BIOLOGICAL ASSESSMENT FRAMEWORKS

AND

INDEX DEVELOPMENT

FOR

RIVERS AND STREAMS IN IDAHO

Prepared for

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EXECUTIVE SUMMARY

The Idaho Department of Environmental Quality (IDEQ) initiated this study to develop and update assessment tools for biological and habitat integrity in streams and rivers throughout the State. The process for creating indices includes defining reference conditions, establishing geographic divisions to classify natural variability, calibrating multimetric indices for macroinvertebrates, fish, and habitat, and developing multivariate predictive models for macroinvertebrates. The ecological indicators could be applied to assess aquatic life use support (ALUS), as required in State programs and the Clean Water Act. The dataset analyzed included over 3000 sites sampled between 1998 and 2008, mostly through the IDEQ Beneficial Use Reconnaissance Program.

The analysis for developing biological and habitat assessment tools relies heavily on the reference condition concept. Therefore, we identified sites in the dataset that were least disturbed and used the biological samples and habitat observations found in them to describe the best possible conditions. All assessments were based on comparisons to these reference conditions and their opposite: stressed conditions found in the most disturbed sites.

To account for the diverse natural settings found throughout Idaho, sites were classified based on biological and environmental waterbody types. In this way, expectations for each assessed waterbody will be reasonable for that waterbody type. Classification based on ecoregions accounts for the major environmental variables that affect biological assemblages and habitat features, such as location in the state, topography, geology, and vegetation. The classification system was purposefully defined for application across indicators and both rivers and streams. Based largely on the stream macroinvertebrate dataset, three site classes were identified: Mountains, Foothills, and Plains, Plateaus, and Broad Valleys (PPBV). For rivers, only two classes were defined: Mountains and Non-Mountains. The classes were defined based on site locations within level 4 ecoregions.

A Multimetric Index, or MMI, is a numeric representation of biological or habitat conditions based on combined signals of many assemblage or physical measurements. Each measurement, or metric, is selected to be included in the index because it shows a consistent response along a known disturbance gradient. The combined index gives a reliable indication of biological or habitat integrity. Indices of benthic macroinvertebrates and fish were successfully developed for all site classes of streams and rivers. Habitat indices were developed for the stream site classes. The indices contained 4-10 metrics each and had discrimination efficiencies (DE) ranging from 70-100%.

Predictive Models are used to compare observed benthic macroinvertebrate taxa (O) to those expected (E) based on site environmental settings and assemblages in reference sites. The ratio, O/E, should be close to 1.0 when the biological assemblage is unimpaired. For macroinvertebrates in streams and rivers, the predictive models contained five predictive environmental variables each. They were precise in reference sites, with root mean square errors of 0.16. With this level of precision, non-reference sites can be distinguished with high levels of confidence, comparable to DEs of 60-80%

The indices recommended in this report show responsiveness to the general stressor gradient, as defined by reference and non-reference sites. The performance characteristics of the indices are reported so that assessments carry a known level of certainty and uncertainty (**Table ES-1**). In general, greater index distinctions between reference and stressed sites were observed in Foothills and PPBV sites compared to Mountains sites. In addition, fish MMIs appeared to be more sensitive to stress than benthic macroinvertebrate MMIs.

Table ES-1. Index Summary.

<table>
<tr><th colspan="6">Benthic Macroinvertebrates</th></tr>
<tr><td colspan="6"><u>MMI – Streams</u></td></tr>
<tr><td colspan="2">Mountains
DE: 73%; 7 Metrics</td><td colspan="2">Foothills
DE: 71%; 6 Metrics</td><td colspan="2">PPBV
DE: 85%; 6 Metrics</td></tr>
<tr><td colspan="6"><u>MMI – Rivers</u></td></tr>
<tr><td colspan="3">Mountains
DE: 70%; 7 Metrics</td><td colspan="3">Non-mountains
DE: 92.7%; 7 Metrics</td></tr>
<tr><td colspan="3"><u>O/E – Streams</u>
Reference RMSE: 0.16 index units
5 Predictors</td><td colspan="3"><u>O/E – Rivers</u>
Reference RMSE: 0.16 index units
5 Predictors</td></tr>
<tr><th colspan="6">Fish</th></tr>
<tr><td colspan="6"><u>MMI – Streams</u></td></tr>
<tr><td colspan="2">Mountains
DE: 78%; 5 Metrics</td><td colspan="2">Foothills
DE: 84.6%; 6 Metrics</td><td colspan="2">PPBV
DE: 86.7%; 6 Metrics</td></tr>
<tr><td colspan="6"><u>MMI – Rivers</u></td></tr>
<tr><td colspan="3">Mountains
DE: 100%; 6 Metrics</td><td colspan="3">Non-mountains
DE: 76.9%; 6 Metrics</td></tr>
<tr><th colspan="6">Habitat</th></tr>
<tr><td colspan="6">MMI – Streams</td></tr>
<tr><td colspan="4">All Classes – SHI
DE: 72.2-95.8%; 10 Metrics</td><td colspan="2">Pool-Glide
DE: 100%; 5 Metrics</td></tr>
<tr><td colspan="2">Mountains (Riffle-Run)
DE: 84.2%; 5 Metrics</td><td colspan="2">Foothills (Riffle-Run)
DE: 88.9; 4 Metrics</td><td colspan="2">PPBV (Riffle-Run)
DE: 85.7%; 5 Metrics</td></tr>
</table>

ACKNOWLEDGEMENTS

All analyses and report production were performed by Tetra Tech, Inc. under contract to Idaho Department of Environmental Quality. Ben Jessup of Tetra Tech was the primary analyst and author. Additional staff with Tetra Tech assisted with data compilation (Erik Leppo), analysis (Jen Stamp, Erik Leppo, and Mike Paul), and report production (Brenda Decker).

A workgroup from IDEQ reviewed analyses and report drafts, offering substantial improvements and ideas for integrating scientific results and programmatic objectives. This group included Jason Pappani, Michael Macintyre, Don Essig, and Mary Anne Nelson.

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ABBREVIATIONS

ALUS	Aquatic Life Use Support
BURP	Beneficial Use Reconnaissance Program
CART	Classification and Regression Tree
CBR	Central Basin and Range
DE	Discrimination Efficiency
DFA	Discriminant function Analysis
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
GIS	Geographic Information System
HUC	Hydrologic Unit Code
IDEQ	Idaho department of Environmental Quality
LDI	Landscape Disturbance Index
MDEQ	Montana Department of Environmental Quality
MMI	Multi-metric Index
NA	Not applicable
NMS	Non-metric Multidimensional Scaling
O/E	Observed/Expected ratio
OTU	operational taxonomic unit
PCA	Principal Components Analysis
PG	Pool-Glide

PPBV	Plains/Plateaus/Broad Valleys
RDI	River Diatom Index
REMAP	Regional Environmental Monitoring and Assessment program
RFI	River Fish Index
RIVPACS	River Invertebrate Prediction and Classification System
RMI	River Macroinvertebrate Index
RMSE	Root Mean Square Error
RR	Riffle-Run
SFI	Stream Fish Index
SHI	Stream Habitat Index
SMI	Stream Macroinvertebrate Index
SRP	Snake River Plain
TMDL	Total Maximum Daily Load

1.0 Introduction

1.1 Purpose

The purpose of this study was to refine and revise the Idaho Department of Environmental Quality (IDEQ) Small Stream Ecological Assessment Framework (Grafe 2002a) and River Ecological Assessment Framework (Grafe 2002b). These frameworks include tools and protocols for assessing ecological integrity throughout the State. The revision includes defining reference conditions, establishing geographic divisions to classify natural variability, revising and updating IDEQ's multimetric indices for macroinvertebrates, fish, and habitat, and developing multivariate predictive models for macroinvertebrates. These ecological indicators would be used in waterbody assessments of aquatic life use support (ALUS) as required in State programs and the Clean Water Act.

IDEQ currently uses three indices for assessing small streams: the Stream Macroinvertebrate Index (SMI), Stream Fish Index (SFI), and Stream Habitat Index (SHI). Similarly, large rivers are assessed with the River Macroinvertebrate Index (RMI), River Fish Index (RFI), and River Diatom Index (RDI). The indicators developed or revised as part of this effort are included in **Table 1-1**. Other indicators were considered or attempted, but not completed. These included predictive fish models for both streams and rivers and habitat and diatoms indices for large rivers. Analyses for these additional indicators were unsatisfactory because of insufficient taxa diversity (fish) or insufficient sample sizes (habitat and diatoms).

Table 1-1. Indicators developed or revised for IDEQ.

Streams	Rivers
Multimetric Macroinvertebrate Index	Multimetric Macroinvertebrate Index
Predictive Macroinvertebrate Model	Predictive Macroinvertebrate Model
Multimetric Fish Index	Multimetric Fish Index
Multimetric Habitat Index	

General Analytical Approach

The analysis for developing biological and habitat assessment tools relies heavily on the reference condition concept (Stoddard et al. 2006). This concept states that the biological and habitat conditions with the greatest ecological integrity are found in sites with the least human disturbance. Therefore, we identify sites in the dataset that are least disturbed and use the biological samples and habitat observations found in them to describe the best possible conditions. All assessments are based on comparisons to the reference conditions and departures in biological indices at a test site from conditions observed at reference sites is indicative of human stress.

Because there are diverse natural settings throughout Idaho, a single reference condition for all streams or rivers would be inappropriate. Rather, the different types of natural settings can be recognized through site classification. Comparative assessments can then be sensitive to site class. In this way, expectations for each assessed waterbody will be reasonable for that waterbody type. Classification should account for the major environmental variables that affect biological assemblages and habitat features, such as location in the state, topography, geology, vegetation, and sample timing. These variables are generally incorporated into statewide ecoregions (McGrath et al. 2002), which are delineated to describe areas with similar environmental characteristics.

A Multimetric Index, or MMI, is a numeric representation of biological or habitat conditions based on combined signals of many assemblage or physical measurements (Gerritsen 1995, Barbour et al. 1999). Each measurement, or metric, is selected to be included in the index because it shows a consistent response along a known disturbance gradient. The combined index gives a reliable indication of biological or habitat integrity. In these analyses, the disturbance gradient is represented by reference and non-reference site designations. Responsiveness of metrics is evaluated within site classes.

Predictive Models are used to compare observed biological taxa (O) to those expected (E) in a system based on site environmental settings and assemblages in reference sites (Hawkins et al. 2000, Clarke et al. 2003). The ratio, O/E, should be close to 1.0 when the biological assemblage is unimpaired. A commonly cited predictive model is the River Invertebrate Prediction and Classification System (RIVPACS, Clarke et al. 2003). The models in this analysis were developed much like the RIVPACS model.

The indices recommended in this report show responsiveness to the general stressor gradient, as defined by reference and non-reference sites. Many details regarding application of the indices can follow from these analyses. For instance, while the indices have numeric ranges that are similar to or different from reference conditions, the decision regarding threshold values of biological impairment is not addressed in this document. In addition, the indices offer multiple ways of assessing a waterbody (multimetric or predictive tools, macroinvertebrates or fish), yet there is no recommendation in this report about how to combine results of the multiple tools.

1.2 Background

Data were compiled in relational databases so that site characteristics and samples could be related and compared and to allow additional data manipulations. Manipulations included metric calculation, basic statistical calculations (e.g., average values at a site), and data output in spreadsheet format for use in analytical programs or for presentation.

1.2.1 Data sources

Idaho Stream Data

All data were collected by IDEQ using the Beneficial Use Reconnaissance Program (BURP) protocols (IDEQ 2007). Sample dates range from June to October, 1998 to 2007 for fish and macroinvertebrates. Benthic macroinvertebrates were collected using a Hess sampler, compositing three riffle samples for each site, and then sub-sampling in the laboratory to a target 500 count. Identifications are made to the greatest practical taxonomic resolution, which is typically genus level. Minimum collection efforts for fish include electro-fishing one 100m upstream pass without block nets. Fish are identified and measured to length in the field. The measured habitat features include instream and riparian conditions, ratings, and morphology.

Three thousand, two hundred and seven (3207) samples were collected. The numbers of samples used in each analysis varied based on site location and completeness of the data record. Some samples were taken at, or close to, a previously sampled site (within one kilometer), so the number of unique sites are less than the number of samples. All data considered for analyses were submitted to IDEQ as an electronic appendix with a data dictionary (**Appendix A**).

Idaho River Data

Rivers are distinguished from streams based on three measures of stream size. Stream order, wetted width, and depth are considered in a rating system that is used to define streams and rivers in Idaho (**Table 1-2**, Grafe et al. 2002). Terms commonly used in describing waterbodies (wadeable, non-wadeable, small, or large) are not used because they can be unclear. As defined here, the stream and river classifications are specifically for DEQ use and the terms may not apply in other contexts. DEQ rates water bodies against each criterion, as shown in

Table-2, and then averages the rating or score (total rating points divided by three criteria). If a water body's average score for these three criteria is greater than or equal to 1.7, DEQ designates it a river; if its average score is less than 1.7, it is classified a stream.

Table 1-2. Rating system for river and stream classification (Grafe et al. 2002).

Waterbody Type	Rating Points	Stream Order	Avg. Wetted Width at Base Flow (m)	Avg. Depth at Base Flow (m)
River	3	≥ 5	≥ 15	≥ 0.4
Stream	1	< 5	< 15	< 0.4

Data from 108 Idaho river sites were collected through two efforts: the U.S. EPA-sponsored Regional Environmental Monitoring and Assessment Program (REMAP) and the IDEQ river sampling program. The REMAP program sampled 47 sites selected probabilistically in 2002-2004. Some sites were sampled multiple times, but only a single sample per site was used in analyses. REMAP data included macroinvertebrates, fish, physical habitat, and water quality.

IDEQ sampled 21 wilderness rivers in 2000-2001 and 57 other rivers in 2006 and 2008. The wilderness rivers were in fairly remote areas of the mountains and fish were not sampled at these sites. Human influence in wilderness sites was nearly absent, making these sites candidate for reference designations. Habitat and macroinvertebrate data were collected at all sites. Fish were collected in a subset of sites. The habitat variables collected by IDEQ were mostly different than those collected for REMAP.

Substrate characteristics for river sites were standardized across collection programs. Percent sand and fines on the riverbed were calculated as the number of observations of sand or fine dominant substrates in the littoral plots. For instance, two 'sand' and one 'fine' observations of dominant substrates among 12 would give % sand and fines as 25%. Both shore and bottom observations were considered.

