5	7.5	128.8	7.0	0.0	0.006	0.003	0.001
25	09/25/2000	8.6	9.8	129.4	7.5	0.0	0.005	0.003	0.004
31	09/23/2000	13.4	9.7	129.6	8.0	0.0	0.008	0.004	0.022
33	10/01/2000	10.1	8.8	112.8	7.9	0.0	0.006	0.003	0.003
34	09/30/2000	11.1	8.5	111.7	7.5	0.0	0.010	0.007	0.029
	Mean		8.4	126.1	7.6	0.0	0.008	0.005	0.016
	Var		1.1	81.6	0.1	0.0	0.000	0.000	0.000

Table 14. Summary of Beaver Creek in-channel and habitat data. Parameters include discharge (Q), % Slope (calculated from the bed surface), Sinuosity (Sin.), Entrenchment ratio (Ent.), bankfull width:depth (W:D), D_{50} and D_{84} substrate counts, large wood (Wood), pool frequency (Pool), and residual pool depth (P Dep). Numbers in parentheses with entrenchment ratios are the number of transects used to calculate site means. Slope, large wood, pool frequency, and pool depth are averages of data within the sample site. Site means (Mean), variance estimates (Var), and grand means (GM) are given at the bottom of the table. The number in parenthesis beneath the entrenchment grand mean is the estimate of variance around the grand mean. See text for explanation of grand mean calculation.

Site	**Q ($m^3 \cdot sec^{-1}$)**	**% Slope**	**Sin.**	**Ent.**	**W:D**	**D_{50}**	**D_{84}**	**Wood $\# \cdot 100m^{-1}$**	**Pools $\# \cdot 100m^{-1}$**	**P Dep (m)**
6	0.1	3.5	1.2	1.53 (10)	20.0	42.2	321.0	2.5	8.3	0.2
11	0.3	7.5	1.1	1.25 (6)	21.7	221.1	1353.0	2.6	4.5	1.1
12	0.0	7.1	1.4	1.85 (9)	15.5	28.3	274.7	5.2	11.7	0.4
21	0.0	4.3	1.2	1.54 (8)	15.3	48.5	2432.1	0.0	5.4	0.4
25	0.0	5.4	1.1	1.34 (8)	11.7	803.4	3241.0	0.7	8.0	1.1
31	0.2	5.6	1.2	1.62 (2)	32.6	180.0	560.0	3.4	1.7	0.2
33	0.0	2.2	1.0	1.28 (11)	18.4	75.9	526.4	2.7	4.7	0.4
34	1.0	8.7	1.1	1.38 (9)	18.1	128.0	2048.0	9.9	14.5	0.6
Mean	0.4	5.5	1.2	1.5	19.2	190.9	1344.5	3.4	7.3	0.6
Var	0.2	4.8	0.0	0.2	39.0	66027	1250176	9.4	17.4	0.1
GM				1.5	18.7	88.0	1100.9	26.9	58.8	

Table 15. Glade Creek water chemistry data. The water chemistry parameters are water temperature (Temp.), dissolved oxygen (DO), conductivity (Cond.), pH, alkalinity (Alk.), total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), and nitrate/nitrite (NO_3) concentrations. Blank cells indicate missing data.

Site	**Date**	**Temp** (°C)	**DO** ($mg \cdot l^{-1}$)	**Cond.** ($\mu S \cdot cm^{-1}$)	**pH**	**Alk.**	**TDP** ($mg \cdot l^{-1}$)	**SRP** ($mg \cdot l^{-1}$)	**NO_3** ($mg \cdot l^{-1}$)
3	10/13/2000	6.8	10.4	77.0	7.9	0.0	0.018	0.012	0.008
5	10/14/2000	6.8	10.0	79.0	8.1	0.0	0.020	0.013	0.010
6	10/18/2000	6.8	10.6	81.0	8.0	0.0	0.011	0.006	0.032
8	10/19/2000	4.0	10.6	170.0	7.9	0.0	0.009	0.003	0.069
9	10/21/2000	4.0	10.0	181.0	8.3	0.0	0.007	0.003	0.084
10	10/20/2000	7.0	11.0	153.0	8.5	0.0	0.014	0.007	0.069
23	10/12/2000	7.0	10.4	113.0	8.5	0.0	0.018	0.010	0.024
25	10/15/2000	7.0	11.0	92.0	8.1	0.0	0.015	0.010	0.021
28	10/17/2000		10.4	116.0	8.2	0.0	0.014	0.007	0.035
			10.4	148.0	8.5	0.0	0.008	0.003	0.059
	Mean		10.48	121.0	8.20	0.0	0.013	0.007	0.041
	Var		0.12	1553.8	0.06	0.0	0.000	0.000	0.001

Table 16. Seven-day average maximum summer temperatures from 1997-99 in Glade Creek, OR. Source: Rouge NF, Ashland RD.

Stream	Year	Date	7 d Average Max (°C)	UTM Location	
Glade Creek	1997	July 3-9	17.7	511,534.52	4,664,957.22
Glade Creek	1998	July 21-27	17.5	511,534.52	4,664,957.22
Glade Creek	1999	Aug. 20-26	18.3	511,534.52	4,664,957.22

Table 17. Summary of Glade Creek in-channel and habitat data. Parameters include: discharge (Q), % Slope (calculated from the bed surface), Sinuosity (Sin.), Entrenchment ratio (Ent.), bankfull width: depth (W: D), D_{50} and D_{84} substrate counts, Large wood (Wood) and Pool (Pool) frequency, and residual pool depth (P Dep). Numbers in parentheses with the entrenchment ratios indicate the number of transects used to calculate the site mean. Slope, large wood, pool frequency, and pool depth are averages of data within the sample site. Site means, variance estimates (Var), and grand mean (GM) are given at the bottom of the table. See text for explanation of grand mean calculation.

Site	**Q ($m^3 \cdot sec^{-1}$)**	**% Slope**	**Sin.**	**Ent.**	**W:D**	**D_{50}**	**D_{84}**	**Wood # · $100m^{-1}$**	**Pools # · $100m^{-1}$**	**P Dep (m)**
2	0.1	1.1	1.1	1.83 (9)	21.4	19.9	152.1	5.4	2.7	0.1
3	0.0	8.4	1.0	1.84 (7)	15.5	0.8	117.3	14.6	1.3	0.5
5	0.5	7.5	1.1	1.60 (9)	17.9	32.0	450.1	3.1	8.1	0.2
6	0.1	15.6	1.0	1.57 (7)	14.4	65.8	250.5	10.2	3.4	0.2
8	0.2	14.4	1.3	1.56 (8)	15.6	39.3	297.2	20.3	6.3	0.3
9	0.3	8.3	1.0	1.54 (8)	15.8	143.4	2019.8	5.8	6.4	0.3
10	0.6	6.3	1.1	1.7 (10)	18.1	101.8	556.4	0.6	3.9	0.2
23	0.8	3.8	1.0	1.50 (7)	15.1	20.3	247.8	4.9	4.9	0.3
25	0.2	9.1	1.1	1.64 (8)	14.7	130.4	2115.3	0.7	2.1	0.7
28	0.3	19.1	1.0	1.8 (10)	11.0	24.7	294.4	6.8	2.1	0.3
Mean	0.3	9.4	1.1	1.6	15.9	57.8	650.1	7.2	4.1	0.3
Var	0.1	30.5	0.0	0.2	7.5	2534.1	575125	38.7	5.1	0.0
GM				1.7	15.9	37.2	359.8	72.5	41.1	

Table 18. Glade Creek fish and amphibian capture data for the six sites surveyed for aquatic and terrestrial amphibians and fish. N is the total number of animals caught. Catch per unit effort (CPUE; in seconds) data are the electrofishing data for aquatic species. Density data are for terrestrial amphibian species in numbers of animals captured per square meter.

Species	N	CPUE	Density
Fish			
Oncorhynchus mykiss	721	0.36	
(Rainbow trout)		(0.04)	
Oncorhynchus clarkii	6	0.01	
(Cutthroat trout)		(0.00)	
Amphibians			
Dicamptodon tenebrosus	37	0.02	0.003
(Pacific giant salamander)		(0.00)	(0.000)
Ascaphus truei	18	0.21	0.003
(Tailed frog)		(0.40)	(0.000)
Pseudacris regilla	2		0.004
(Chorus frog -- AKA Pacific tree frog)			(0.000)

Table 19. Results of the two survey methodologies applied to the Glade Creek mainstem, summer 2000. The Stream Survey methodology was a customized version of the Hankin and Reeves stream survey protocol. The Intensive Sites were surveyed according to the methodologies presented in the main text.

Survey Type	**Stream Survey**	**Intensive Sites**
Length of stream inventoried (m)	8406 (± 453)	1510 (± 0)
# of bankfull/entrenchment measurements	41	88
Mean Bankfull Width: depth Ratio	17.29	16.63
Range of width: depth Ratios	5.59 - 32.14	7.88 - 57.26
Mean Entrenchment Ratio	1.92	1.61
Range of Entrenchment Ratios	1.21 - 8.74	1.1 - 3.7
Avg. Residual Pool Depth (m)	0.35	0.28
Pools (total #)	210	58
Pools (# per 100 m)	3	4.7
# Pools > 1m deep	19	17*
Large wood (total # of pieces)	369	76
Large wood (pieces per 100 m)	4.4	4.9

*Denotes stream walk data

Table 20. Stream walk summary information is given for each subwatershed. In addition to the mainstem, each tributary that was surveyed is listed. Kilometers surveyed are the number kilometers of stream channel walked on public lands, while Stream kilometers on public land is the total number of stream miles on public lands as taken from 1:100,000 scale maps. The percent of public land stream channel surveyed is given in the % Surveyed column.

Stream Name	Kilometers Surveyed	Stream kilometers on public land	% Surveyed
Lobster Creek, OR.			
Lobster Creek	8.53	9.17	93
E.Fork Lobster Creek	3.86	3.86	100
S.Fork Lobster Creek	2.90	3.54	82
Preacher Creek	2.25	3.22	70
Total	**17.54**	**19.79**	**89**
Illabot Creek, WA.			
Illabot Creek	5.31	8.85	60
Total	**5.31**	**8.85**	**60**
Arrow Creek, WA.			
Arrow Creek	3.54	4.35	81
Total	**3.54**	**4.35**	**81**
Beaver Creek, CA.			
Beaver Creek	7.89	11.75	67
Buck Rock Creek	2.41	5.63	43
Smokehouse Creek	4.99	7.24	69
Total	**15.29**	**24.62**	**62**
Glade Creek, OR.			
Glade Creek	11.75	12.39	95
Garvin Gulch	1.13	2.09	54
Jack Creek	1.13	1.77	64
Wrangle Creek	1.13	1.61	70
Total	**15.13**	**17.86**	**85**

Table 21. Total number of features cataloged in all five subwatersheds. See Appendix 1 for definitions of the features.

Features documented	Number found in all five subwatersheds
Beaver Dam	7
Beaver Activity	1
Culvert	8
Deep Pool	200
Habitat Structure	23
Landslide (Active)	44
Landslide (Inactive)	12
Log Jam	47
Lakes	2
Mining Activity	7
Off-Channel Pond	1
Potential Natural Barrier	2
Road Ford	12
Special Feature	1
Tributary Channel	70
Tributary Junction	48
Watershed Basin	76
	17
Total	**571**

Table 22. Below is a breakdown of the costs per sub-watershed by six major categories of AREMP operation. The columns titled Categories and Subcategories reflect the general areas of and subcategories of AREMP operation, respectively. The Description column describes, in general terms, the type of tasks that makeup an area of operation. The next three columns give the cost per sub-watershed for each of four scenarios: Survey of 16, 32, & 50 sub-watersheds respectively. The final column is a projection of cost per sub-watershed after initial final implementation, i.e., long term operational costs after startup costs are realized. The TOTAL 1 row represents the sum of the six areas of operation for a single sub-watershed. The TOTAL 2 row represents the cost per sub-watershed based on only the Field, Raw Data Processing, Data Analysis, & GIS Support. This total represents the cost per sub-watershed without overhead, fuzzy curve development, etc.

Categories	Subcategories	Description	*Cost per sub-watershed @ 16 for pilot*	Cost per sub-watershed @ 32 for pilot	Cost per sub-watershed @ 50 full implementation	Cost per sub-watershed @ 50 full implementation
Coordinating Field Logistics		Hiring, training, safety, travel, T&A for field crews; equipment purchasing[1]; acquiring sampling permits	$24,000	$20,000	$19,000	$17,000
Data Processing						

[1] AREMP has already invested approximately $80,000 in equipment during the 2000 & 2001 fiscal years.

Categories	Subcategories	Description	*Cost per sub-watershed @ 16 for pilot*	Cost per sub-watershed @ 32 for pilot	Cost per sub-watershed @ 50 full implementation	Cost per sub-watershed @ 50 full implementation
	Raw Data handling	Gathering, checking for errors, & archiving raw data; generating summaries for the EMDS modeling process	$8,000	$6,000	$6,000	$6,000
	EMDS model development	Refining existing models, staying abreast of recent literature & research that is relevant to the AREMP process	$1,000	$1,000	$500	$500
	Data Analysis	Processing the field and GIS generated data; analysis for an specialized questions	$2,000	$1,000	$1,000	$1,000

Categories	Subcategories	Description	*Cost per sub-watershed @ 16 for pilot*	Cost per sub-watershed @ 32 for pilot	Cost per sub-watershed @ 50 full implementation	Cost per sub-watershed @ 50 full implementation
Fuzzy Curve maintenance		Staying abreast of the current literature & research relevant to AREMP; acquiring literature relevant to AREMP; analyzing exterior datasets; working with local/regional expert input	$3,000	$2,000	$1,000	$1,000
GIS Support		Development of field maps; processing of upslope data; developing, acquiring & maintaining GIS layers	$10,000	$5,000	$3,000	$2,000
Coordinating with other agencies		Maintaining communication & coordination with other agencies; development of "bridges" between	$4,000	$2,000	$1,000	$1,000

Categories	Subcategories	Description	*Cost per sub-watershed @ 16 for pilot*	Cost per sub-watershed @ 32 for pilot	Cost per sub-watershed @ 50 full implementation	Cost per sub-watershed @ 50 full implementation
		protocols & program needs				
Overhead costs		Building support, non-field computers,	$6,000	$3,000	$2,000	$2,000
TOTAL 1[2]			$58,000	$40,000	$34,000	$30,000
TOTAL 2[3]			($43,000)	($32,000)	($30,000)	($26,000)

[2] TOTAL 1 represents the full cost of the project divided by the number of watersheds.
[3] TOTAL 2 represents only the costs associated with the Field, Raw Data Processing, Data Analysis, and GIS Support

Table 23. Geographic Information System data needs for the Aquatic and Riparian Effectiveness Monitoring Program.

- NFP-area wide coverages
    - 6^{th}-field HUC boundaries
    - Roads layer with maintenance category
    - Vegetation
- For the 250 subwatersheds sampled
    - 10 m digital elevation models (DEM)
    - 30 m DEM
    - Ownership layer
    - Stream layer (1:100,000 and 1:24,000)
    - Digital Orthoquads
    - Landslide layer

Figures

Figure 1. Lobster Creek sample sites.

Figure 2. Illabot Creek sample sites.

Figure 3. Beaver Creek sample sites.

Figure 4. Glade Creek sample sites.

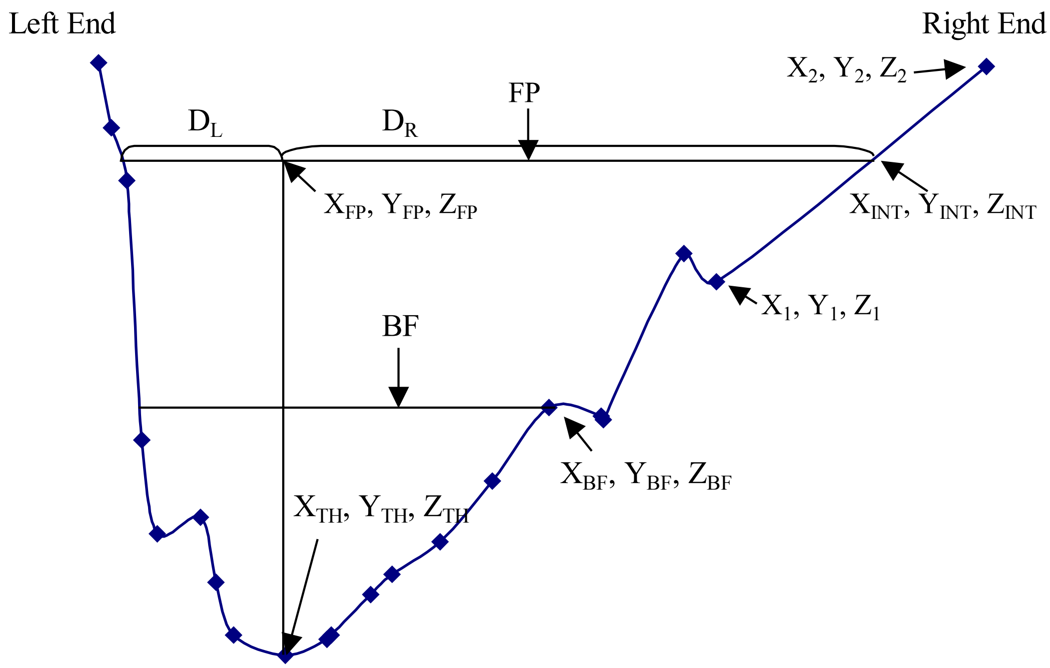

Figure 5. Example of a cross-section demonstrating all the relevant points used to calculate the flood-prone width. The three dimensional coordinates are represented by (X, Y, and Z). The subscript TH stands for thalweg, BF stands for bankfull stage, the numbers represent any two given points below (1) and above (2) the flood-prone height, and the subscript INT represents the intersection point where the flood-prone width crosses the transect. Only the right side of the cross-section is labeled for simplicity.