1.2.2 Ecoregions in Idaho

After preliminary experimentation with freshwater ecoregions (Abell et al. 2008) and major river basins as spatial frameworks for organizing sites in Idaho, the EPA level 3 and 4 ecoregions (McGrath et al. 2002) were established as the predominant framework for indicator development in this study. The ecoregion characteristics (topography, vegetation, geology, predominant land uses) are described in detail in the original documentation. There are ten level 3 ecoregions in Idaho (**Table 1-3, Figure 1-1**) and 59 level 4 ecoregions that have at least one site (**Figure 1-2**).

Table 1-3. Level 3 ecoregions in Idaho.

Level 3 Code	Level 3 Name	Level 3 Code	Level 3 Name
10	Columbia Plateau	16	Idaho Batholith
11	Blue Mountains	17	Middle Rockies
12	Snake River Plain	18	Wyoming Basin
13	Central Basin and Range	19	Wasatch and Uinta Mountains
15	Northern Rockies	80	Northern Basin and Range

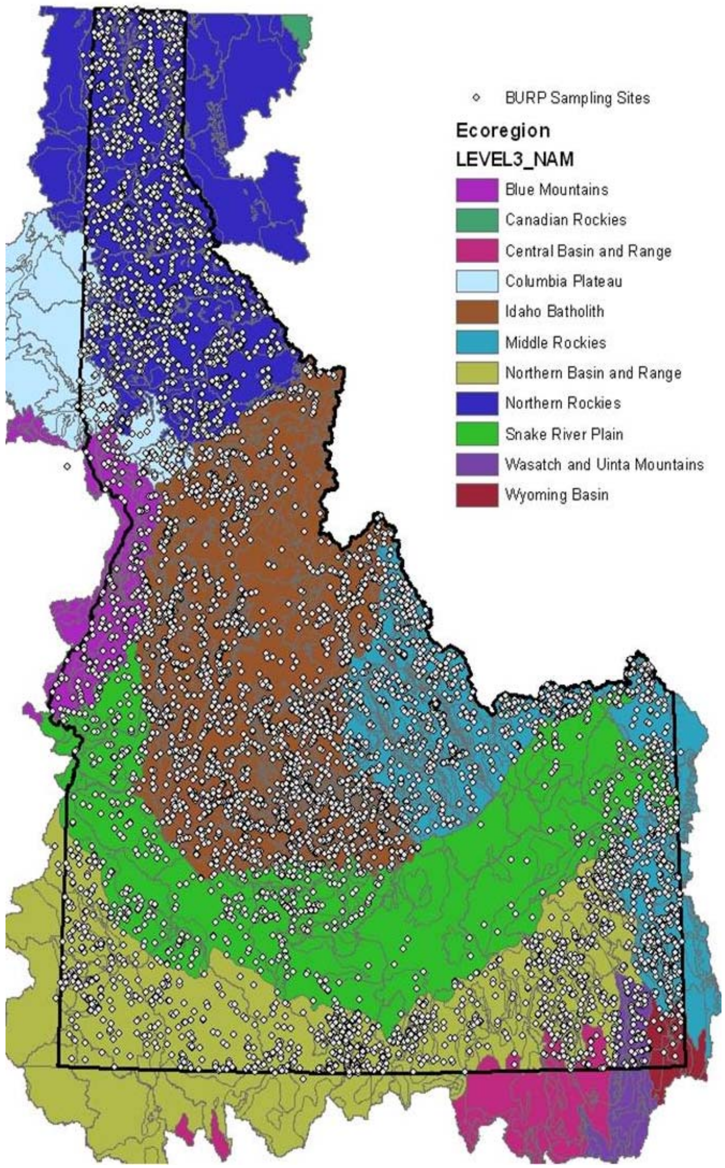

Figure 1-1. Map of level 3 ecoregions in Idaho, including BURP stream sampling sites.

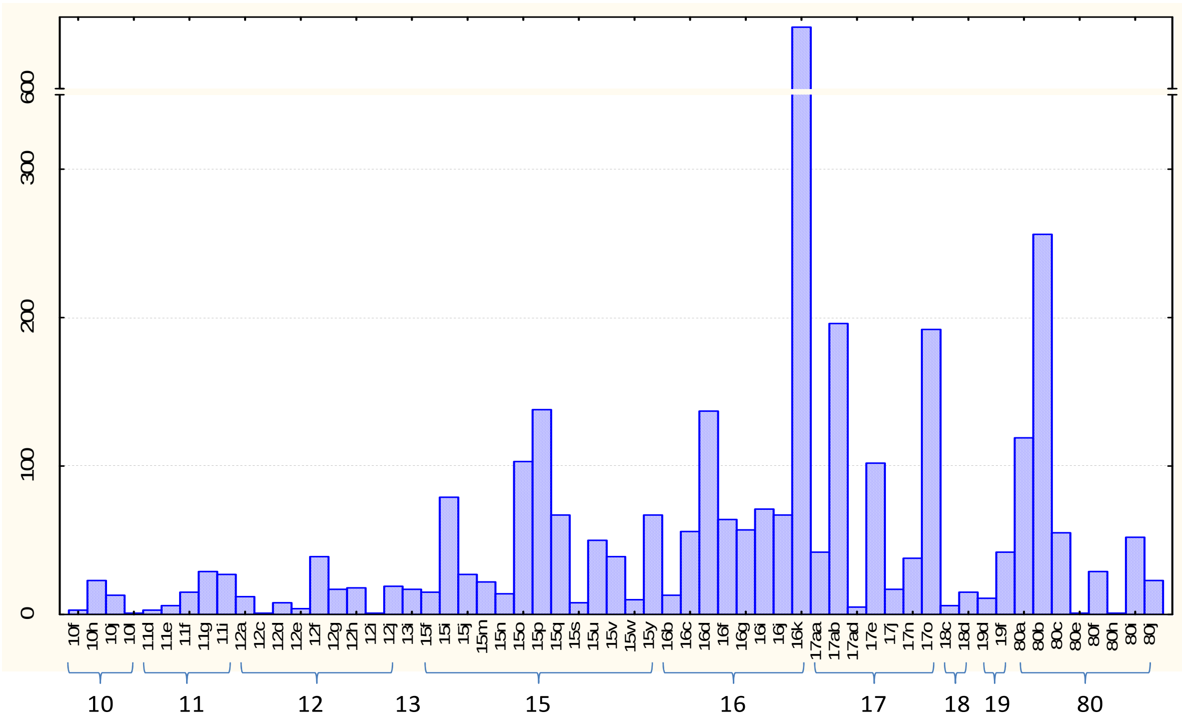

Figure 1-2. Numbers of sites in each of the level 3 and 4 ecoregions in Idaho. See Table 1-3 for ecoregion names.

1.2.3 Geographic Information System (GIS) analysis

Each sampling site was geo-referenced, making it possible to analyze site characteristics that were available as geographic information layers. Analyses were performed using Geographic Information System (GIS) software (ArcGIS 9.2; ESRI 1999-2006). The information analyzed at the site scale included elevation, level 3 and 4 ecoregion, freshwater ecoregion, temperature, average annual precipitation, minimum and maximum temperature, population density, major lithologic type, stream gradient. Sources for these data layers and those used in catchment delineations are in **Appendix B**.

Upstream catchment delineations for stream sites were provided by IDEQ. For the stream sites, the entire upstream catchments were taken into consideration. For river sites, delineations were not available, so contributing areas were outlined using hydrologic unit codes (12-digit HUCs). The contributing area included the HUC subwatersheds in which the sites were located plus any upstream HUC subwatersheds that were within 10 km of the site. For some sites with changing land uses up- and down-stream of the site, the downstream portion of the HUC was excluded. Limits on the upstream extent of the contributing area was established (versus including all upstream HUCs) because far distant upstream areas have diminishing effects on conditions at individual sites. For both rivers and streams, the variables analyzed at the catchment scale included land use/cover, road density, road crossings, road proximity to streams, proportions of ecoregions, average population density, proportions of lithologic types, density of water diversions, density of dams, and density of canals. Summary statistics were developed for land use/cover - the Landscape Disturbance Index (LDI, **Appendix C**) - and lithologic erodibility (**Appendix D**).

1.2.4 Metric Calculations

Of the 3207 sample records in the streams database, 2345 macroinvertebrate samples and 1375 fish samples were valid for analysis. All samples included at least partial habitat data. Samples were excluded because of non-existent samples, small or large counts of individuals in the macroinvertebrate sample, close or overlapping sites, or in a few cases, sites outside of Idaho. The samples included 770 macroinvertebrate taxa and 71 fish taxa. For the most part, attributes of the taxa had been previously assigned by IDEQ. New attributes were added, especially for fish, based on standard taxonomic conventions, Environmental Monitoring and Assessment Program (EMAP) classifications, or other sources (Montana DEQ). When new attributes were added in the database taxa lists, the attribute sources were listed. In the cases of EMAP and MDEQ, the taxa lists were publicly available as electronic datasets. Metric calculations were performed in a relational database, where data manipulations prior to calculations could be automated (e.g., standardizing taxonomic identifications).

2.0 Idaho Reference (and Stressed) Site Identification

The reference condition concept is one in which the acceptable indicator conditions are defined by the conditions observed in sites with minimal disturbance (Barbour et al. 1999, Stoddard et al. 2006). Index values that are not similar to those observed in reference sites indicate the presence of stressors at the site. During calibration of the indices currently in use in the Idaho Small Stream Ecological Assessment Framework and River Ecological Assessment Framework, reference conditions were independently developed for each index. Development of reference sites to be applied in state-wide calibration of new indices for habitat and all assemblages will unify the reference condition concept and standards across indices in Idaho. For multimetric indices, defining the most disturbed (or stressed) sites as well as the least disturbed is necessary to establish clear signals of metric and index responsiveness. The reference and stressed sites defined for this analysis are only meant for calibration of indices. They are not meant to be applied in other IDEQ programs.

Reference sites were defined using measures of the intensity of human activity in the watersheds (such as GIS derived land use intensity). We did not use field habitat data to define reference sites so that we could calibrate habitat indices along an independent scale of disturbance. Water quality measures were available for rivers but not for streams. Therefore, the indicators resulting from these analyses will respond to the stressors used in defining reference and stressed sites (primarily intensity of human activity), not to any specific stressors such as habitat conditions or water quality.

In defining reference sites for streams and rivers, we intended to recognize overarching patterns of land use intensity as we set reference criteria. In this way, we could assure that reference sites would be distributed spatially throughout the state. At the same time, we concede that reference conditions are not identical across the state. The intention was to have representative sites for all natural stream types, and to recognize where the reference sites are less than natural, to a degree appropriate to their locations. We only accept less-than-natural conditions as reference where truly natural sites could not be found or are too remote to be used in valid comparisons. In other words, we did not want to compare streams in the agriculturally dominated areas to forested mountain streams far away, so we sought the best streams that were in the same geographical setting as the agriculturally dominated areas. In this way the reference sites have climate, geology, and other controlling natural conditions that are similar to the test sites that are compared to them.

Land uses in Idaho are aligned with the natural settings, such that steep forested terrain that is relatively inaccessible is less intensively used than flatter, accessible plains and foothills. Natural ecoregions (McGrath et al. 2002) are therefore a reasonable framework for recognizing human geography as it relates to variations in expectations for degrees of disturbance across the State. After preliminary classification analyses that considered land use in the site catchments, the ecoregional framework (levels 3 and 4) was determined to be better for defining reference expectations than frameworks based on freshwater ecoregions (Abell et al. 2008) or major river basins.

The streams dataset includes several variables related to human disturbance. These variables were evaluated as reference site criteria. By plotting distributions of these variables, we were able to set thresholds of disturbance for defining relative stress levels for each variable. Plotting the distributions in ecoregional groups allowed us to adjust the thresholds as appropriate for the natural setting and human geography. Threshold adjustments were made to reach a target sample size in each level 3 ecoregion: at least 10% of the data set should be reference sites and another 10% should be stressed sites. This target was somewhat arbitrary, but was based on the assumption that the best and worst 10% of the sites would represent extremes of the stressor gradient and be numerous enough for the proposed analyses.

2.1 Stream Reference Designations

Preliminary reference criteria were developed by examining distributions of the following eleven variables across level 4 ecoregions.

- Population density at the site (#/km2)
- Proportion of the upstream catchment with natural land uses (percentage)
- Land Disturbance Index (LDI) for the upstream catchment (index units)
- Density of roads in the upstream catchment (km/km2)
- Proportion of the upstream stream length within 100 meters of roads (km/km2)
- Density of mines in the upstream catchment, weighted by mine size (wghtd #/km2)
- Density of water diversion rights in the upstream catchment (#/km2)
- Density of NPDES permits in the upstream catchment (#/km2)
- Disruptive pressure observed in riparian zones during site visits (rating [1-20])
- Density of dams in the upstream catchment (#/km2)
- Grazing activity at the site (presence/absence)

The criteria established for each variable (**Table 2-1**) were based on the distributions of values in each level 4 ecoregion (**Appendix E**) and the intent of defining 10% of sites as reference and 10% as stressed. In most cases, distributions of values were similar among the level 4 ecoregions of each level 3 ecoregion. However, ecoregions 15f and 15j are in the valley of the Clearwater River, which is more densely populated than the other parts of ecoregion 15. Likewise, all sites in ecoregion 12e had more intensive land uses than almost all other sites in ecoregion 12. Therefore, criteria were adjusted to recognize the overarching land use patterns in these areas.

Table 2-1. Reference and stressed site scoring criteria for streams, by ecoregion. See Table 1-3 for ecoregion definitions.