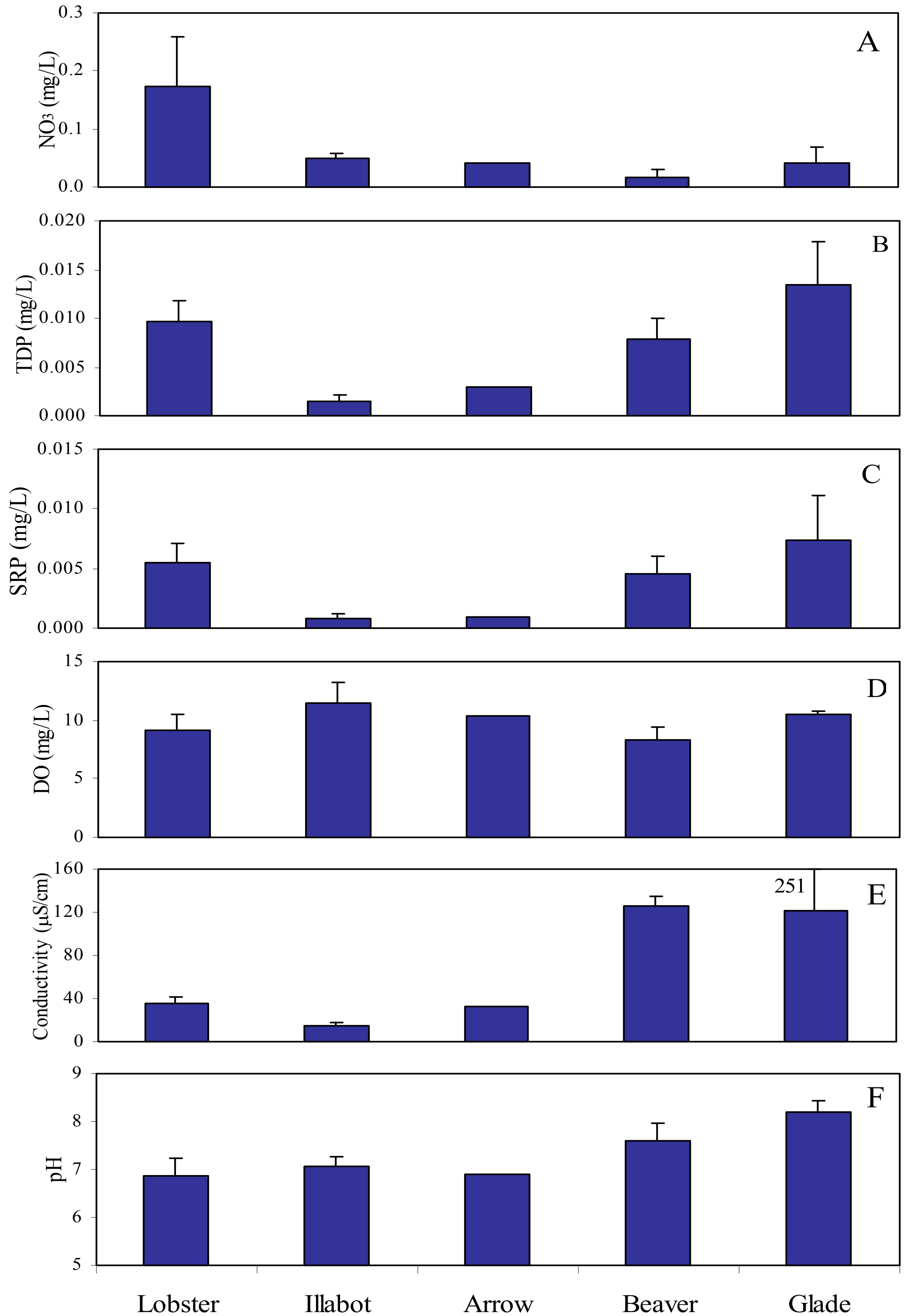

Figure 6. Water-chemistry variables for the five subwatersheds sampled during the summer of 2000. These variables include concentration of nitrate in mg · l^{-1} (panel A), total dissolved phosphorus in mg · l^{-1} (B), soluble reactive phosphorus in mg · l^{-1} (C), dissolved oxygen in mg · l^{-1} (D), conductivity in µS · cm^{-1} (E), and pH (F). All values are means and errors bars are ±1 S.D.

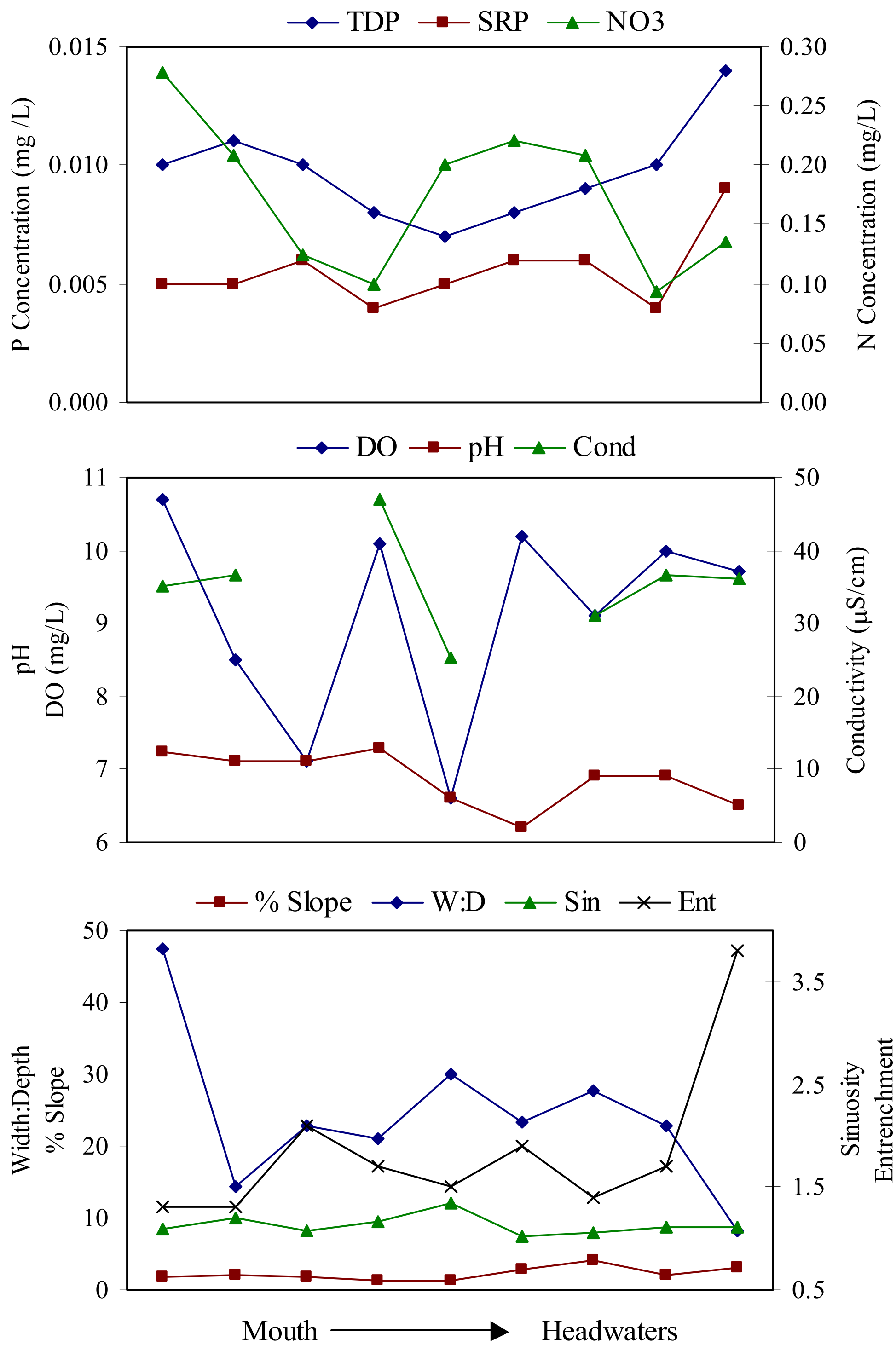

Figure 7. Water-chemistry variables measured at Lobster Creek. Nitrate and nitrite concentrations in mg · l^{-1} are shown in the top panel, as are concentrations of total dissolved phosphorus (TDP) in mg · l^{-1} and soluble reactive phosphorus (SRP) in mg · l^{-1}. The center panel shows dissolved oxygen (DO) in mg · l^{-1}, pH, and conductivity in µS · cm^{-1}. Bankfull-width-to-depth, % slope, sinuosity, and entrenchment ratios are shown in the bottom panel. In all panels, the first four points on the left are mainstem, points five through seven are East Fork Lobster, and the last two points are South Fork Lobster Creek.