Variable	Criteria Type	Score	ECOREGION CODE											
			10	11	12		13	15		16	17	18	19	80
					12e	other 12		15f, 15j	other 15					
Land Disturbance Index	Ref	-1	<0.25	<0.05	<0.05	<0.05	<0.25	<0.25	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Stress	1	>2	>2	>2	>2	>2	>2	>2	>2	>2	>2	>2	>2
% natural land cover	Ref	-2	>98	>98	>98	>98	>98	>98	>98	>98	>98	>98	>98	>98
	Ref	-1	>95	>95	>95	>95	>95	>95	>95	>95	>95	>95	>95	>95
	Stress	1	<50	<70	<50	<70	<70	<50	<70	<70	<70	<70	<70	<70
Road Density	Ref	-1	<1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.01	<0.05	<0.05	<0.05
	Stress	1	>2.5	>2.5	>2.5	>2.5	>2.5	>2.5	>2.5	>2.5	>2.5	>2.5	>2.5	>2.5
Roads near Channels	Ref	-1	<0.3	<0.15	<0.15	<0.15	<0.15	<0.1	<0.1	<0.05	<0.05	<0.3	<0.1	<0.1
	Stress	1	>0.6	>0.6	>0.6	>0.6	>0.6	>0.6	>0.6	>0.6	>0.6	>0.6	>0.6	>0.6
Population	Ref	-1	<10	<5	<5	<5	<5	<5	<5	<5	<5	<10	<10	<5
	Stress	1	>30	>30	>30	>30	>30	>30	>30	>30	>30	>30	>30	>30
Weighted Mine Density	Ref	-1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stress	1	>0.1	>0.1	>0.1	>0.1	>0.1	>0.1	>0.1	>0.1	>0.1	>0.1	>0.1	>0.1
Diversions	Ref	-1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Stress	1	>4	>4	>4	>4	>4	>4	>4	>4	>4	>4	>4	>4
Disruptive Pressure	Ref	-1	>5	>5	>5	>5	>5	>5	>5	>5	>5	>5	>5	>5
	Stress	1	<=3	<=3	<=3	<=3	<=3	<=3	<=3	<=3	<=3	<=3	<=3	<=3
Dams	Stress	1	>0.02	>0.02	>0.02	>0.02	>0.02	>0.02	>0.02	>0.02	>0.02	>0.02	>0.02	>0.02
NPDES permits	Stress	1	>0.01	>0.01	>0.01	>0.01	>0.01	>0.01	>0.01	>0.01	>0.01	>0.01	>0.01	>0.01
Grazing Activity	Ref	-1	No 'GR'	No 'GR'	No 'GR'	No 'GR'	No 'GR'	No 'GR'	No 'GR'	No 'GR'	No 'GR'	No 'GR'	No 'GR'	No 'GR'

For each site, each variable was assigned a value of -1 (met reference criterion), 0 (fair) or 1 (stressor present). For one variable, proportion of catchment with natural land uses, we divided reference into two tiers: -2 = best reference; -1 = reference. We calculated cumulative scores of all the reference criteria for each site in reference and stressed ranges separately, so that Reference Score = sum of all negative (-1 or -2) scores and Stressor Score = sum of all positive (1) scores. Then we looked at the distribution of sites in each score category, to achieve our 10% goal within each ecoregion using these criteria (**Table 2-2**). This process resulted in 407 reference stream sites and 266 stressed sites distributed throughout the state and across all ecoregions.

Table 2-2. Numbers of sites in each level 3 ecoregion with reference scores 0 to -10 and stressed scores 0 to 7. Lines and shaded areas denote thresholds and site tallies of reference and stressed sites. See Table 1-3 for ecoregion codes.

Level 3 Ecoregion	10	11	12	13	15	16	17	18	19	80	All Regions
RefScore -10	0	6	2	0	100	189	50	1	0	0	348
RefScore -9	1	5	4	0	67	131	28	2	7	27	272
RefScore -8	3	21	8	0	166	273	65	0	6	86	628
RefScore -7	0	9	6	0	65	132	41	1	4	36	294
RefScore -6	1	2	13	1	23	53	18	0	1	13	125
RefScore -5	1	1	5	1	4	8	5	0	1	6	32
RefScore -4	0	0	4	1	3	4	0	0	0	4	16
RefScore -3	1	0	1	1	0	0	0	0	0	2	5
RefScore -2	1	1	1	0	2	0	0	0	0	0	5
RefScore -1	0	0	1	0	2	0	0	0	0	0	3
RefScore -0	32	35	75	13	208	316	383	17	34	359	1472
StressScore +0	11	66	84	8	479	909	492	8	44	358	2459
StressScore +1	5	11	23	5	112	161	92	7	9	140	565
StressScore +2	12	3	7	3	36	25	6	6	0	23	121
StressScore +3	8	0	3	1	10	6	0	0	0	9	37
StressScore +4	2	0	0	0	2	4	0	0	0	2	10
StressScore +5	1	0	0	0	0	1	0	0	0	1	3
StressScore +6	1	0	1	0	0	0	0	0	0	0	2
StressScore +7	0	0	1	0	0	0	0	0	0	0	1
Total Sites	40	80	119	17	639	1106	590	21	53	533	3198

Not all of the sites designated as reference and stressed were used in all analyses. Sites lacking either adequate samples or descriptive data were excluded. In addition, sites that were within one kilometer of each other were considered redundant, and only one of the pair was used (the one with more complete data or randomly selected if completeness was equal). A reach was defined as a stream segment between stream nodes, so two sites that were close, but on either side of a tributary were both included. Throughout this document, the numbers of samples used in each analysis are stated. The numbers of adequate samples differ among analyses because adequate samples for benthic macroinvertebrates, fish, and habitat were not always available at each site.

2.2 River Reference Designations

Because of the covariance of natural and stressor variables for Idaho rivers, a different approach had to be taken for defining the disturbance gradient among river sites. In preliminary analyses (**Appendix F**), we identified reference and stressed rivers based on criteria for disturbance variables, much like we did for streams. This resulted in reference and stressed sites that were divided unevenly among regions of the State. Almost all reference sites were in mountainous regions and almost all stressed sites were in plains regions. This necessitated an iteration of two steps in the process – reference identification and site classification. Because of an interest in developing parallel classification systems for the multiple indicators, we tested the stream classification system (see Chapter 3) for viability with rivers.

Within the river site classes, the stressor gradient was defined using multiple stressor variables in a Principal Components Analysis (PCA). Reference criteria were developed for the PCA factor scores and for those variables that were strongly related to the PCA axes. Reference criteria were established so that reference and stressed sites could be identified in each site class.

River Reference Results

The rivers dataset was relatively small compared to the streams dataset, with 139 sites and samples in total, but only 108 unique sites with valid benthic samples. Site classification based on reference sites alone was impractical because as a fraction of all sites, the number of reference sites would be too small for analysis. As stated above, the re-iteration of classification and reference designation steps was necessary because of apparent covariance of natural and stressor variables in Idaho river sites. Therefore, before defining the stressor gradient in rivers, natural characteristics of the river sites were considered.

Reference criteria for rivers were established for Mountains and Non-mountains (**Table 2-3**), which were the site classes established in the river classification analysis (Section 3.7). The primary variables were those derived from GIS analysis because they were available for all sites. As can be seen from the differences in criteria among the two regions, stressed sites in the Mountains could be only marginally stressed and reference sites in the Non-mountains could have as much stress as stressed mountain sites. There is not a clear separation. The purpose of defining these stressor gradients is for indicator development, that is, finding metrics which best respond to the gradient that is present. These reference designations are compatible with the concept of best available reference (Stoddard et al. 2006), which are not meant to represent undisturbed conditions. ‘Reference’ and ‘stressed’ are merely convenient labels for the two ends of the gradient within a classification, and may be misleading regarding site environmental quality across classifications.

Table 2-3. Reference and stressed site scoring criteria for rivers, by site class.

Variable	Criteria Type	Score	Mountains	Non-mountains
Road density	Ref	-1	<0.3	<0.6
(km/km^2)	Stress	1	>0.5	>1.0
Roads close to channels	Ref	-1	<0.1	<0.2
(km/km)	Stress	1	>0.2	>0.3
LDI	Ref	-1	<0.002	<0.05
(index units)	Stress	1	>0.0025	>0.6
Population density	Ref	-1	<=0.5	<=1
(# per square mile)	Stress	1	>2	>20
PCA axis 1	Ref	-1	>1.4	>2
	Stress	1	<-1.5	<-1.5

Application of these criteria, interpretation of cumulative scores for each site, and consideration of non-quantitative information (anecdotal or familiar qualities) allowed identification of 24 reference and 13 stressed sites in the Mountains and 10 reference and 17 stressed sites in the Non-mountains. These designations were then used for indicator development.

In the Mountains, the reference criteria selected for only the most undisturbed sites. Using the criteria alone, most of the reference river sites were concentrated in the wilderness areas of the Upper Selway River and Middle Fork Salmon River. In order to increase geographic representation, IDEQ staff recommended that eight sites that did not meet all the reference criteria be added to the reference data set. This expanded the geographic area represented by reference sites. The professional judgments affected reference designations in sites with mixed results after applying the criteria (**Table 2-4**).

Table 2-4. River sites designated as reference based on professional judgment.

Site ID	Site name	Reason for change in designation
2006RDEQA074 IDW02353-027	Lochsa River	These segments failed the stressed criteria for land use (logging), which IDEQ staff considered of minimal impact, considering excellent conditions otherwise.
2008RDEQA026 IDW02353-004	Upper NF Clearwater River	These segments failed the stressed criteria for roads. The IDEQ staff considered roads alone to be of minimal impact, considering excellent conditions otherwise.
2008RDEQA086	Upper St Joe River	This segment did not pass the reference criteria for roads, but was otherwise undisturbed.
2006RDEQA075	Salmon river	Some activity near this segment included logging and roads near the river channel. However, these disturbances were considered by IDEQ staff to be minor.
2008RDEQA068	Camas Creek	The only activity at this site was roads near the river channel. Otherwise, conditions were excellent.
2008RDEQA087	SF Payette	This site failed the stressed criterion for population density. However, the criterion is very strict and other conditions at the site were excellent.

3.0 Classification in Idaho Streams

Site classification is the process by which natural gradients among sites are examined to identify appropriate classes or "bins" of sites with similar indicator characteristics. The purpose of classification is to minimize within-class natural variability of indicators (biological and habitat) so that human disturbance can be recognized with less background noise. Potential site classification variables and indicators were analyzed simultaneously to identify patterns of covariance. Only reference sites were used for site classification so that the patterns in the natural settings of Idaho could be discerned with less influence from human disturbances. Resulting site classes were the framework upon which multimetric indices were calibrated. Predictive models do not classify sites into bins, but classify on a continuous scale, such that classification variables define partial membership of a site in each biologically distinct group. Predictive classification is covered in Section 4.3.

Approach

We used the benthic macroinvertebrate assemblage in reference streams as the primary data set for indicating stream classes throughout Idaho. The fish assemblage, habitat features, and river data were considered subsequently, as supporting evidence for the classification scheme derived from macroinvertebrate data. This decision was based on several factors. In preliminary analyses of fish in reference streams, we observed that the potential for refined classification was limited due to a limited diversity in the assemblage (there are few fish taxa relative to macroinvertebrate taxa). Habitat features were expected to affect macroinvertebrate community structure, and the classification signals from habitat features were expected to either support the biologically derived classes or require a different classification scheme. River data were sparse relative to the stream data, which limits the potential for refined river classes.

We assumed that classification based on macroinvertebrates in streams would be more refined than possible with or necessary for the other data types. Therefore, if it was necessary to lump macroinvertebrate stream classes for other data types, we would be starting from the most detailed classification scheme. In addition, there was a programmatic goal to simplify application of multiple indicators. One simplification that was suggested at the outset of the project was to not only use identical reference sites for all indicators, but also to have a single classification scheme, so that a site could be classified once for assessment of macroinvertebrates, fish, and habitat. This was a secondary goal, so the technical merits of a single classification scheme were weighed against the simplicity of application.

We hypothesized that ecoregions (levels 3 and 4, McGrath et al. 2002) would be important determinants of natural biological and habitat conditions. Ecoregions were integral to the reference site selection process and are therefore somewhat entwined in the classification determination, in which reference site data are key.

Technical Analysis

We used several techniques to help discern environmental factors that could account for biological variability in reference sites. The community structure of benthic macroinvertebrate samples was explored using Non-metric Multidimensional Scaling (NMS) ordination. Environmental factors were related to the major ordination axes. Because some areas of Idaho had scant reference sites, we also used Principal Components Analysis (PCA) of environmental variables in all sites. By using only variables that are unresponsive to human activities, the natural settings of the sites could be distinguished. Variables responsible for major differences among sites were related to ecoregions and biological metrics. In this way, the best site classes were identified for grouping site types with similar biological expectations.

3.1 Operational Taxonomic Units (OTU)

In preparation for ordination and clustering of taxa, in which sites are grouped by taxonomic similarities, taxonomic identifications were examined to reduce uncertainties and increase distinctiveness. Taxa were aggregated into Operational Taxonomic Units (OTU, Cuffney et al. 2007) or eliminated from the analysis. The OTUs were used not only for ordination, but also for predictive model development (see Section 4.3). Aggregation and elimination of ambiguous macroinvertebrate taxa were necessary in the specific analyses for two reasons. First, rare taxa can influence ordination results to a degree greater than their actual significance in the ecological settings, and should therefore be removed from analysis. Second, the ordination routine assumes that each taxonomic identification is unique when it may not be so because of our inability to reliably identify all individuals at the species level. For instance, a family level identification is interpreted to be different from a genus within that taxon, though the family level identification is ambiguous and may well be of a member of the same genus. This taxonomic uncertainty can lead to meaningless ordination configuration, and therefore *must* be resolved. Aggregation and elimination of taxa was performed so that the least amount of taxonomic information would be lost in the analysis. The OTUs and ambiguous taxa mentioned in this section do not affect metric calculations (see Section 4.1).

Taxa were considered rare and removed or aggregated when they occurred in less than 14 sites (5% of 285 valid reference sites). When there were several rare taxa in a taxonomic group and no common taxa in that group, all taxa in the group were re-assigned to the next higher taxonomic level (e.g. species lumped into the parent genus). If the common taxa outnumbered the rare taxa in a group, the rare taxa were eliminated. When there were higher level identifications for a group, they were eliminated from analysis if the lower level identifications in the same group were common and numerous.

The mayfly family Baetidae is shown as an example of elimination of higher level taxa or lumping of lower level rare taxa (**Table 3-1**). Eight taxa were eliminated because they were rare or higher level identifications. *Acentrella* and *Diphetor* were grouped at the genus level and three *Baetis* species were retained as unique identifications. If *Baetis* was grouped at the genus level, the important distinction between *Baetis bicaudatis* and *Baetis tricaudatis* would be lost.

Table 3-1. Modification of Baetidae identifications as an example of OTU designations**.**

Taxa List ID	No. Samples	Sum of Individuals	Modified ID or action
Baetidae	1	1	<eliminated>
Baetis flavistriga	12	104	<eliminated>
Baetis notos	1	4	<eliminated>
Baetis sp.	13	50	<eliminated>
Callibaetis sp.	1	8	<eliminated>
Centroptilum sp.	5	6	<eliminated>
Fallceon quilleri	3	38	<eliminated>
Plauditus punctiventris	1	2	<eliminated>
Acentrella insignificans	11	150	*Acentrella*
Acentrella sp.	12	28	*Acentrella*
Acentrella turbida	12	62	*Acentrella*
Baetis alius	14	59	*Baetis alius*
Baetis bicaudatus	64	1634	*Baetis bicaudatus*
Baetis tricaudatus	231	11802	*Baetis tricaudatus*
Diphetor hageni	78	488	*Diphetor*

In an example using Empididae, the non-rare distinct taxa at genus level included *Chelifera, Clinocera, Neoplasta, Oreogeton,* and *Wiedemannia*. Retaining these taxa necessitated elimination of Empididae (family), *Hemerodromia*, and *Trichoclinocera*. *Chelifera/Metachela* was lumped with *Chelifera*. In another example, the species of *Ephemerella* are lumped at genus level because dropping one rare species and the genus-only identifications is a greater loss of information than lumping all at the genus level.