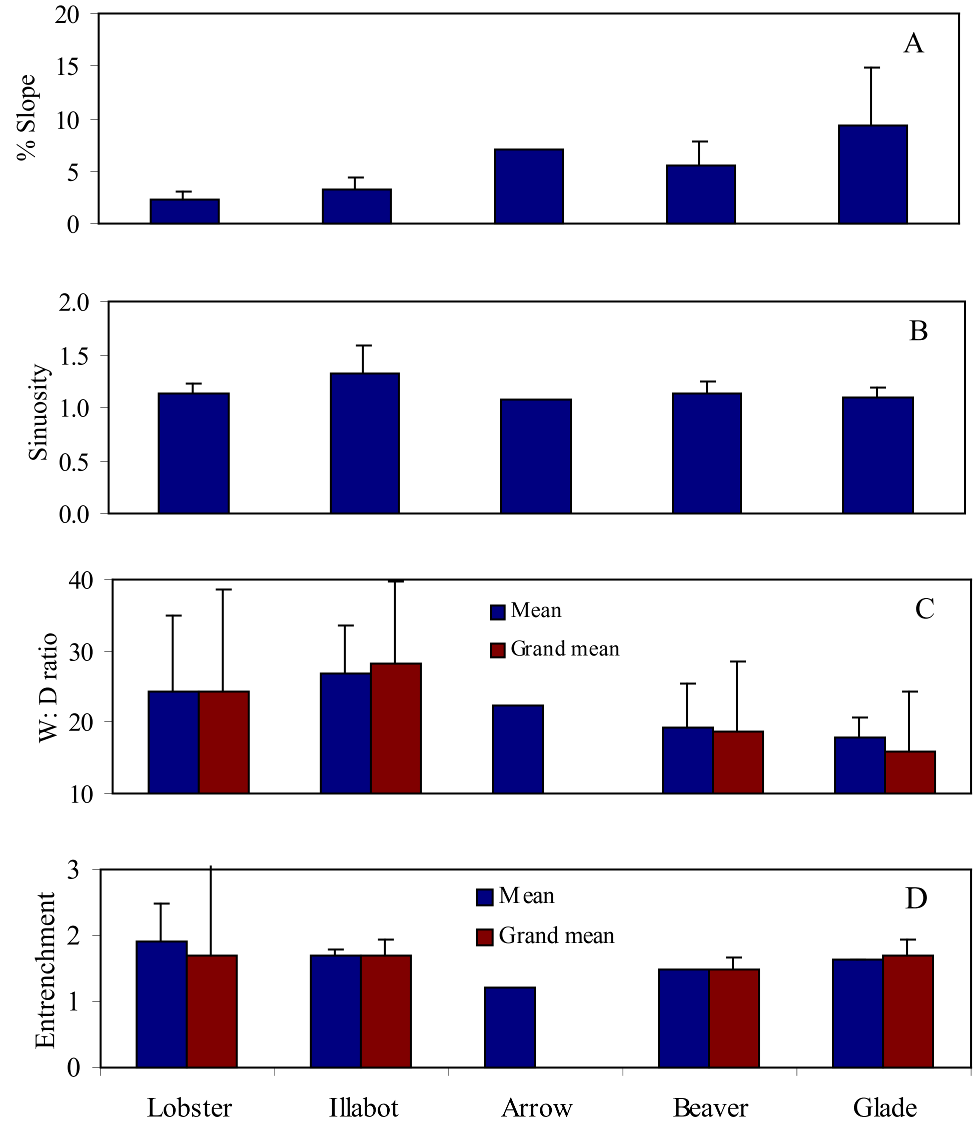

Figure 8. Comparison of physical habitat variables for the five subwatersheds surveyed. Panel A is the average slope, panel B is the sinuosity, panel C is the bankfull width-to-depth ratios, and panel D is the entrenchment ratio. All values are means and error bars represent ±1 S.D. See text for explanation of mean and grand-mean calculations.

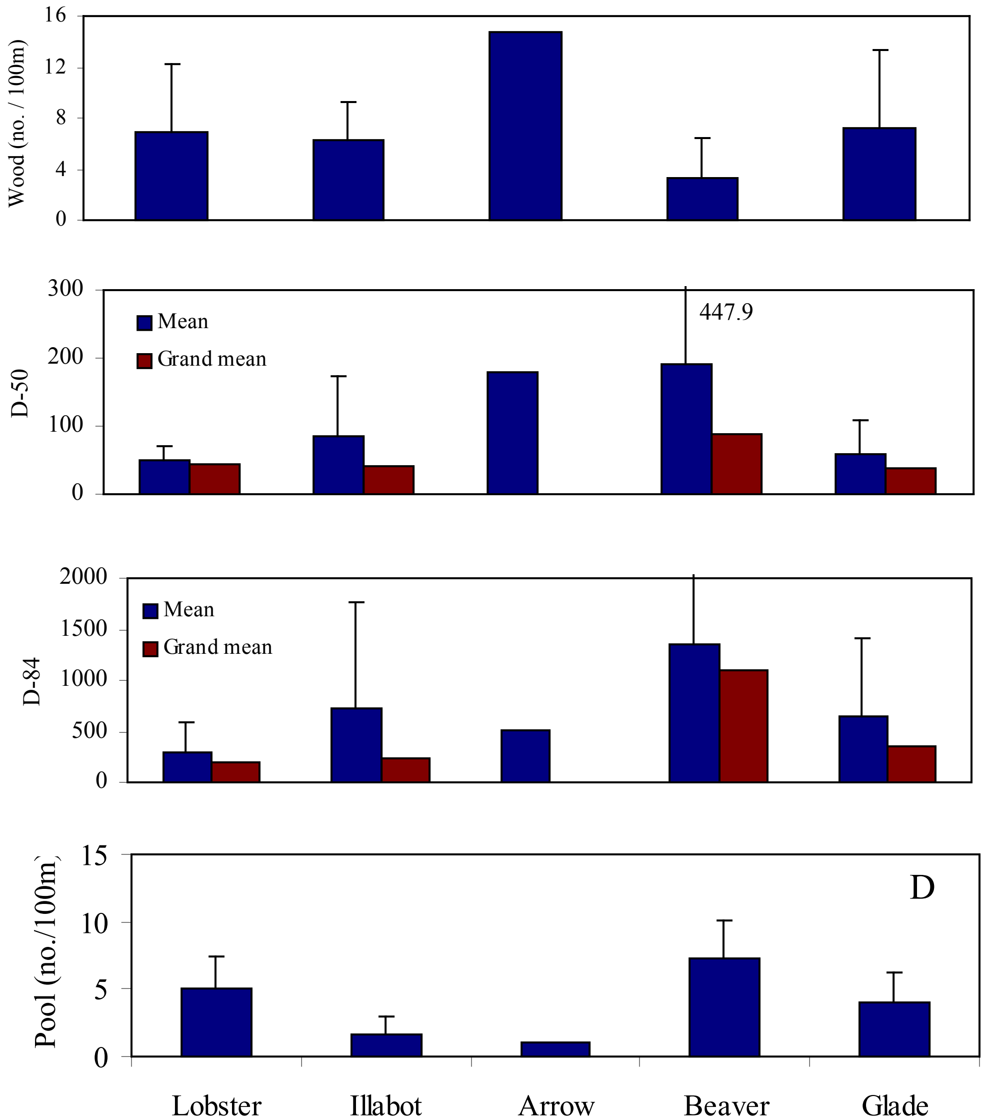

Figure 9. Comparison of additional physical habiat variables for the five subwatersheds surveyed. Panel A is large-wood frequency, panel B is the substrate D_{50}, panel C is the substrate D_{84}, and panel D is the pool frequency. All data are subwatershed means and error bars are ±1 S.D. See text for explanation of grand-mean calculation.

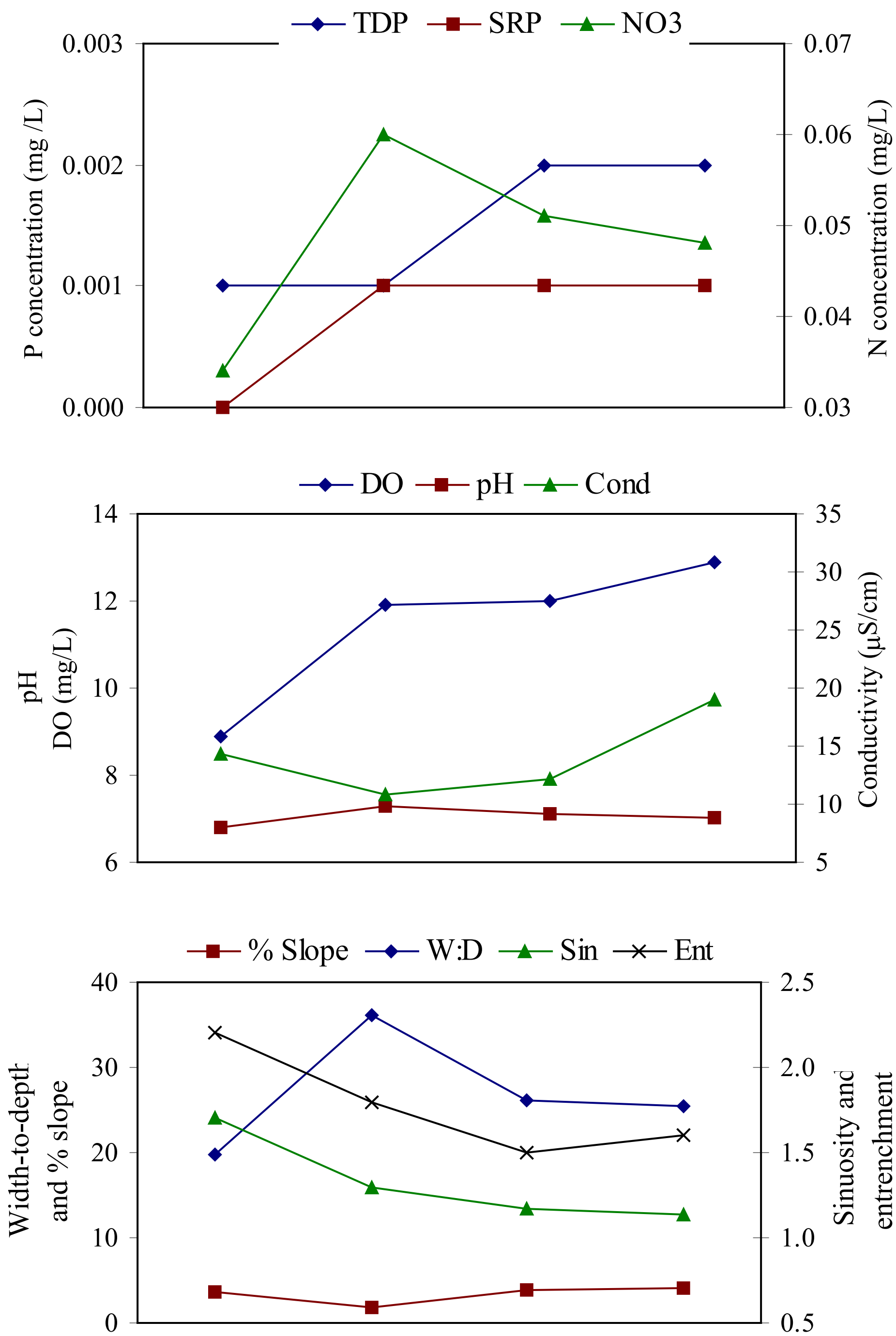

Figure 10. Water-chemistry variables measured at Illabot Creek. Nitrate and nitrite concentrations in mg · l^{-1} are shown in the top panel with concentrations of total dissolved phosphorus (TDP) in mg · l^{-1} and soluble reactive phosphorus (SRP) in mg · l^{-1}. The center panel shows dissolved oxygen (DO), pH, and conductivity in µS · cm^{-1}. Bankfull width-to-depth ratio, % slope, sinuosity, and entrenchment ratios are shown in the bottom panel.

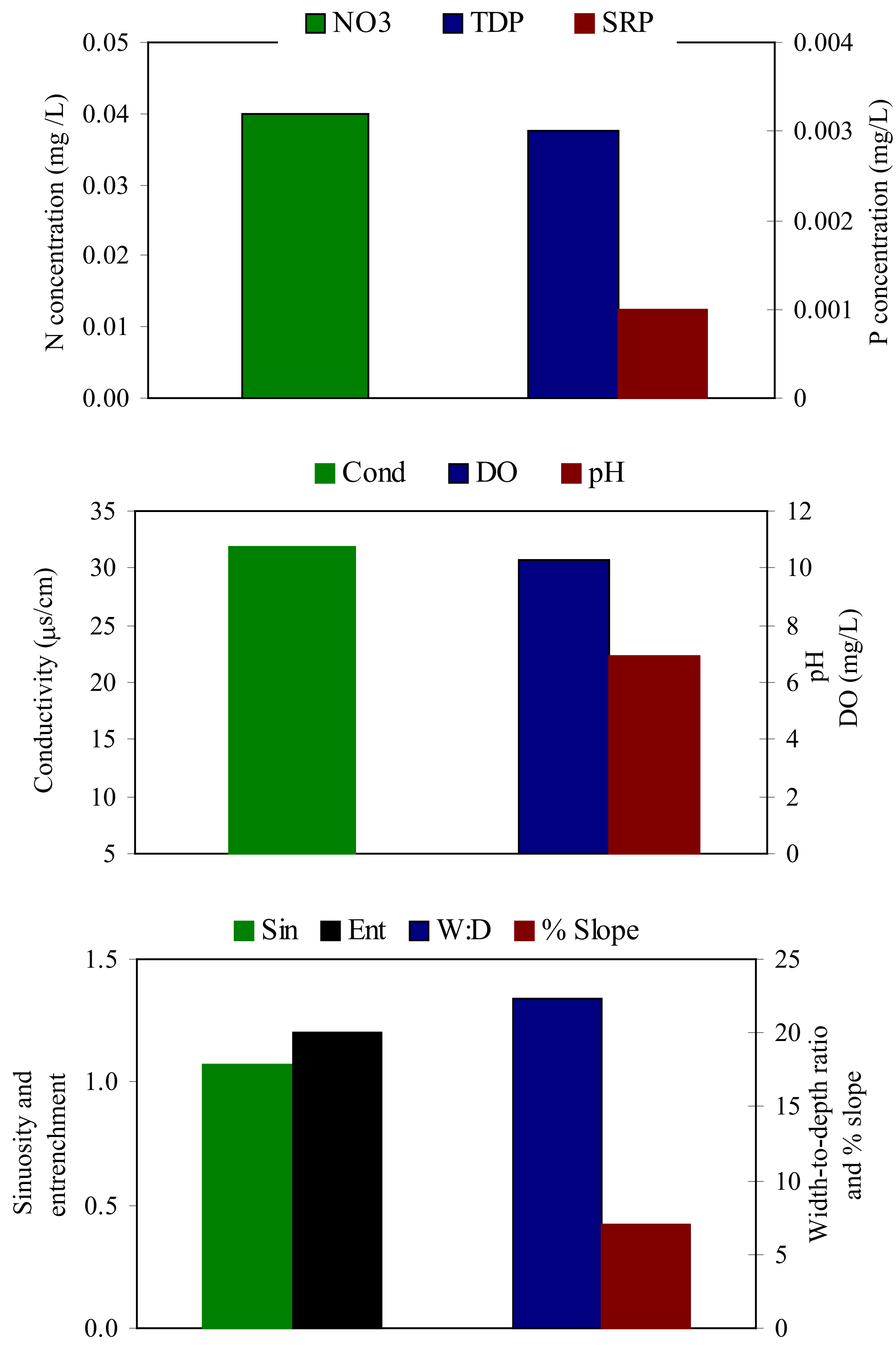

Figure 11. Water-chemistry variables measured at Arrow Creek. Nitrate and nitrite concentrations in mg · l^{-1} are shown in the top panel with concentrations of total dissolved phosphorus (TDP) in mg · l^{-1} and soluble reactive phosphorus (SRP) in mg · l^{-1}. The center panel shows dissolved oxygen (DO), pH, and conductivity in µS · cm^{-1}. Bankfull width-to-depth ratio, % slope, sinuosity, and entrenchment ratios are shown in the bottom panel.

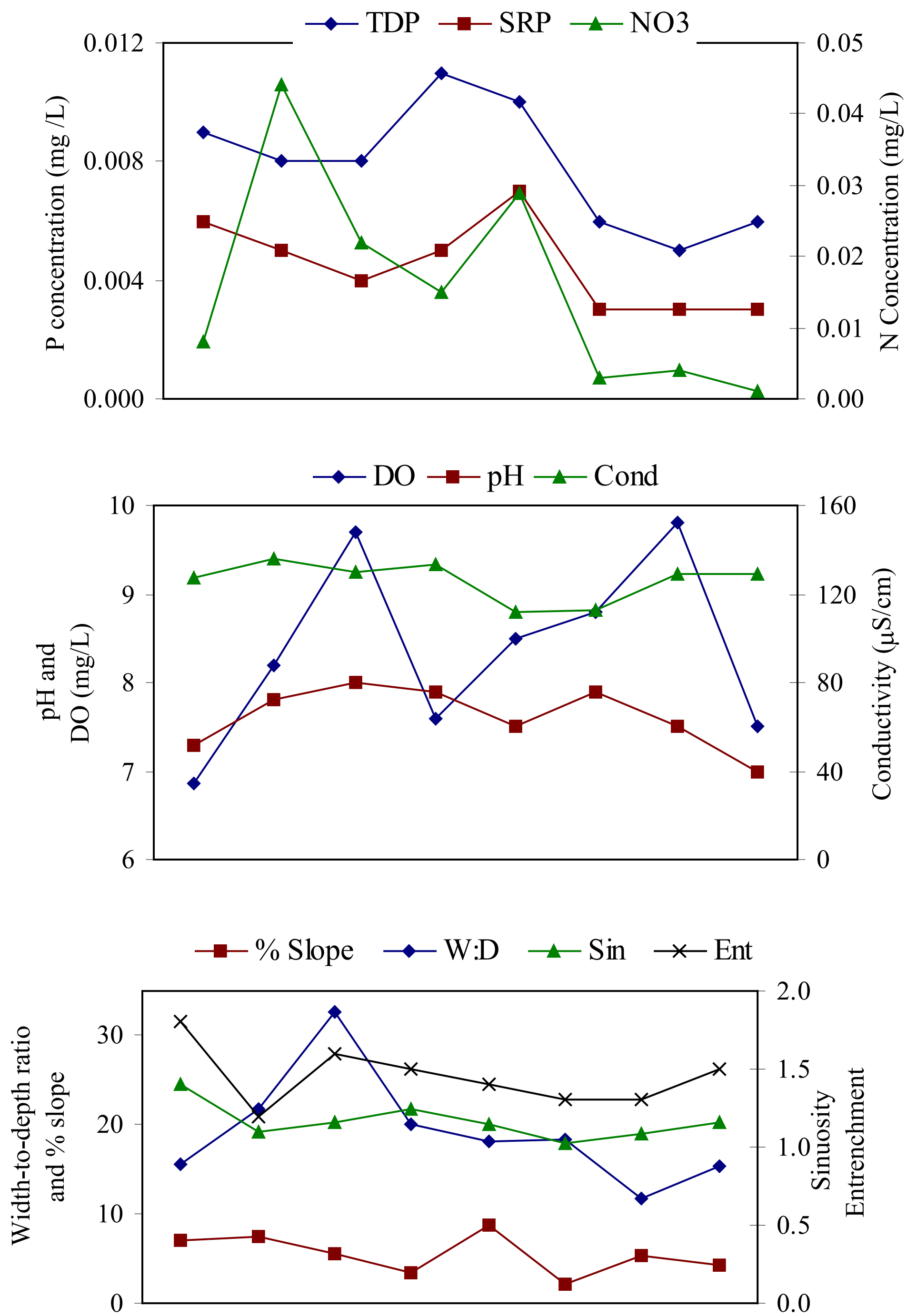

Figure 12. Water-chemistry variables measured at Beaver Creek. Nitrate and nitrite concentrations in mg · l^{-1} are shown in the top panel with concentrations of total dissolved phosphorus (TDP) in mg · l^{-1} and soluble reactive phosphorus (SRP) in mg · l^{-1}. The center panel shows dissolved oxygen (DO), pH, and conductivity in µS · cm^{-1}. Bankfull width-to-depth ratio, % slope, sinuosity, and entrenchment ratios are shown in the bottom panel.