In a few cases, “Other” taxa were defined as the aggregate of a group that otherwise contains distinct taxa. For example, in the Chloroperlidae (**Table 3-2**), three genera are distinct, while three others and the family level identification are lumped as Other Chloroperlidae so as not to lose the abundant family level information. While there may be some ambiguous Chloroperlidae that are now analyzed as completely distinct from the three distinct genera, they are not lost entirely from the analysis, nor are the rare genera.

Table 3-2. Modification of Chloroperlidae identifications as an example of OTU designations**.**

Taxa List ID	No. Samples	Sum of Individuals	Modified ID
Chloroperlidae	39	295	Oth_Chloroperl
Kathroperla sp.	4	4	Oth_Chloroperl
Neaviperla forcipata	6	16	Oth_Chloroperl
Plumiperla sp.	4	34	Oth_Chloroperl
Paraperla sp.	67	164	*Paraperla*
Suwallia sp.	41	184	*Suwallia*
Sweltsa sp.	220	3630	*Sweltsa*

3.2 NMS Ordination

Similarity among reference macroinvertebrate samples was determined using the Bray-Curtis (BC) similarity measure in a non-metric multidimensional scaling (NMS) ordination. Sites were arranged in ordination space based on a site-by-site matrix of BC similarity. Sites with similar taxonomic composition were plotted in close proximity and those with less similarity were plotted at a distance. Multiple dimensions were compressed into two or three dimensions that we can perceive. The stress associated with this compression indicates how closely the Bray-Curtis distance is reflected in the plot. Interpretation of the ordination diagram with respect to taxa within the samples and characteristics of the sites takes place through visual inspection of variable overlays and correlation along the ordination axes.

The NMS ordination was performed using PC-Ord software (McCune and Mefford 2006). A site-by-taxon matrix was compiled with abundance of each OTU in each site. A preliminary Detrended Correspondence Analysis (DCA) was performed to establish stable starting coordinates for the NMS ordination. Ordination was performed using taxa presence and square-root transformed relative abundance. In addition, a PCA ordination using a suite of 68 sample metrics was performed. Percentage metrics were arcsine-square-root transformed prior to ordination.

The NMS ordination of the 137 OTU taxa in 285 reference samples resulted in a three-dimensional solution with a final stress of 17.9 for relative abundance and a two dimensional solution with a final stress of 24.3 for taxa presence. Ordination stresses less than 20 are considered stable (McCune and Mefford 2006). In the PCA of transformed metrics, the first two axes explained 36% of the variance. In each of the ordinations, ecoregions of the sites appeared to distinguish regions of the ordination space, with two mountainous ecoregions (15-Northern

Rockies and 16-Idaho Batholith) clearly overlapping (**Figure 3-1**). Two other ecoregions (12-Snake River Plain and 80- Northern Basin and Range) were overlapping and distinct from the mountains. The sites situated around and between these two core groups were from smaller or more diverse ecoregions or from ecoregions intermediate to the mountains and plains.

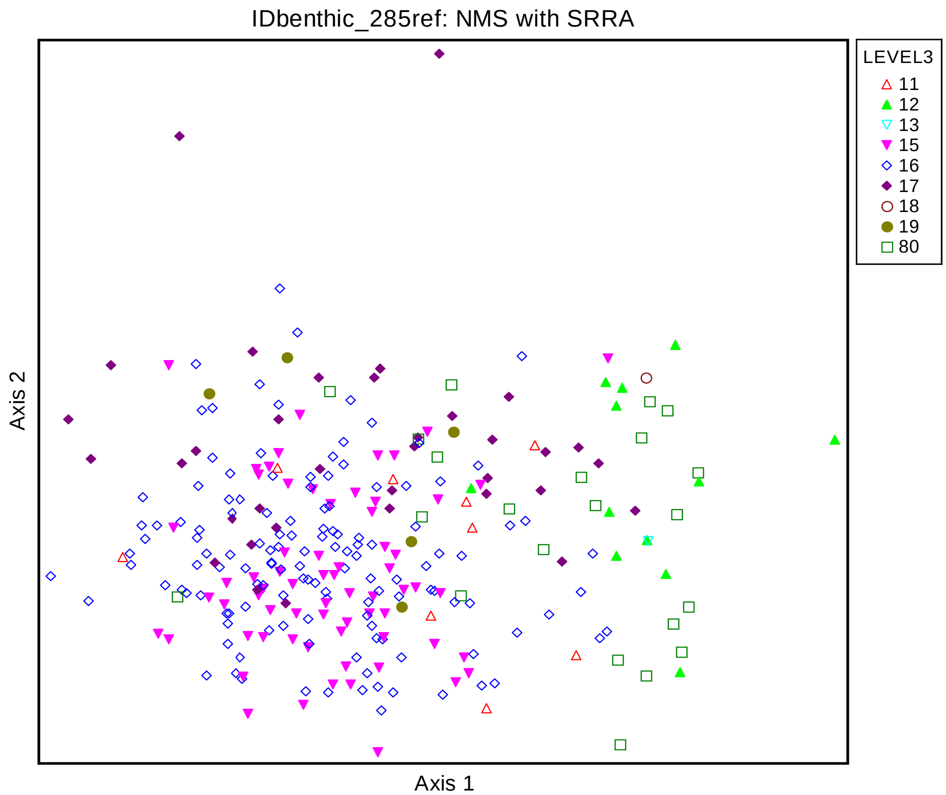

Figure 3-1. NMS ordination showing reference sites in taxonomic space based on transformed relative abundance of taxa, with level 3 ecoregions marked. See Table 1-2 for ecoregion definitions.

Environmental variables and benthic metrics were correlated to the ordination axes to determine potential classification variables. The first axes of all ordinations were related to temperature, scrub-shrub cover, and drainage area. These were also the axes on which benthic metrics were most strongly correlated. The correlations of these variables were not strong enough (Pearson r max = 0.62) to suggest that they would be appropriate for classifying sites. However, they were related to level 3 and 4 ecoregions, which were the preferred classification variables.

3.3 Principal Components Analysis

All sites were used in a PCA with natural variables because several level 4 ecoregions were sparsely represented in the reference dataset. The selected natural variables were those with minimal responsiveness to human disturbance. This PCA could be used to find appropriate classifications for regions lacking reference sites. PCA results from the reference biological metrics were compared to the natural variable PCA axes to find which axes were most important for classifying sites.

The 41 natural variables used in the PCA included variables related to location, climate, channel characteristics, topography, physical habitat, and vegetative land cover. Habitat features and vegetative land cover can be influenced by human activity, but we assumed that variations caused by human activity were a small portion of the total variation. These variables included measures of stream substrate, pool dimensions, organic debris, forest cover and scrub/barren/grass cover. Variables were transformed using logarithms or arcsine, square roots to approximate normal distributions when necessary.

The PCA with natural variables resulted in five factors with eigenvalues greater than 2.0 and 48% of variance explained, cumulatively. Among reference sites, PCA scores on the third factor were strongly related to first factor scores of the benthic metric PCA (**Figure 3-2**). Therefore, we assumed that the third factor, which explained 10.4% of the variance in natural variables, was the best factor to consider for classifying sites. The variables correlated with the third factor included % forests (0.73), precipitation (0.63), stream gradient (0.59), maximum air temperature (-0.63), and %Scrub/Barren/Grass cover (-0.65). These variables conceptually correspond to ecoregional distinctions.

When the natural variable PCA scores were plotted as distributions among level 4 ecoregions, groupings of ecoregions that were similar in those characteristics that most affected benthic macroinvertebrates could be discerned (**Figure 3-3**). While reviewing the potential level 4 ecoregions for groupings as site classes, we simultaneously reviewed ecoregion maps and distributions of metric PCA results in reference sites among level 4 ecoregions. Additional techniques were attempted to help define the classes, including Discriminant Function Analysis (DFA) and Classification and Regression Tree (CART) analysis on reference benthic clusters. We did not have convincing results using these methods, probably because of the uneven representation of reference sites. The combined analyses resulted in a decision to define three site classes and to use level 4 ecoregions to delineate the classes. The site classes included Mountains, Foothills, and Plains, Plateaus, and Broad Valleys (PPBV) as defined in **Table 3-3**.

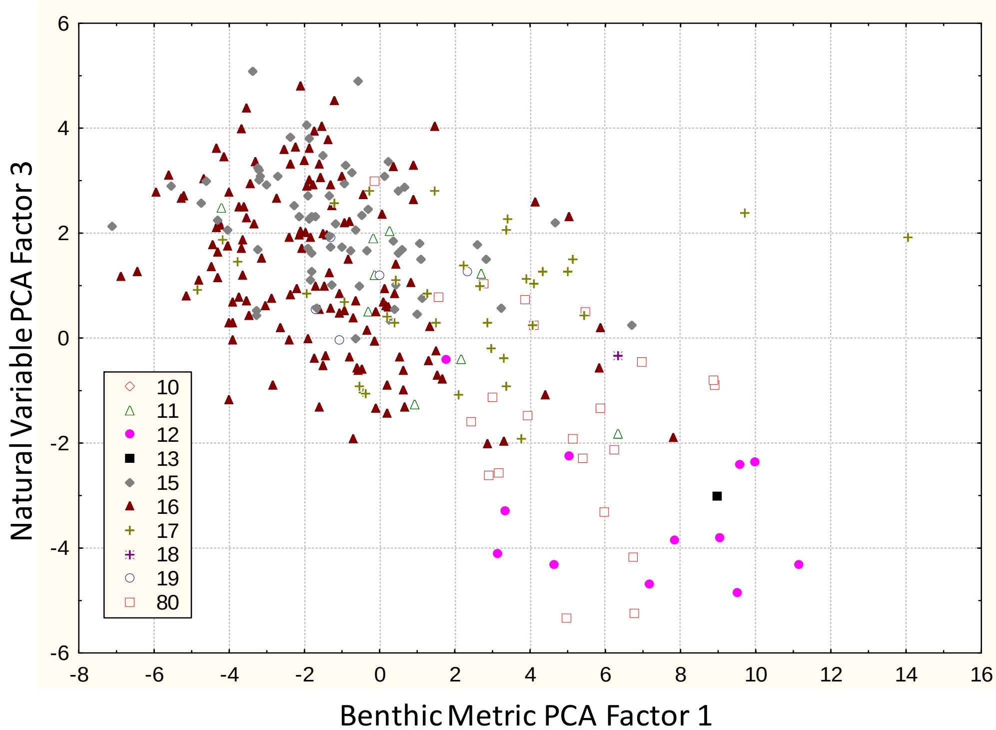

Figure 3-2. Relationship between PCA scores for natural variables and those for benthic metrics in reference sites, with ecoregions marked. See Table 1-3 for ecoregion codes.

Distributions of PCA scores for benthic metrics in reference sites and environmental variables in all sites confirm that the selected site classes are distinct (**Figure 3-4**). These site classes should account for much of the natural variability that influences benthic reference expectations. Site classes were mapped across the state to illustrate the regional patterns (**Figure 3-5**). Discussion of factors that influenced the categorization of level 4 ecoregions into site classes follows for each ecoregion.

3.4 Site Class Justifications

Ecoregion 10 – the **Columbia Plateau** – was not represented by any reference sites. Because this is an ecoregion dominated by flatland and hills, we would expect that it would have a reference biological community similar to other non-mountainous regions. It might also be similar to the western parts of the Northern Rockies (15f, 15j, 15n, 15v, which are also not represented by reference sites). The PCA of natural variables in all sites showed that the sub-ecoregions of ecoregion 10 were relatively homogenous in the factors that were related to macroinvertebrate metrics (factor 3, and to some extent, 2 and 4). They were also similar to factor scores in ecoregions 18 and 80. **Recommendation**: All of ecoregion 10 should be assessed among plains sites.

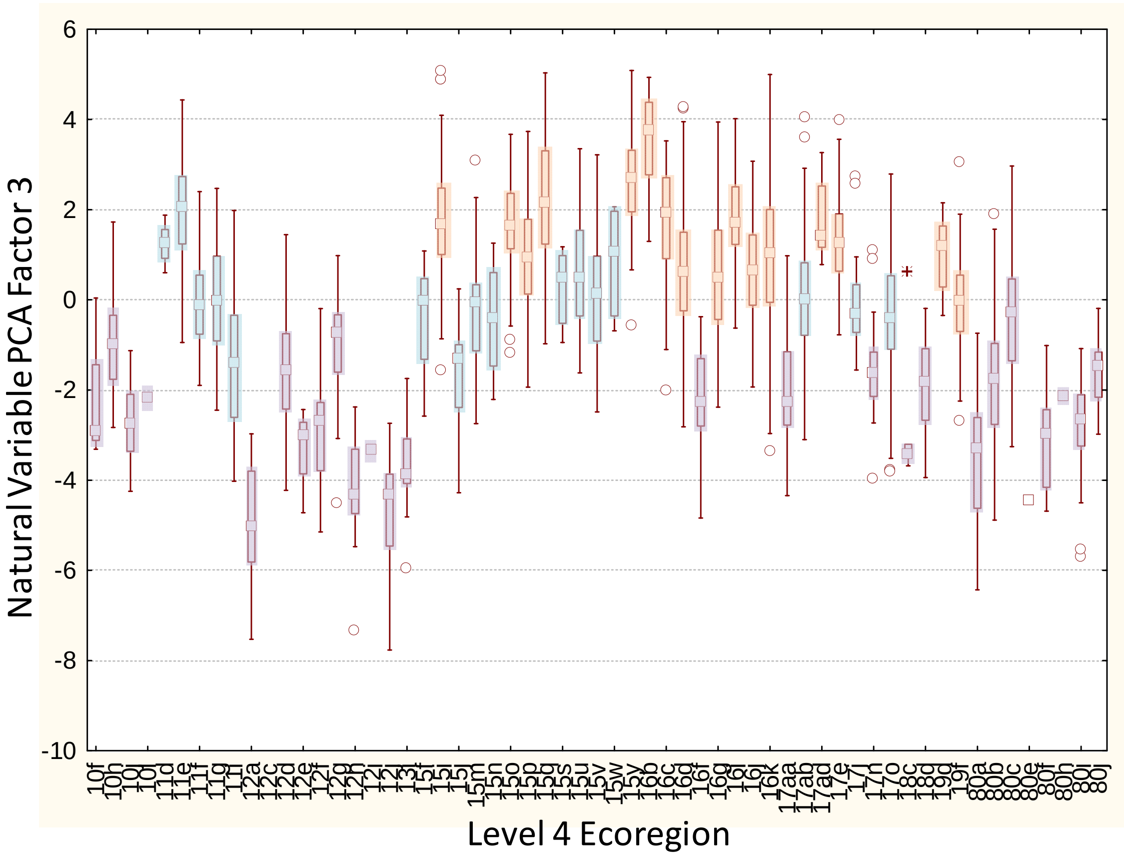

Figure 3-3. Distribution of PCA factor scores for all sites in level 4 ecoregions. Colors relate to final classification scheme; Mountains (pink), Foothills (blue), and PPBV (purple).

Table 3-3. Site classes resulting from multivariate analyses of natural environmental variables and the benthic assemblage in streams sites.

Site Class Description Ecoregion Code
Mountains The Wasatch-Uinta Mountains and selected sub-ecoregions of the Northern Rockies, Idaho Batholith, and the Middle Rockies 15i, 15o, 15p, 15q, 15y, 16 (except 16f), 17ad, 17e, 19
Foothills (intermediate, transitional) (Non-mountains) The Blue Mountains and selected sub-ecoregions of the Northern Rockies and the Middle Rockies 11, 15j, 15f, 15m, 15n, 15s, 15u, 15v, 15w, 17o, 17ab, 17j
Plains/Plateaus/Broad Valleys (PPBV) (Non-mountains) The Columbia Plateau, the Northern Basin and Range, the Central Basin and Range, the Snake River Plain, the Wyoming Basin and selected sub-ecoregions of the Middle Rockies and the Idaho Batholith 10, 12, 13, 16f, 17aa, 17n, 18, 80

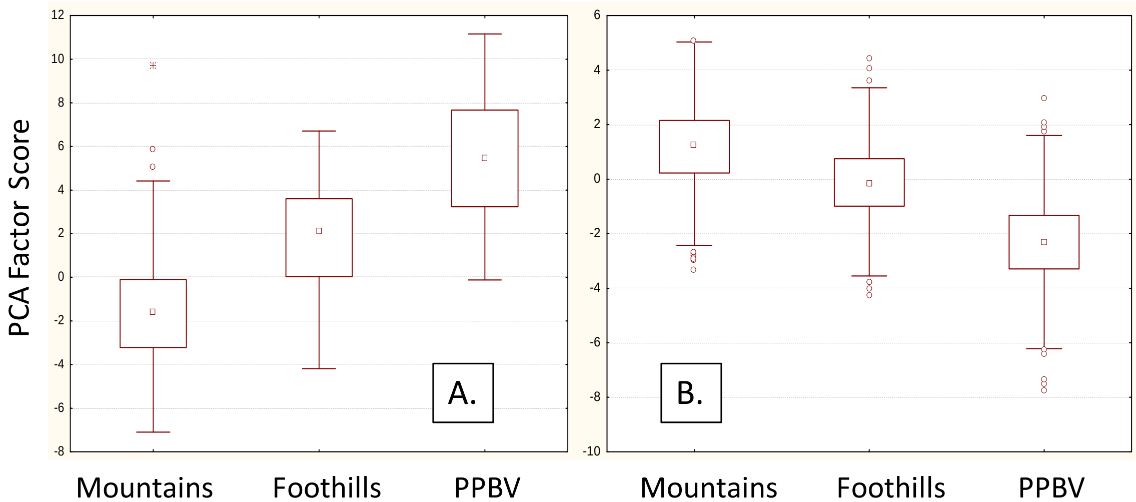

Figure 3-4. PCA factor score distributions in site classes (medians, interquartile ranges, and ranges). A) Benthic metrics in reference sites, axis 1. B) Natural variables in all sites, axis 3.

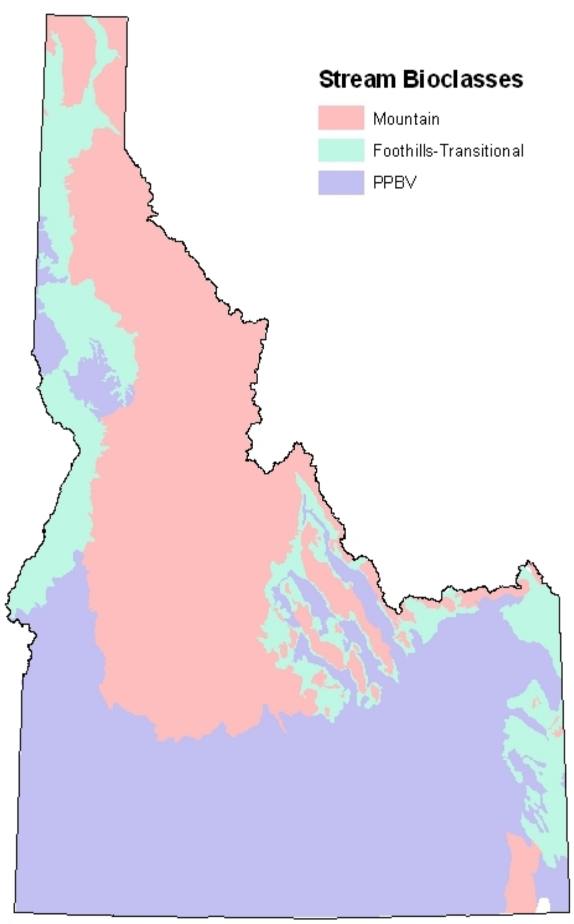

Figure 3-5. Map of Idaho showing the three stream bio-classes; Mountains, Foothills, and Plains/Plateaus/Broad Valleys (PPBV).

Ecoregion 11 – the **Blue Mountains –** The first metric PCA axis suggests that the metrics in the Blue Mountains are intermediate between mountainous and non-mountainous sites, but may be more similar to the mountainous sites. The southern subecoregion (11i) was least similar to the mountainous sites, on average. However, only 4 reference sites were in this subecoregion and lumping it with the Snake River Plain, to its south, was not immediately justified. The PCA of natural variables suggested that the Blue Mountains have intermediate characteristics, which are not always homogenous among sub-ecoregions, but that the unusual subecoregions are represented by only a few samples. **Recommendation**: All of ecoregion 11 should be assessed among foothills sites. Variability among metrics may be further investigated to find if adjustment to specific conditions may be warranted, especially in regards to conditions in sub-ecoregion 11i.

Ecoregion 12 – the **Snake River Plain –** Sites in the Snake River Plain (SRP) were consistently different than mountainous sites. This was evident not only in PCA scores generated from metrics, but also in ordinations of taxa presence/absence, relative abundance, and metrics. While the ecoregion spans from the western to the eastern border of southern Idaho, almost all of the reference sites are in the western half of the ecoregion (where most of the water is). The reference sites in the SRP were relatively homogenous biologically and were grouped together without reservation. The PCA of natural variables showed that subecoregions were not homogenous on factors 3 and 4, with some ecoregions showing characteristics of other intermediate regions. This may be due to stream sites in the eastern portion of the ecoregion, which were near the ecoregional border. With the lack of reference sites in all subecoregions, splitting the ecoregion would be difficult to validate. **Recommendation**: All of ecoregion 12 should be assessed among plains sites. Variability among metrics may be further investigated to find if adjustment to specific conditions may be warranted.

Ecoregion 13 – the **Central Basin and Range –** The CBR, on the southeastern border of the state, was represented by a single reference site that was biologically similar to other non-mountainous sites. The PCA of natural variables showed that the CBR was similar to other plains regions on the third axis. **Recommendation**: All of ecoregion 13 should be assessed among plains sites.

Ecoregion 15 – the **Northern Rockies –** Sites in the Northern Rockies were fairly homogenous biologically, though some subecoregions were not represented by reference sites (in the southwestern part of the ecoregion). Two subecoregions (15m [Kootenai] and 15v [southwestern] with 3 and 1 sites, respectively) were somewhat different than the rest, bearing some resemblance to non-mountainous sites. These under-represented and unusual subecoregions should be explored further when more samples can be analyzed. The PCA of natural variables showed that sub-ecoregions were important in the Northern Rockies, with regions *i, o, p, q,* and *y* (eastern and northern) similar amongst themselves and different from regions *f, j, m, n, s, u*, *v,* and *w* (western and southern). **Recommendation**: Eastern and northern ecoregion 15 should be assessed among Mountain sites, while western and southern ecoregion 15 should be assessed among Foothill sites.

Ecoregion 16 – the **Idaho Batholith –** Biological conditions in reference sites of the Idaho Batholith are quite similar across subecoregions, except that one site in 16f and 2 of 4 sites in 16g were somewhat different. Reference samples were more numerous in subecoregion 16k than in any other (78 sites) and the distribution of metric PCA factor 1 and 3 scores had broad ranges, perhaps due to some environmental variable that should be investigated. The PCA of natural variables showed that sub-ecoregion 16f on the southern perimeter of the ecoregion was somewhat distinct from all other subecoregions, resembling intermediate and plains sites more than mountain sites. **Recommendation**: Eastern and northern ecoregion 16 should be assessed among mountain sites, while sub-ecoregion 16f should be assessed among plains sites.

Ecoregion 17 – the **Middle Rockies –** Metric PCA and ordination results for the Middle Rockies suggest that the ecoregion is diverse biologically, with reference sites intermediate and spanning the mountainous and non-mountainous types. The most diverse subecoregion is 17e, which has sites resembling both mountainous sites, intermediate sites, and two outliers that do not resemble any other sites. One of the outliers has only four taxa (all chironomids) and the other has only 9 taxa. Because the ecoregion has such broad biological characteristics, there may be some explanatory environmental variables that can be discovered through other techniques. The PCA of natural variables showed that the sub-ecoregions of the Middle Rockies were highly variable, as might be expected from the diverse landform and location of the ecoregion in Idaho. **Recommendation**: Divide the subecoregions among site classes based on the PCA of natural variables.

Ecoregion 18 – the **Wyoming Basin –** The Wyoming Basin extends into the southeast corner of Idaho and is represented by a single reference site. This is a non-mountainous ecoregion and the single reference sample resembles other non-mountainous samples in the data set. The PCA of natural variables showed that the sub-ecoregions of the Wyoming Basin resembled other plains ecoregions. **Recommendation**: All of ecoregion 18 should be assessed among plains sites.

Ecoregion 19 – the **Wasatch and Uinta Mountains –** The Wasatch and Uinta Mountains cover a small portion of the southeastern corner of Idaho and are represented by five reference sites, all of which resemble other mountainous sites on the first three PCA factors. The PCA of natural variables in all sites showed that the Wasatch and Uinta Mountains might be placed with either the Mountain or Intermediate class. The grouping recommendation is based on metric similarity to mountain sites. **Recommendation**: All of ecoregion 19 should be assessed among mountain sites.

Ecoregion 80 – the **Northern Basin and Range –** On the first metric PCA axis, reference sites in the NBR resemble sites in the non-mountainous Snake River Plain more than any other ecoregion, though the range is somewhat nearer to the intermediate sites as in the Middle Rockies. On the second PCA axis, NBR sites resemble mountainous sites, and on the third axis, they are intermediate. The PCA of natural variables showed that most sub-ecoregions of the NBR were aligned with other plains regions. **Recommendation**: All of ecoregion 80 should be assessed among plains sites.

3.5 Classification for Fish

Site classification to account for differences in expected stream fish assemblage characteristics proceeded to answer the question: Was there justification to use the site classes defined for the benthic macroinvertebrates for fish index development? The follow-up question was: Was there evidence that other classification schemes would perform better? To answer the first question, we conducted a PCA of fish metrics in reference sites and compared the principal axes among the proposed benthic site classes.

The PCA of fish metrics included 36 metrics that were transformed as needed to approximate normal distributions. The first three factors explained 65% of the variance in the data. The first PCA axis was related to % cold-water taxa and minnows and the second axis was related to intolerant taxa and salmonids. From these major metric axes, it was clear that the PPBV sites had different metrics, especially in comparison to the Mountains sites (**Figure 3-6**). The Foothills sites had characteristics similar to the Mountains on the first PCA axis, but somewhat different on the second axis. Based on these results, the classification scheme developed for benthic macroinvertebrates in streams appears to be valid for fish also.

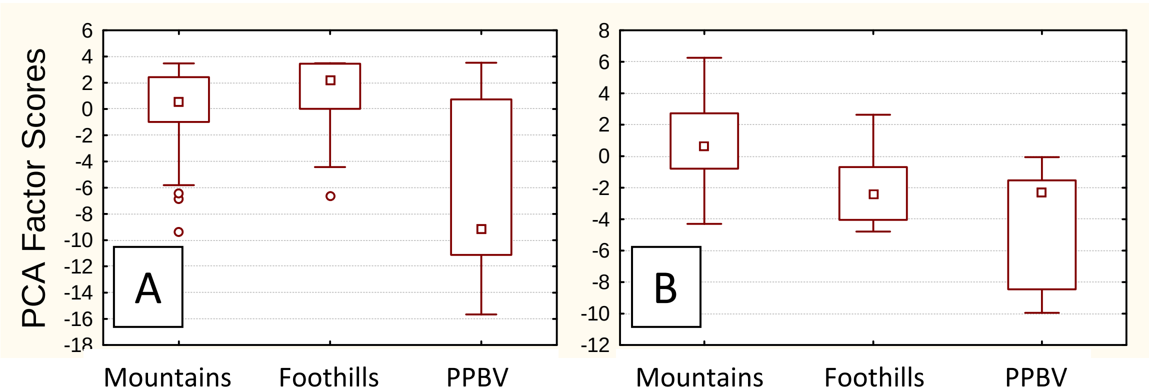

Figure 3-6. PCA factor score distributions in site classes (medians, interquartile ranges, and ranges). A) Fish metrics in reference sites, axis 1. B) Fish metrics in reference sites, axis 2.

To answer the second question (Was there evidence that other classification schemes would perform better than benthic classes?), we compared NMS ordination results of reference taxonomic presence and relative abundance with natural variables along the same axes. Pearson correlations of NMS scores with natural variables indicated that water temperature and drainage area were the most important variables related to the ordination axes ($r = 0.48$ and 0.41, respectively, on the first axis), though the r values indicated that the relationships were not very strong. Water temperature was related to the established site classes and stream size could be accounted for in metric scoring schemes. Categorical variables were superimposed on the diagram and visually assessed. The categorical variables did not show patterns stronger than those exhibited with the established site classes. Therefore, the established site classes were accepted as appropriate classes for developing fish indices.