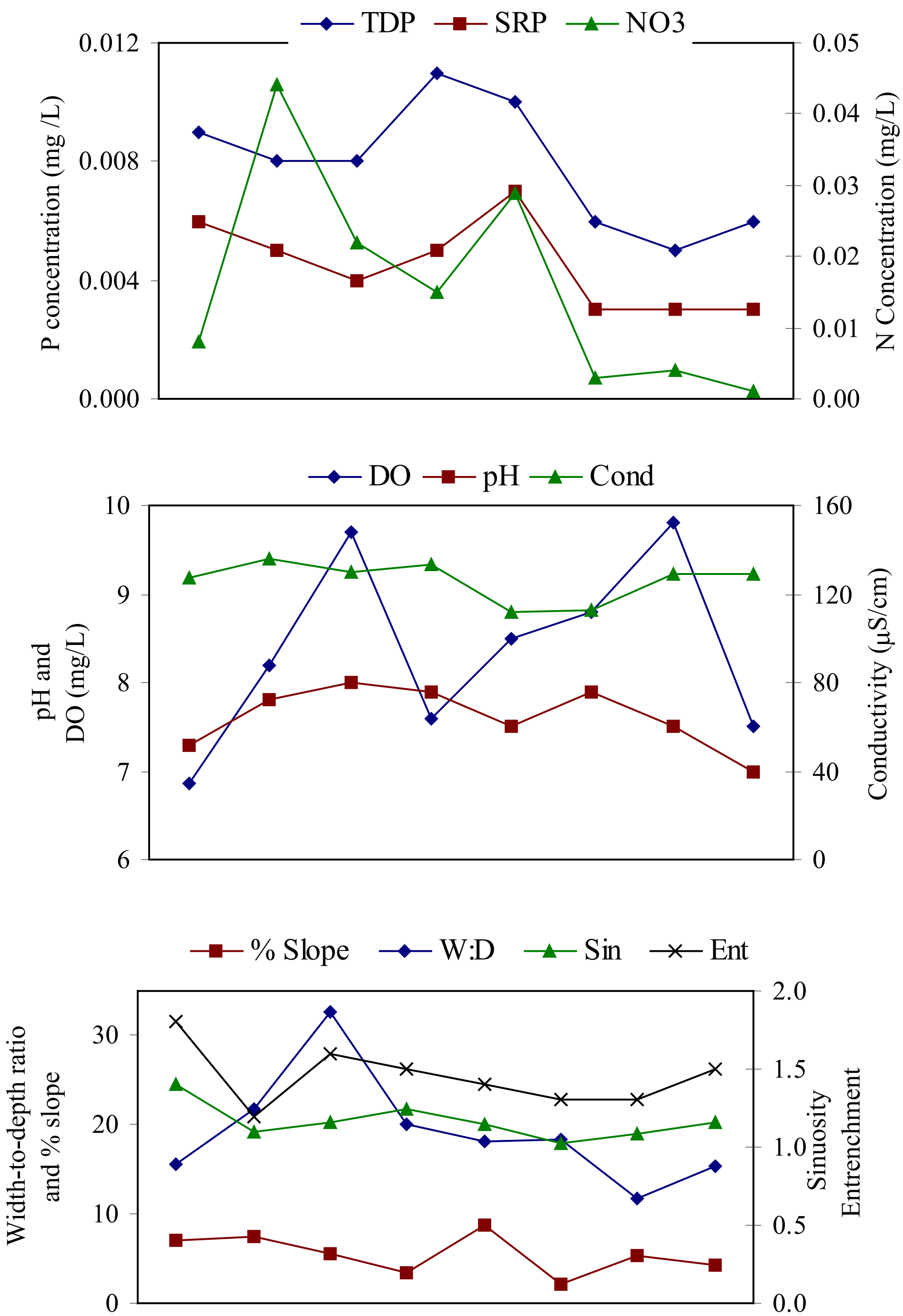

Figure 13. Water-chemistry variables measured at Glade Creek. Nitrate and nitrite concentrations in mg · l^{-1} are shown in the top panel with to concentrations of total dissolved phosphorus (TDP) in mg · l^{-1} and soluble reactive phosphorus (SRP) in mg · l^{-1}. The center panel shows dissolved oxygen (DO), pH, and conductivity in µS · cm^{-1}. Bankfull width-to-depth ratio, % slope, sinuosity, and entrenchment ratios are shown in the bottom panel.

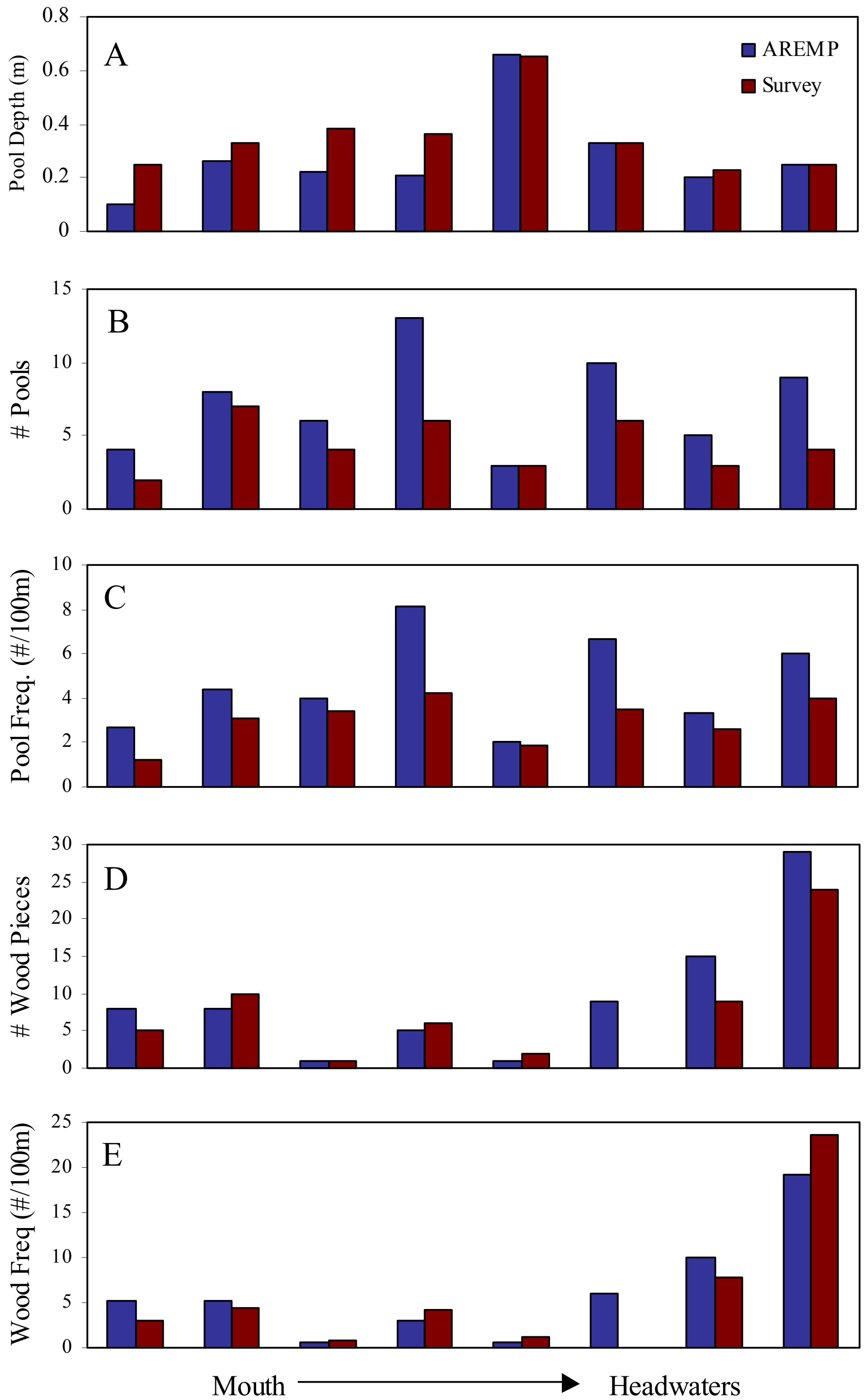

Figure 14. Comparison of intensive-survey reach results with results from the stream-habitat inventory in Glade Creek, 2000. Monitoring plan data are the means from 11 transects in each reach. The survey represents the means from the habitat inventory of the stream segments adjacent to and including the intensive-survey sites.

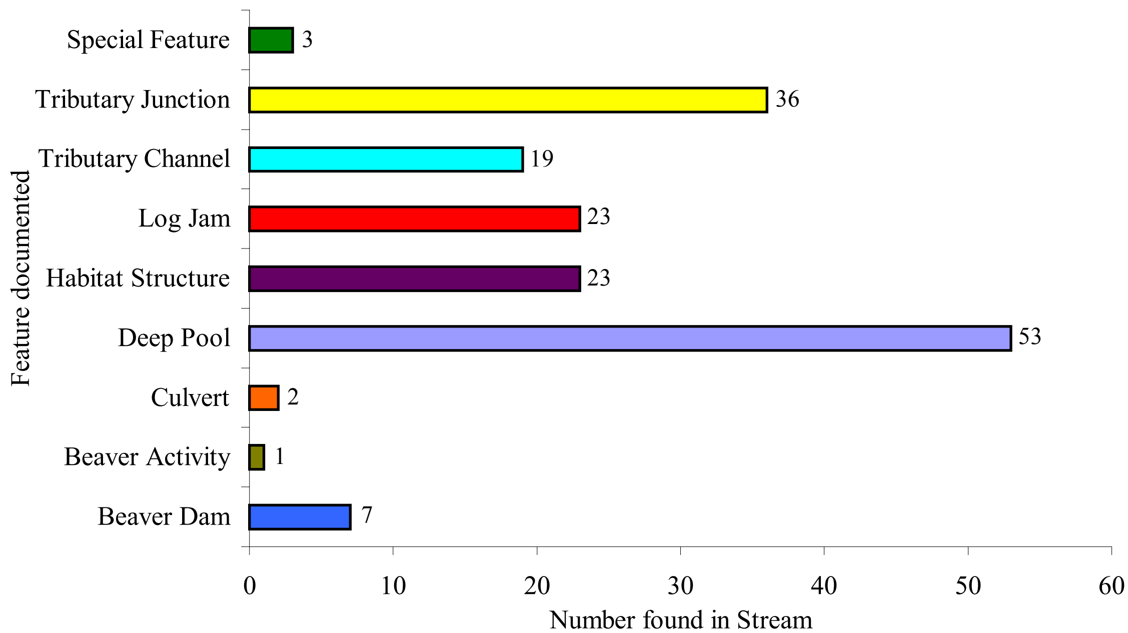

Figure 15. Distribution of features cataloged during the stream walk in Lobster Creek, Oregon.

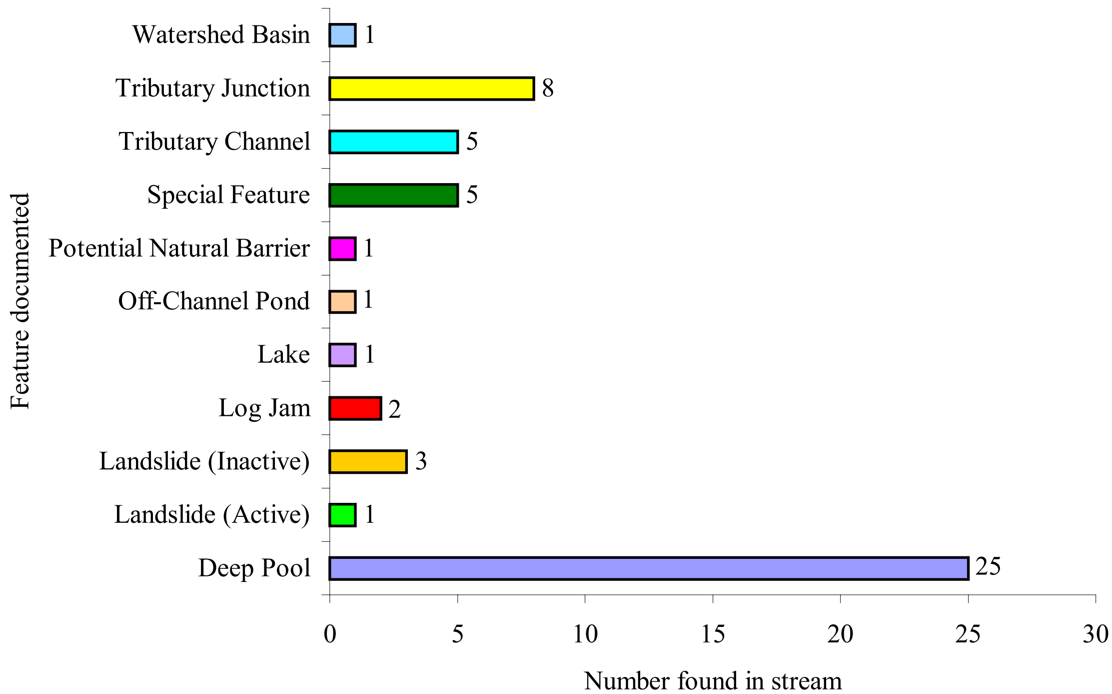

Figure 16. Distribution of features cataloged during the stream walk in Illabot Creek, Washington.

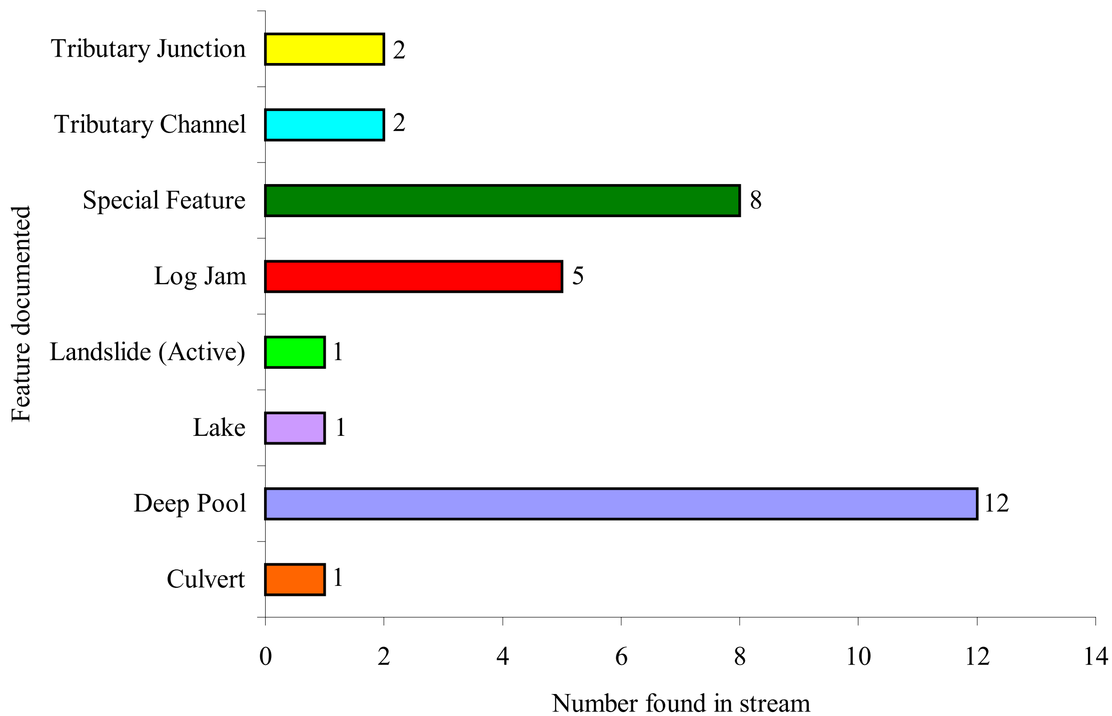

Figure 17. Distribution of features cataloged during the stream walk in Arrow Creek, Washington.

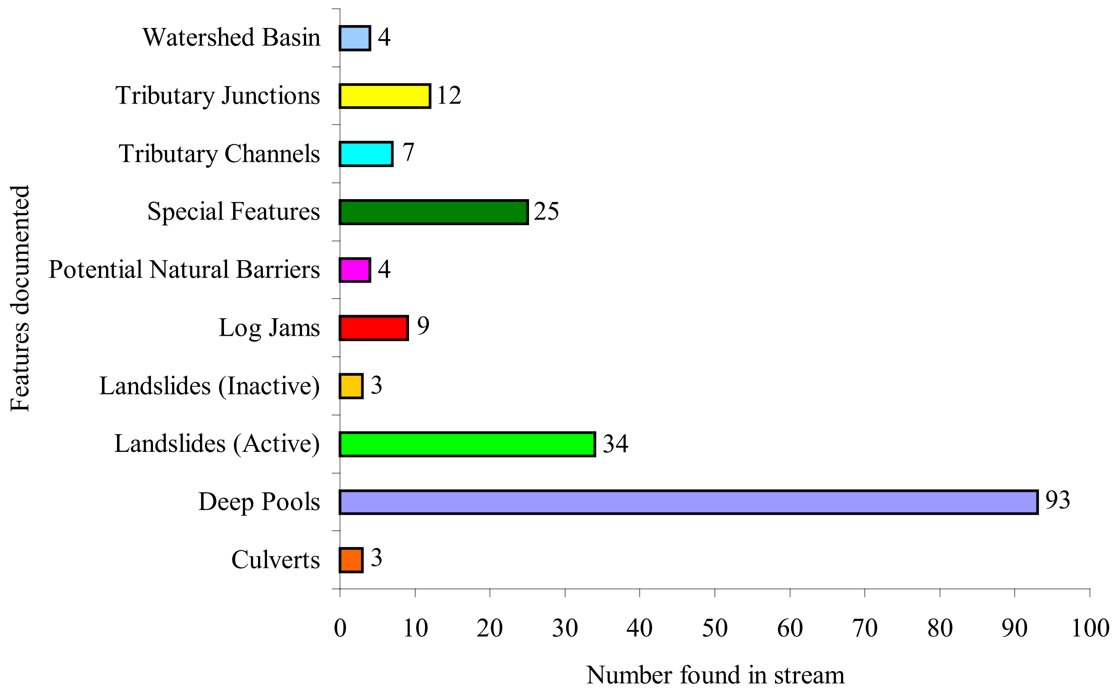

Figure 18. Distribution of features cataloged during the stream walk in Beaver Creek, California.