3.6 Classification for Habitat

As for benthic macroinvertebrates and fish, classification for habitat was explored using PCA. After preparing the data (transforming to approximate normal distributions when needed), we performed a PCA with 29 habitat variables in reference sites. Objectives of this analysis were to examine which habitat variables explained the greatest amount of variance at minimally disturbed sites and to examine potential classification schemes. We considered groupings based on the established site classes (Mountains, Foothills, PPBV), level 3 ecoregion, Rosgen code, freshwater ecosystems of the world, size (stream order, average wetted width), type of habitat (riffle/run vs. pool/glide), gradient, power, and lithologic erodibility.

PCA results suggested three groups, based on dominant stream habitat type and drainage area (**Figure 3-7**). The greatest differences in habitat axes were seen between habitat types; riffle/run (RR) vs. pool/glide (PG). In this analysis, sites with < 35% riffle/run habitat were classified as PG sites, and those with ≥ 35% riffle/run habitat were classified as RR sites. These measurements were based on longitudinal habitat distributions (meters of riffle, run, glide, and pool in a sampling reach). The 35% threshold was established based on summary statistics and examination of box plots.

When compared to RR sites, PG sites generally have higher pool measure values (pool length, pool variability, pool substrate, pool:riffle ratio, etc.), higher percent fines and embeddedness, lower canopy cover, lower instream cover, fewer Wolman size classes, and different channel shape (more rectangular-trapezoidal with higher mean bank angle). In addition, the existing habitat indicator, the SHI, was generally lower in PG sites.

A small group of RR sites did not conform to the majority of sites. These were identified as having a smaller wetted width, less than 0.7m. There were only five sites in the reference data set that fell into this category. After reviewing these sites with IDEQ, it appeared that the smaller RR sites might not warrant a separate classification category for two reasons. First, the group was too small for statistically robust indicator development. Second, some of the reference sites were of questionable reference quality. These sites were excluded from analyses, which will have implications for habitat index applications.

The PCA analysis did not show strong evidence for classifying by the same site classes established for benthic macroinvertebrates. However, we continued to investigate this possibility because the RR group was large and diverse and because the uniform recognition of site classes across indicators was useful to IDEQ. When the existing habitat indicator, the SHI, was plotted in the Mountains, Foothills, and PPBV riffle-run sites, the mountains appeared to have higher reference values (**Figure 3-8**). The Foothills and PPBV had similar distributions, slightly higher than those in the pool-glide sites, on average. Development of the habitat indicators proceeded using four site classes, though an indicator for all riffle-run sites was also considered.

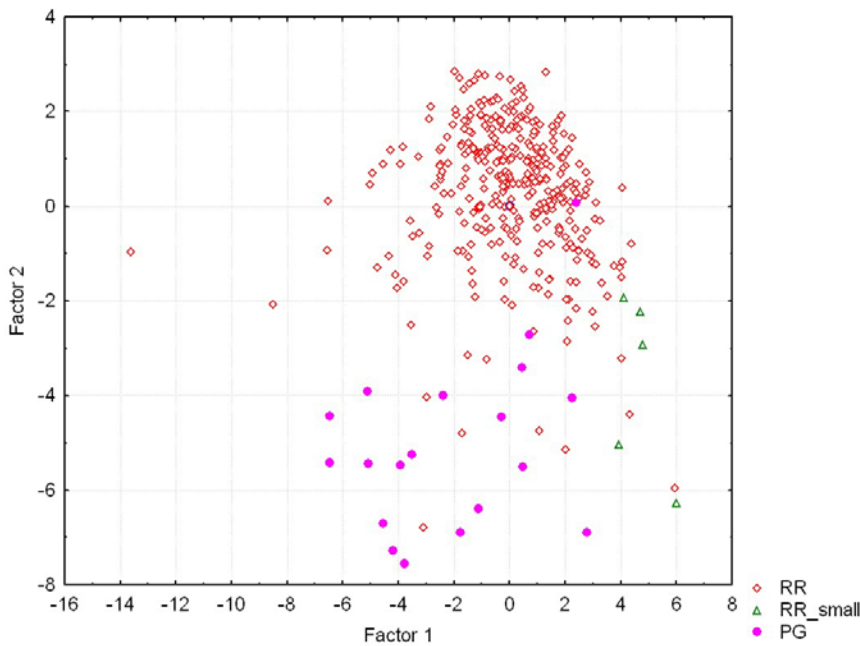

Figure 3-7. Sites on the first two axes of the habitat PCA, showing designations in three prominent groups (RR = Riffle-run, RR_small = RR streams with width < 0.7m, PG = pool-glide).

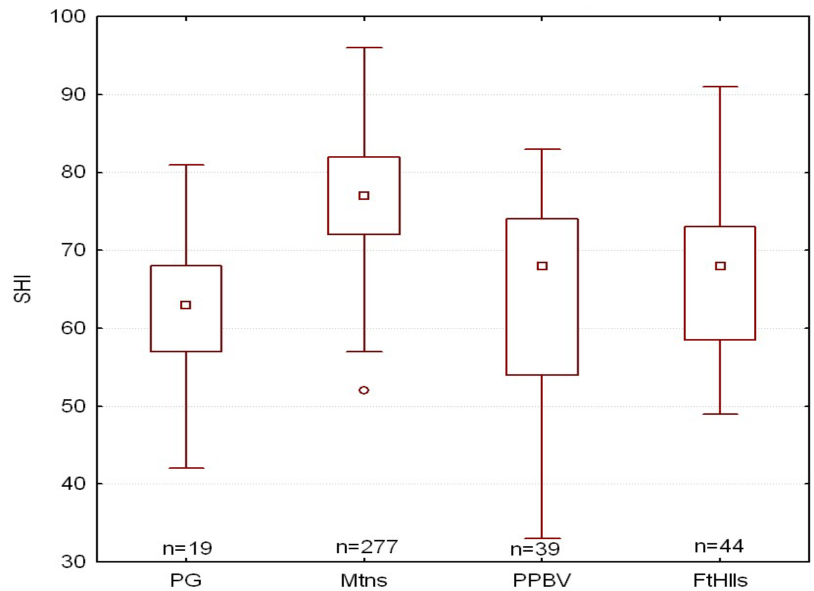

Figure 3-8. Reference SHI values in pool-glide dominated streams (PG) and in riffle-run dominated streams in the three benthic site classes.

3.7 Classification for Rivers

Classification of Idaho rivers required an iterative analysis for identification of minimally disturbed (reference) sites and classifying sites into relatively homogeneous groupings. At first, we developed and applied reference criteria for stressor variables, much as we did for streams. This analysis was eventually abandoned because the resulting reference and stressed sites were unequally distributed among the obvious site types: mountains and plains. Almost all of the reference sites were in the mountains and almost all of the stressed sites were in the plains. This arrangement would have caused river classes based on reference site characteristics to be biased, such that the plains sites would be underrepresented and possibly misclassified.

Because the preliminary analysis showed imbalanced distribution of reference sites, we considered that the classification system developed for streams would be a good starting place for classifying rivers. Applying the stream classification scheme to rivers resulted in 51 Mountain rivers, 16 Foothill rivers, and 41 PPBV rivers. We sought to combine the Foothill sites with another class because the sample size was too small for development of independent indices in that class. PCA was used to determine whether the Foothills rivers had more similarities with the Mountains or the PPBV rivers, and thus determine the best combination of regions.

A GIS analysis on river sites was conducted to assess site and surrounding natural and stressor conditions. The areas analyzed for effects contributing to conditions at the sampling site were not the entire upstream catchment. Instead, the areas included the HUC6 watersheds that the sites are located in, plus any upstream HUC6 watersheds that enter within 10 km of the site. For some sites, we clipped the HUC6 watersheds that the sites are located in to include only the upstream portions of the watersheds. We did this when the downstream portions of the watershed had areas of different land use than the upstream areas. This was determined through visual inspection of GIS land use categories. If the areas of the watershed that were upstream and downstream of the site had consistent land use, then we did not clip the watershed, but rather included the downstream areas in our calculations.

The PCA was conducted in several ways so that influences of natural and stressor variables could be considered both independently and together. In all three versions (both natural and stressor variables, natural variables only, stressor variables only), the stream site classes were substantially separated on the first factor and overlapped on the second and third factors (**Figure 3-9**). The separation among site classes was strongest when considering natural variables only. The natural variables pertained to location, climate, topography, physical river characteristics, and land cover. The first factor in all three PCA arrangements was related to natural land uses, described as % forest for natural variables and the LDI for stressor variables. Variables on the second factor were longitude and elevation for natural variables and adjacent roads for the stressor variables. The third factor was inconsequential.

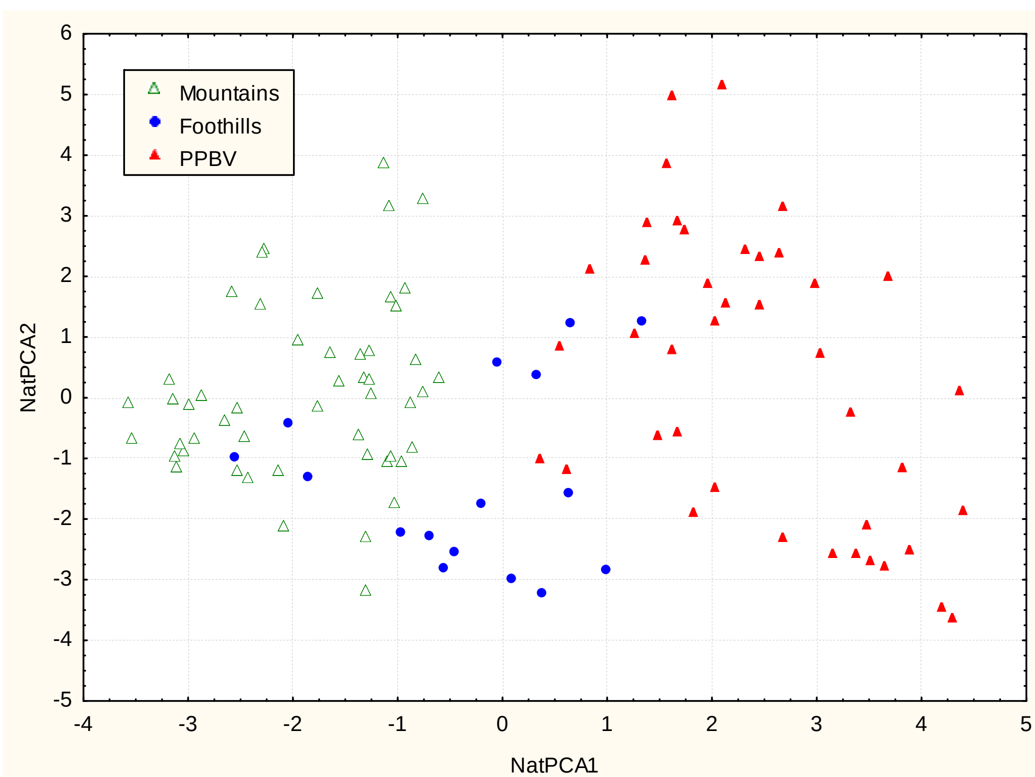

Figure 3-9. River sites displayed on the first and second axes of the PCA of natural site variables, showing differences among the site classes established for streams.

The Foothills river sites were grouped with the PPBV sites. The PCA did not provide convincing evidence that the Foothill sites had more in common with the PPBV than with the Mountains. However, a cluster analysis of taxa in reference samples suggested that Foothills sites grouped with PPBV sites more often than with Mountains (see Section 4.4). Because the Foothills sites were intermediate to mountains and plains on the PCA stressor gradients, it is possible that grouping them with the PPBV could result in assessment bias. However, it was more reasonable to expect a PPBV site to meet biological expectations derived from PPBV and Foothills sites than to expect a Foothills site to meet biological expectations derived from Mountain and Foothills sites.

4.0 Benthic Macroinvertebrate Indicators

Two types of indicators were developed for benthic macroinvertebrate assessments: multimetric indices (MMI) and predictive models of observed and expected taxa (O/E). The MMIs were based on categorical site classification and diverse community metrics of each sample. In contrast, the O/E classification is continuous, where each site has varying degrees of membership in each class, and the single metric compares the taxa expected based on the unique site characteristics with those actually observed in the sample. This section explains the MMI development process for benthic macroinvertebrates in streams. The same processes were used for developing indices for fish and habitat measures and in rivers.

4.1 Multimetric Indices

A biological metric is a numerical expression of some attribute of the biological assemblage (based on sample data) that responds to human disturbance in a predictable fashion (Barbour et al. 1999). A suite of commonly-applied, empirically-proven, and theoretically-responsive metrics was calculated for possible inclusion in an MMI. The MMI formulation required data preparation for uniform metric calculation, assignment of taxa attributes, metric calculations, metric adjustments for environmental factors, evaluation of metric sensitivity, combination of metrics in multiple candidate indices, and selection of the most robust and meaningful index for assessment.

Metrics were calculated based on the lowest practical identification level of each specimen. Identifications were not collapsed to a standard level, such as genus. However, mites (Arachnida) were not identified beyond the class level until 2002, and not commonly until 2004. Therefore, all metrics considered all mites at the class identification level. OTUs developed for classification were not applicable in metric calculations. Large and rare macroinvertebrate specimens were identified after sorting organisms for the subsample. These were eliminated from metric calculations because they were not identified consistently in all samples or in all years.

Benthic macroinvertebrate sample sizes were highly variable, though the target subsample size is 500 organisms. The range of sample sizes was from 7 to 6721 individuals. The intra-quartile range was more precise, from 477 to 547 individuals. Taxa richness was positively correlated with total number of individuals in the sample. Based on the precedent of the SMI (Grafe 2002a), we did not modify sample lists to reduce sample size and richness. However, samples closer to the target subsample size (e.g. 200-800 individuals) will likely yield more robust assessment results.

Taxa attributes existed for most taxa in the Idaho taxa list. For those taxa missing attributes, attributes were assigned when there was high confidence in the assignment. For instance, taxonomic hierarchy could be established for each taxon using the Integrated Taxonomic Information System (ITIS, http://www.itis.gov) as an authoritative reference. Some attributes were assigned to taxa based on proximity in the taxonomic hierarchy. If all species of a genus had similar tolerance values, a tolerance value for the genus would be assigned based on the mode of species traits. For habits, the foremost reference (Merritt et al. 2008) only lists habits at the genus level, so these traits were also assigned to species within the genera. In some cases, traits from other western state databases were used to complete traits in Idaho. Sources of the trait assignments were recorded in the database if they were not as originally designated by IDEQ.