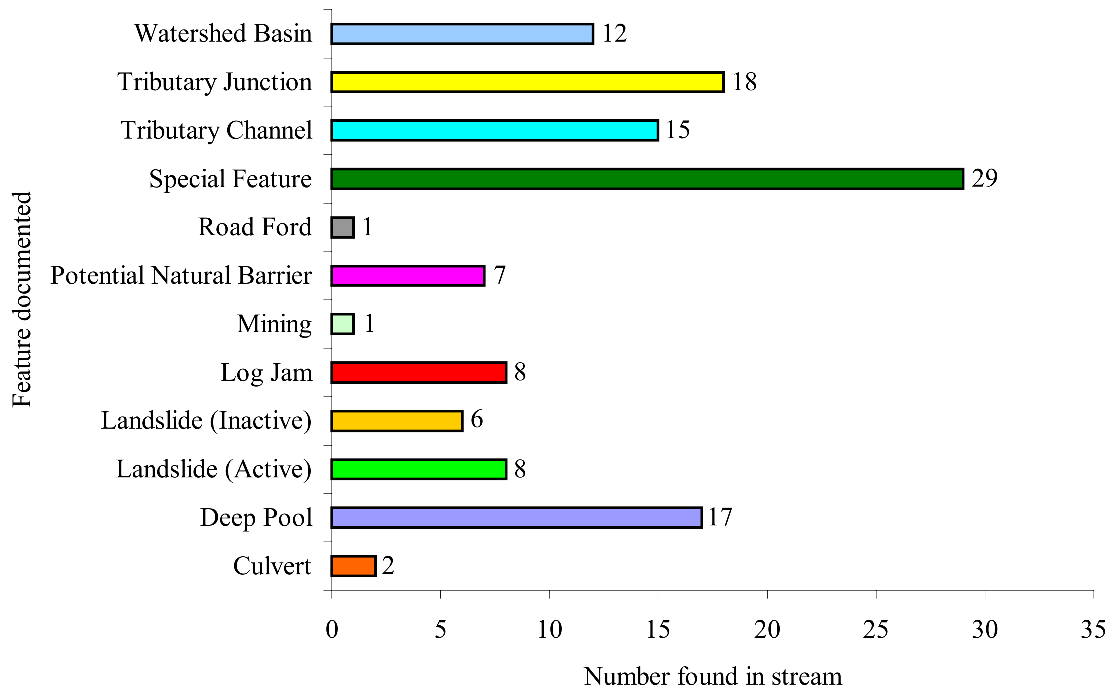

Figure 19. Distribution of features cataloged during the stream walk in Glade Creek, Oregon.

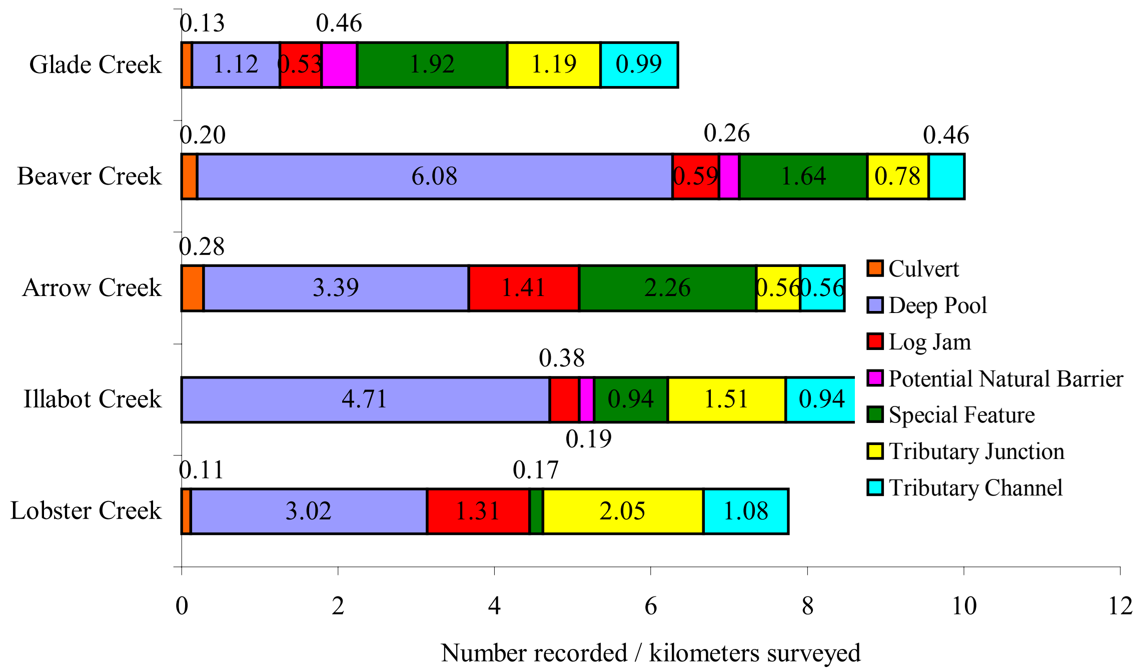

Figure 20. Distribution of common features per kilometer surveyed cataloged in each of the five subwatersheds.

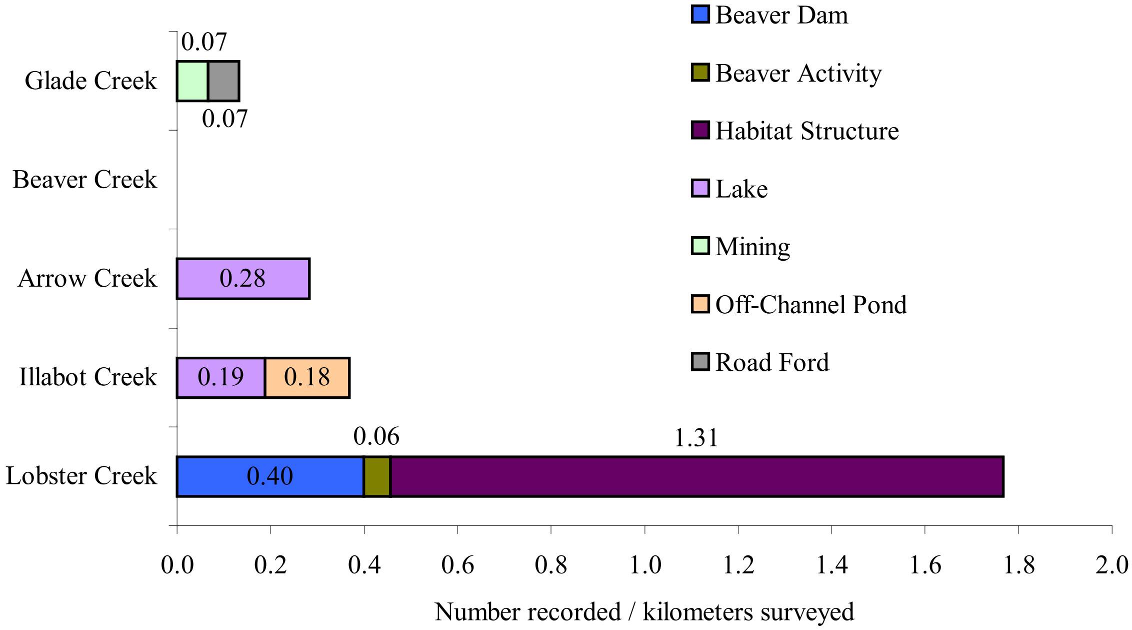

Figure 21. Distribution of uncommon features per kilometer surveyed cataloged in each of the five subwatersheds.

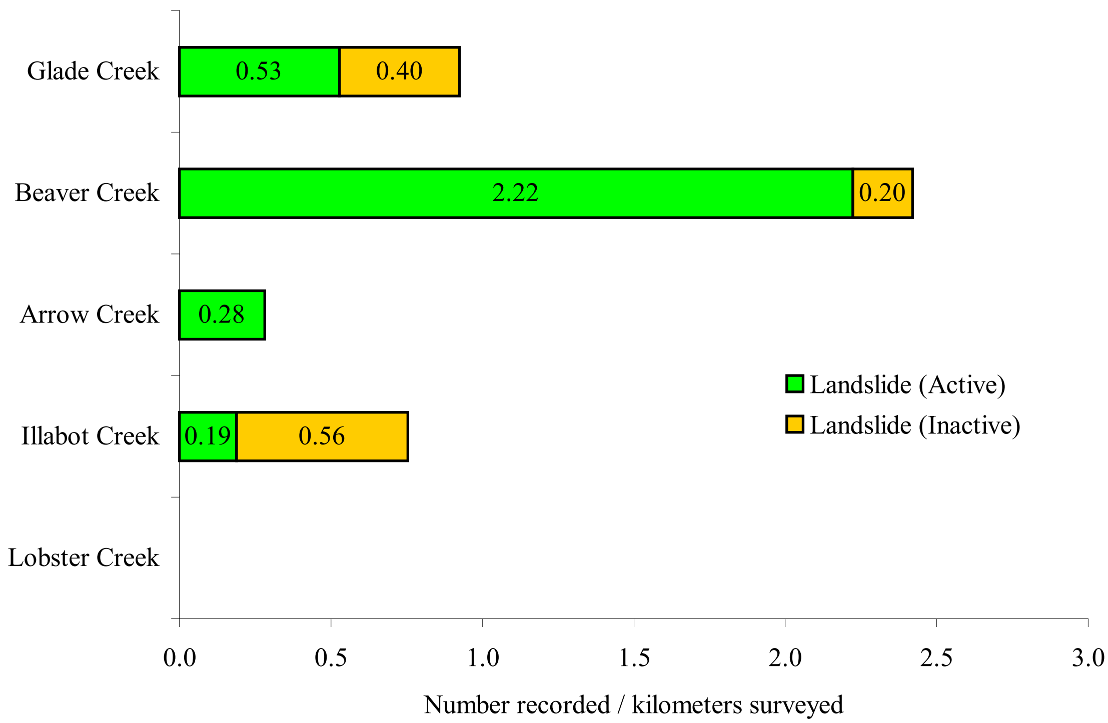

Figure 22. Distribution of land movements per kilometer surveyed cataloged in each of the five subwatersheds.