Benthic macroinvertebrate metrics were organized into six categories: taxonomic richness, assemblage composition, feeding group, habit (methods of attachment or locomotion), pollution tolerance, and voltinism (**Table 4-1**). Each category addresses aspects of the sample that are expected to change with general or specific stressors. Richness is high when habitats are complex and water quality does not limit sensitive taxa. Homogeneous habitats within a sampling reach or polluted water can limit taxonomic diversity overall or in specific groups of taxa. Composition of taxa, numbers of individuals in various groups, can vary with stressor intensity depending on the tolerances or opportunistic abilities of each group. Feeding group and habit metrics exhibit patterns when niche space in stressed sites is limited due to food resource quality or habitat types. Tolerance metrics are based on standardized scales of pollution tolerance to which each taxon is measured. Typically, general types of pollution are incorporated into the scale, including nutrients, sediments, and organic pollutants. Voltinism measures the life cycle timing of each taxon. If a sample is dominated by taxa that reproduce slowly, a stable environment is implicated and conversely, organisms with fast life cycles may dominate an unstable system. For rivers and streams, 77 metrics were calculated and tested. Metric calculations were performed in a Microsoft Access relational database that allowed calculations based on sample taxonomic lists and taxa attributes.

All richness metrics (e.g., total taxa or EPT taxa) were calculated such that only unique taxa were counted. Taxa that were identified at higher taxonomic levels because of damage or under-developed features were not counted as unique taxa if other individuals in the sample were identified to a lower taxonomic level within the same sample.

4.1.1 Benthic Macroinvertebrate Metric Adjustments

After sites were classified by ecoregions, we examined the remaining variability of each metric with a set of natural variables. These variables included drainage area, elevation, slope, stream power, percentage of forest cover in the catchment, percentage of scrub-shrub cover in the catchment, predominance of pool habitat in the reach, and percent fine sediments in the reach.

Adjusting fish richness metrics to site drainage area is an established practice (McCormick et al. 2001, Fausch et al. 1984) that can also be applied to benthic macroinvertebrate metrics. We sought to identify meaningful relationships that would explain some of the metric variability in reference sites before we attempted to use the metric for assessing biological responses to stress. Adjustments were only attempted for stream sites, because the reference river data were too sparse to establish meaningful relationships between metrics and environmental variables.

The metric adjustments for benthic macroinvertebrates were addressed within the site classes because the classes already accounted for some metric variability. In addition, remaining variability within one site class may differ from that observed in another. The Spearman correlation coefficients between metrics and natural environmental variables in reference sites were the first indicator of meaningful relationships. When correlations were significant ($p<0.05$), the strongest relationships were examined in bi-plots to determine which of multiple possible relationships could be reasonably estimated. Relationships that were consistent along the environmental gradient (not driven by outliers), were linear (or could be estimated with non-linear relationships), and that could result in relatively precise reference distributions after adjustment (not wedge-shaped), were considered for adjustment.

Non-linear relationships between metric values and meaningful environmental factors were defined using logarithmic or exponential equations. Predicted metric values based on these equations can have positive or negative trends and converge on an asymptote. The residual of the observed metric value and the value predicted for the reference data was used as the adjusted metric (**Figure 4-1**). A constant was added to the residuals to shift the scale of values into the positive range. For instance, adjustments to drainage area standardized the metric residual to a 100 square kilometer catchment.

In each site class, 10 to 20 benthic macroinvertebrate metrics were adjusted to account for natural variability after site classification (**Table 4-1**). Many of the significant metric relationships with environmental variables in reference sites were non-linear. Metric values trended towards maximum or minimum values at the extremes of the environmental scales. Logarithmic or exponential equations were used in these metric adjustments. The exponential growth model fit many relationships because it has a realistic intersect at the low end of the environmental scale and an asymptote at the higher end. The logarithmic equation results in precipitous changes at the low end of the environmental scales, but was used in some cases because this form has precedence in the literature (McCormick et al. 2001). Relationships with site elevation and percent land cover types were essentially linear. Metrics were not adjusted for relationships that had significant Spearman correlation coefficients but that we did not deem meaningful after examination of biplots (**Figure 4-2**).

Table 4-1. Benthic macroinvertebrate metrics and adjustments.

Metric Type	Metric Code	Metric Name	Environmental Adjustment Factor by Site Class [a] PPBV	Mountains	Foothills
	TotalInd	Total Individuals			
Richness	TotalTax	Total Taxa	dr_area		PoolHab
	InsctTax	Insect Taxa	dr_area		PoolHab
	NonInsPT	Non-insect % of Taxa			
	EPTTax	EPT Taxa			Pfines
	EphemTax	Ephemeroptera Taxa			Pfines
	PlecoTax	Plecoptera Taxa			
	TrichTax	Trichoptera Taxa			
	ColeoTax	Coleoptera Taxa			
	DipTax	Diptera Taxa	dr_area		PoolHab
	ChiroTax	Chironomidae Taxa	dr_area		PoolHab
	ChiroTax	Chironomini Taxa			
	OrthoTax	Orthocladiinae Taxa			
	OligoTax	Oligochaeta Taxa			
	CrMolTax	Crustacea & Mollusca Taxa			
	TanytTax	Tanytarsini Taxa			
Composition	Dom01Pct	% Dominant Taxon			
	Evenness	Evenness	power		PoolHab
	D_Simp	Simpson's Index			PoolHab
	D_Marg	Margaleff's Index	dr_area		PoolHab
	Shan_base_2	Shannon-Weiner Index (base 2)	dr_area		PoolHab
	EPTPct	% EPT			
	EPTpct_NH	% EPT (no Hydropsychidae)			
	EPpct	% EP			
	EphemPct	% Ephemeroptera	ScrBarGr		
	PlecoPct	% Plecoptera		dr_area	
	TrichPct	% Trichoptera			
	NonInPct	% Non-Insect			Pfines
	ColeoPct	% Coleoptera			
	OdonPct	% Odonata			
	DipPct	% Diptera			
	ChiroPct	% Chironomidae			
	Orth2ChiPct	% Orthocladiinae of Chironomidae			
	CrCh2ChiPct	% Cricotopus and Chironomus of Chironomidae			
	TanytPct	% Tanytarsini			
	Metric Code	Metric Name	PPBV	Mountains	Foothills
	Tnyt2ChiPct	% Tanytarsini of Chironomidae			
	OligoPct	% Oligochaeta			
	CrMolPct	% Crustacea & Mollusca			
	AmphPct	% Amphipoda			
	GastrPct	% Gastropoda			
	BivalPct	% Bivalvia			
	MitePct	% Acarina			

Table 4-1. Continued.

Metric Type			Environmental Adjustment Factor by Site Class [a]		
Feeding	CllctTax	Collector Taxa	dr_area	dr_area	PoolHab
	FiltrTax	Filterer Taxa		dr_area	
	PredTax	Predator Taxa			
	ScrapTax	Scraper Taxa		dr_area	
	ShredTax	Shredder Taxa			PoolHab
	CllctPct	% Collector	3forests		
	FiltrPct	% Filterer	3forests		
	PredPct	% Predator			
	ScrapPct	% Scraper	3forests		
	ShredPct	% Shredder	dr_area	dr_area	PoolHab
	FltClctTax	Filterer/Collector Taxa			
Tolerance	HBI	Hilsenhoff's Index	elev	dr_area	Pfines
	BeckBI	Beck's Index	ScrBarGr		
	Hyd2TriPct	% Hydropsychidae of Trichoptera	elev		
	Baet2EphPct	% Baetidae of Ephemeroptera			
	Hyd2EPTPct	% Hydropsychidae of EPT			
	IntolPct	% Intolerant		dr_area	
	TolerPct	% Tolerant	elev		
	IntolTax	Intolerant Taxa		dr_area	Pfines
	TolerTax	Tolerant Taxa	dr_area	dr_area	
Habit	BrrwrTax	Burrower Taxa			PoolHab
	ClmbrTax	Climber Taxa			
	ClngrTax	Clinger Taxa	dr_area	dr_area	
	SprwlTax	Sprawler Taxa			PoolHab
	SwmmrTax	Swimmer Taxa			PoolHab
	BrrwrPct	% Burrower			
	ClmbrPct	% Climber			
	ClngrPct	% Clinger			
	SprwlPct	% Sprawler			
	SwmmrPct	% Swimmer			
Voltinism	SemVolTax	Semi-voltine Taxa			
	SemVolPct	% semi-voltine			
	UniVolPct	% uni-voltine			
	MltVolPct	% multi-voltine	ScrBarGr		

[a] dr_area = drainage area, PoolHab = % pool habitat, pfines = % fines, power = stream power, ScrBarGr = % scrub/barren/grass cover in the catchment, elev = elevation.

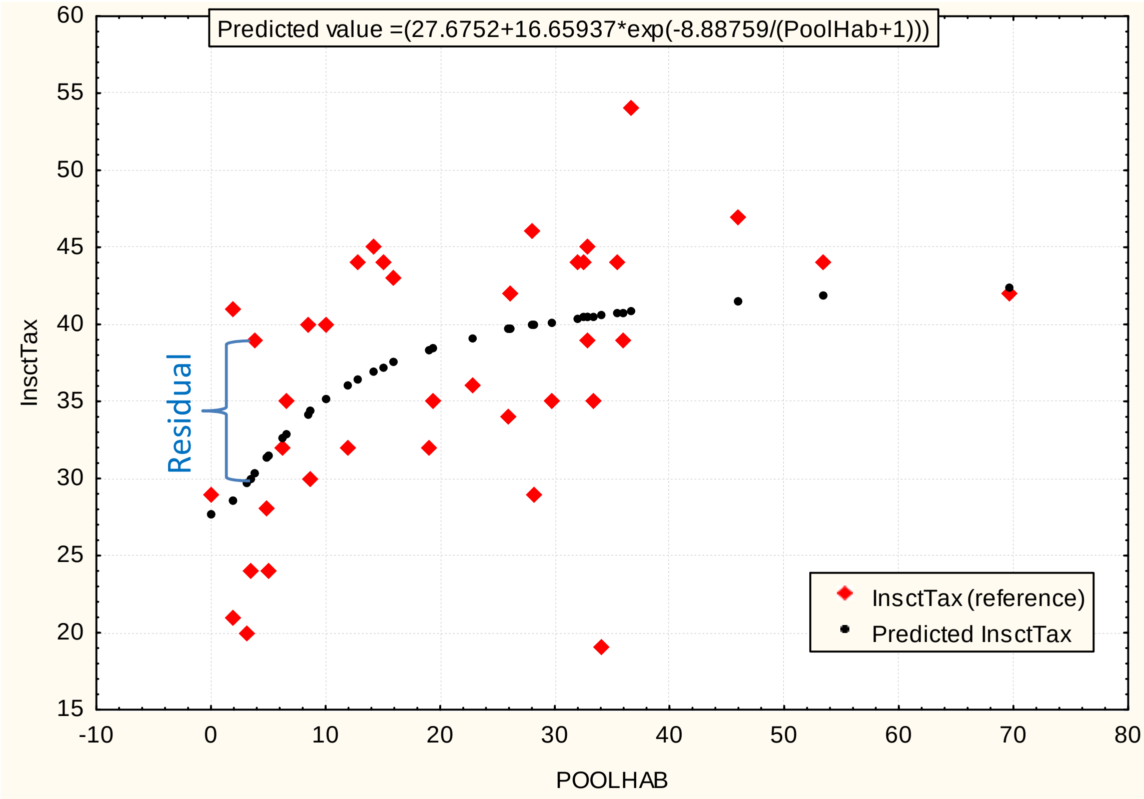

Figure 4-1. Example of residual metric value calculation, showing observed and predicted insect taxa richness in reference Foothill sites in relation to the percentage of pool habitat at the sampling sites.

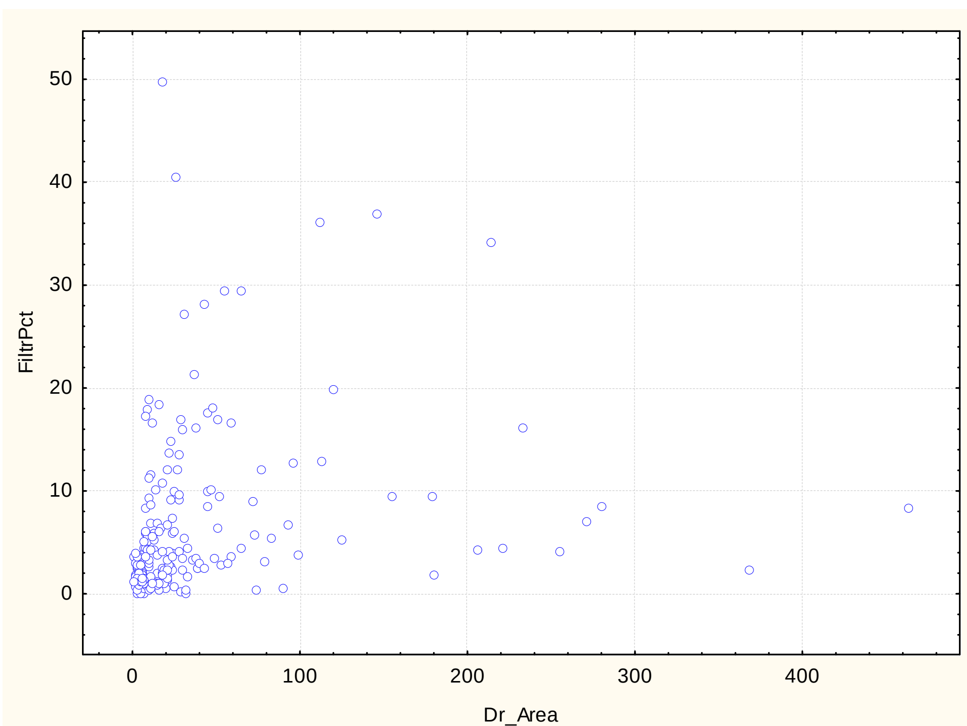

Figure 4-2. Example of a metric with significant and relatively high Spearman correlation coefficient that was not adjusted to the environmental variable.

Metric adjustments in the PPBV were common with the following environmental variables: drainage area, percentage scrub-shrub cover in the catchment, percentage forest cover in the catchment, stream gradient, site elevation, and stream power. In the Mountains, adjustments were less common and always used drainage area as a predictor. In the Foothills, all metric adjustments were made with predominance of pool habitat in the reach and percent fine sediments in the reach.

4.1.2 Metric Evaluation

The ability of each metric to distinguish between reference and stressed sites within a site class was measured as discrimination efficiency (DE) (Flotemersch et al. 2006). DE was calculated as the percentage of metric scores in stressed sites that were worse than the worst quartile of those in the reference sites. For metrics with a pattern of decreasing value with increasing environmental stress, DE is the percentage of stressed values below the 25^{th} percentile of reference site values. For metrics that increase with increasing stress, DE is the percentage of stressed sites that have values higher than the 75th percentile of reference values. DE can be visualized on box plots of reference and stressed metric or index values with the inter-quartile range plotted as the box (**Figure 4-3**). Higher DE denotes more frequent correct association of metric values with site conditions. DE values ≤25% show no discriminatory ability in one direction. DE values ≥50% are generally adequate for consideration in an index. However, in a site class, adequacy was usually dependent on relative DE values within a metric category. A second measure of metric discrimination was the *z*-score, which was calculated as the difference between reference and stressed metric or index values divided by the standard deviation of reference values. There is no absolute *z*-score value that indicates adequate metric performance, but among metrics or indices, higher *z*-scores suggest better separation of reference and stressed values.

In each metric category, at least one metric in each class had a DE greater than 50%, except for feeding group and habit metrics in the Mountains (**Table 4-2**). The Mountains had the lowest DEs overall, with only three metric DEs greater than 60%. In contrast, 15 and 29 metrics had DEs higher than 60 in the Foothills and PPBV, respectively. One possible reason for a lack of responsive metrics in the Mountains might be a less severe stressor gradient compared to the more populated Foothills and PPBV regions.

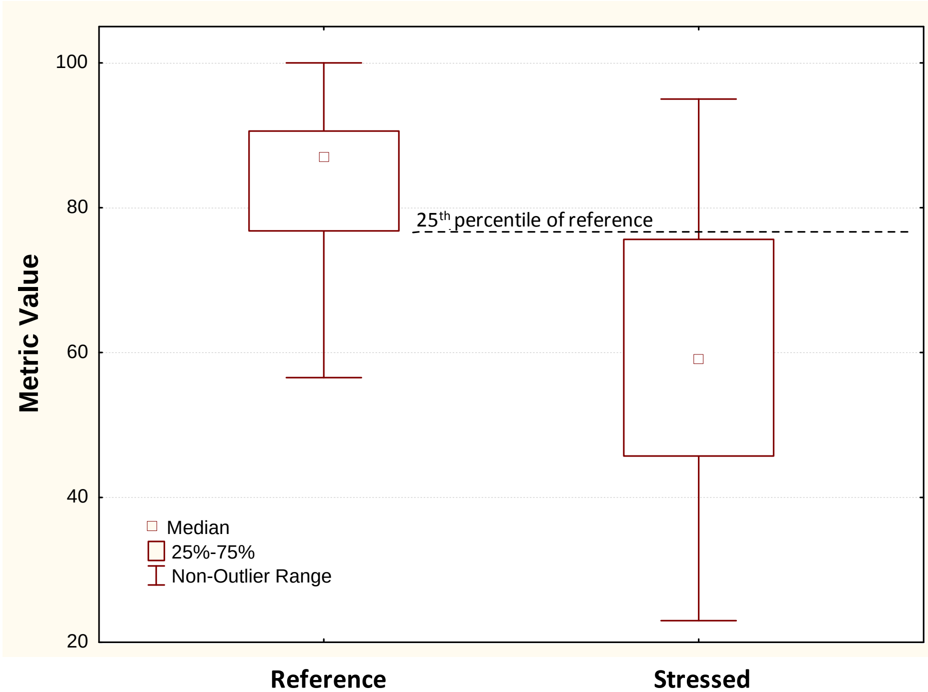

Figure 4-3. Box and whisker plot illustrating a metric that decreases with increasing stress and that has a DE slightly greater than 75%.

Table 4-2. Stream benthic metric discrimination efficiency, trend with increasing impairment (-,+), and *z*-scores in three site classes. Metric codes are named as in Table 4-1 and site classes are Mountains (Mtn), Foothills (FH) and Plains, Plateaus, and Broad Valleys (PP). These statistics reflect adjusted scores. Metrics are as in Table 4-1.

Metric type	Metric Code	Mtn DE	Mtn Z	FH DE	FH Z	PP DE	PP Z
Richness	TotalTax	51.5 d	0.59	42.9d	0.21	70.0d	1.56
	InsctTax	54.5d	0.72	35.7d	0.42	72.5d	1.78
	NoninsPT	30.3i	0.52	50.0i	0.87	62.5i	1.55
	EPTTax	60.6d	1.18	64.3d	0.87	75.0d	1.02
	EphemTax	57.6d	1.25	50.0d	0.40	60.0d	0.80
	PlecoTax	48.5d	0.65	64.3d	1.28	57.5d	0.53
	TrichTax	39.4d	0.51	50.0d	0.20	67.5d	0.87
	ColeoTax	NA	0.04	NA	0.27	42.5d	0.67
	DipTax	27.3i	0.11	35.7d	0.37	62.5d	0.99
	ChiroTax	NA	0.10	35.7d	0.12	60.0d	0.75
	ChiroTax	NA	0.10	35.7d	0.10	60.0d	0.75
	OrthoTax	NA	0.04	42.9d	1.01	52.5d	0.43
	OligoTax	NA	0.09	28.6d	0.74	25.0d	0.12
	CrMolTax	30.3i	0.54	50.0i	0.46	45.0i	0.60
	TanytTax	42.4d	0.41	NA	0.44	NA	0.38

Table 4-2. Continued.

Metric type	Metric Code	Mtn DE	Mtn Z	FH DE	FH Z	PP DE	PP Z
Composition	Dom01Pct	48.5i	0.35	28.6i	0.02	42.5i	0.93
	Evenness	45.5d	0.72	50.0d	0.17	60.0d	1.11
	D_Simp	45.5i	0.56	42.9i	0.32	42.5i	1.36
	D_Marg	54.5d	0.65	NA	0.14	72.5d	1.55
	Shan_base_2	45.5d	0.62	42.9d	0.32	57.5d	1.39
	EPTPct	45.5d	0.60	NA	0.11	70.0d	0.72
	EPTpct_NH	51.5d	0.67	50.0d	1.04	NA	NA
	EPpct	54.5d	0.52	50.0d	0.46	NA	NA
	EphemPct	45.5d	0.54	35.7d	0.21	60.0d	0.68
	PlecoPct	30.3d	0.10	71.4d	0.80	60.0d	0.28
	TrichPct	45.5d	0.19	57.1i	0.87	70.0d	0.49
	NoninPct	30.3d	0.08	57.1d	0.08	75.0i	2.43
	ColeoPct	36.4i	0.06	50.0i	1.07	37.5d	0.21
	OdonPct	NA	0.11	42.9i	6.55	NA	0.26
	DipPct	57.6i	0.72	57.1d	0.50	55.0d	0.40
	ChiroPct	48.5i	0.29	NA	0.37	50.0d	0.34
	Orth2ChiPct	30.3d	0.04	57.1d	0.97	50.0i	0.52
	CrCh2ChiPct	30.3i	0.07	71.4i	1.17	37.5i	0.55
	TanytPct	30.3d	0.09	NA	0.31	50.0d	0.43
	Tnyt2ChiPct	36.4d	0.24	21.4d	0.07	52.5d	0.51
	OligoPct	NA	0.07	57.1d	0.17	57.5i	1.74
	CrMolPct	33.3i	0.06	35.7d	0.18	72.5i	3.20
	AmphPct	NA		NA	0.16	50.0i	2.47
	GastrPct	NA	0.10	42.9i	1.26	55.0i	3.01
	BivalPct	39.4i	0.32	NA	0.11	62.5i	0.68
	MitePct	42.4d	0.21	35.7d	0.15	25.0d	0.31
Feeding	CllctTax	45.5d	0.53	42.9d	0.32	62.5d	1.23
	FiltrTax	27.3i	0.18	64.3i	0.95	40.0d	0.15
	PredTax	30.3d	0.58	28.6d	0.02	55.0d	0.92
	ScrapTax	45.5d	0.57	50.0d	0.67	65.0d	1.05
	ShredTax	30.3d	0.31	35.7d	0.36	47.5d	0.72
	CllctPct	45.5d	0.51	64.3d	1.18	50.0i	0.67
	FiltrPct	45.5i	1.31	57.1i	1.60	67.5d	0.62
	PredPct	33.3i	0.15	NA	0.43	45.0d	0.19
	ScrapPct	36.4d	0.61	35.7d	0.31	32.5i	0.11
	ShredPct	33.3d	0.15	42.9i	0.13	45.0d	0.25
	FltClctTax	39.4d	0.43	35.7d	0.17	75.0d	0.40

Table 4-2. Continued.

Metric type	Metric Code	Mtn DE	Mtn Z	FH DE	FH Z	PP DE	PP Z
Tolerance	HBi	54.5i	0.85	64.3i	1.10	75.0i	1.32
	BeckBi	57.6d	1.04	64.3d	1.18	72.5d	1.06
	Hyd2TriPct	33.3i	0.32	71.4i	2.10	50.0d	0.15
	Baet2EphPct	30.3i	0.55	NA	0.14	35.0i	0.01
	Hyd2EPTPct	27.3d	0.52	64.3i	5.73	45.0d	0.18
	intolPct	66.7d	0.85	71.4d	0.26	NA	0.11
	TolerPct	36.4i	0.74	42.9i	0.59	72.5i	0.94
	intolTax	60.6d	1.18	64.3d	1.59	NA	0.35
	TolerTax	48.5i	0.71	71.4i	2.28	40.0d	0.42
Habit	BrrwrTax	33.3i	0.24	42.9i	0.90	NA	0.31
	ClmbrTax	NA	0.60	50.0i	1.25	NA	0.04
	ClngrTax	48.5d	0.98	NA	0.11	70.0d	1.55
	SprwlTax	NA	0.03	64.3d	0.86	35.0d	0.39
	SwmmrTax	NA	0.18	28.6	0.75	37.5i	0.10
	BrrwrPct	30.3d	0.08	35.7	0.05	27.5i	0.49
	ClmbrPct	42.4i	0.04	64.3i	2.18	30.0i	0.17
	ClngrPct	30.3d	0.10	57.1i	0.58	65.0d	1.54
	SprwlPct	27.3i	0.02	50.0d	0.74	37.5i	0.68
	SwmmrPct	NA	0.01	NA	0.31	40.0d	0.22
Voltinism	SemVolTax	54.5d	0.72	NA	0.18	67.5d	1.14
	SemVolPct	30.3d	0.25	NA	0.05	57.5d	0.40
	UniVolPct	48.5d	0.30	50.0d	0.38	67.5d	0.65
	MltVolPct	57.6i	0.72	NA	0.05	37.5i	0.33

NA = Not applicable – not responsive.

4.1.3 Metric Scoring

Metrics were scored on a common scale prior to combination (as an average of scores) in an index. The scale ranges from 0 to 100 (as in Hughes et al. 1998, and Barbour et al. 1999). The optimal score is determined by the distribution of metric values. For metrics that decrease with increasing stress, the 95th percentile of all data within the site class was considered optimal (to lessen the influence of outliers [Barbour et al. 1999]), and scored as 100 points using the equation:

$$MetricScore = \frac{100 * MetricValue}{95^{th}\ Percentile}$$

Metrics that increase with increasing stress (reverse metrics) were scored using the 5th percentile of data as the optimal, receiving a score of 100. Decreasing scores were calculated as metric values increased to the 95th percentile using the equation:

$$MetricScore = \frac{100 * (95^{th}\ Percentile - MetricValue)}{95^{th}\ Percentile - 5^{th}\ Percentile}$$

In some cases, percentiles other than the 95th were used in the equation above to reduce the effects of a skewed distribution. The metric scoring range was from 0 to 100. Scores outside of this range were re-set to the nearest extreme before the index was calculated.

4.1.4 Index Composition

A multimetric index is a combination of metric scores that indicates a degree of biological stress in the aquatic community (Barbour et al. 1999). Individual metrics were candidates for inclusion in the index if they:

- discriminated well between least and most disturbed sites;
- were ecologically meaningful (mechanisms of responses can be explained);
- represented diverse types of information (multiple metric categories); and
- were not redundant with other metrics in the index.

Several index alternatives were calculated using an iterative process of adding and removing metrics, calculating the index as an average of the metric scores, and evaluating index responsiveness. The first index alternatives included those metrics that had the highest DEs within each metric category. Subsequent index alternatives were formulated by adding, removing, or replacing one metric at a time from the initial index alternatives that performed well. The index alternatives considered for the site classes in Idaho met the criteria listed above.

Each alternative index was evaluated based on DE and *z*-scores in calibration data, and inclusion of representative and non-redundant metrics. In addition, the IDEQ workgroup reviewed indices with similar performance characteristics to select a final index that included metrics that were meaningful to their programs. As many metric categories as practical were represented in the index alternatives so that signals of various stressor-response relationships would be integrated into the index. While several metrics should be included to represent biological integrity, redundant metrics can bias an index to show responses specific to certain stressors or taxonomic responses. Redundancy was evaluated using a Spearman rank order correlation analysis. In this index development effort, we excluded metrics that were redundant at the 0.90 level or higher.

Index performance was validated with a set of samples that were not used in index calibration. Validation data was expected to perform as well as calibration data or to have a DE within 10%

of the calibration DE. Index alternatives that were not adequately validated were reconsidered by the workgroup and a new alternative was selected.

4.1.5 Stream Macroinvertebrate MMI Results

Mountains

Thirty-nine (39) different metric combinations were tested to find the best index for the Mountain site class (**Appendix G**). Combinations were tested that included all six metric categories. The selected index included metrics from all six metric categories (**Table 4-3**), had a calibration DE of 73%, and a z-score of 1.48. Discrimination of reference from stressed sites was adequate in calibration data (**Figure 4-4**) and was confirmed in validation data (validation DE = 69%). The index metrics were not redundant, with the highest correlations existing between EPT taxa and clinger taxa (**Table 4-4**).

Table 4-3. Stream MMI metrics for the Mountain site class.

Index Metrics	Metric Category	DE	Response
Total Taxa	Richness	55.1	decreaser
EPT Taxa	Richness	65.3	decreaser
% Ephemeroptera and Plecoptera	Composition	55.1	decreaser
% filterers	Feeding group	40.8	increaser
HBI (adjusted)	Tolerance	57.1	increaser
Clinger taxa (adjusted)	Habit	53.1	decreaser
Semi-voltine taxa	Voltinism	57.1	decreaser

Table 4-4. Correlations (Spearman r) among MMI metrics in the Mountain site class.

index Metrics	Metric #	1	2	3	4	5	6
Total taxa	1						
EPT taxa	2	0.67					
% EP	3	-0.17	0.25				
% filterers	4	0.17	-0.04	-0.29			
HBi	5	0.03	-0.26	-0.44	0.37		
Clinger taxa	6	0.79	**0.86**	0.06	0.22	-0.06	
Semi-voltine taxa	7	0.47	0.67	0.19	0.06	-0.24	0.68

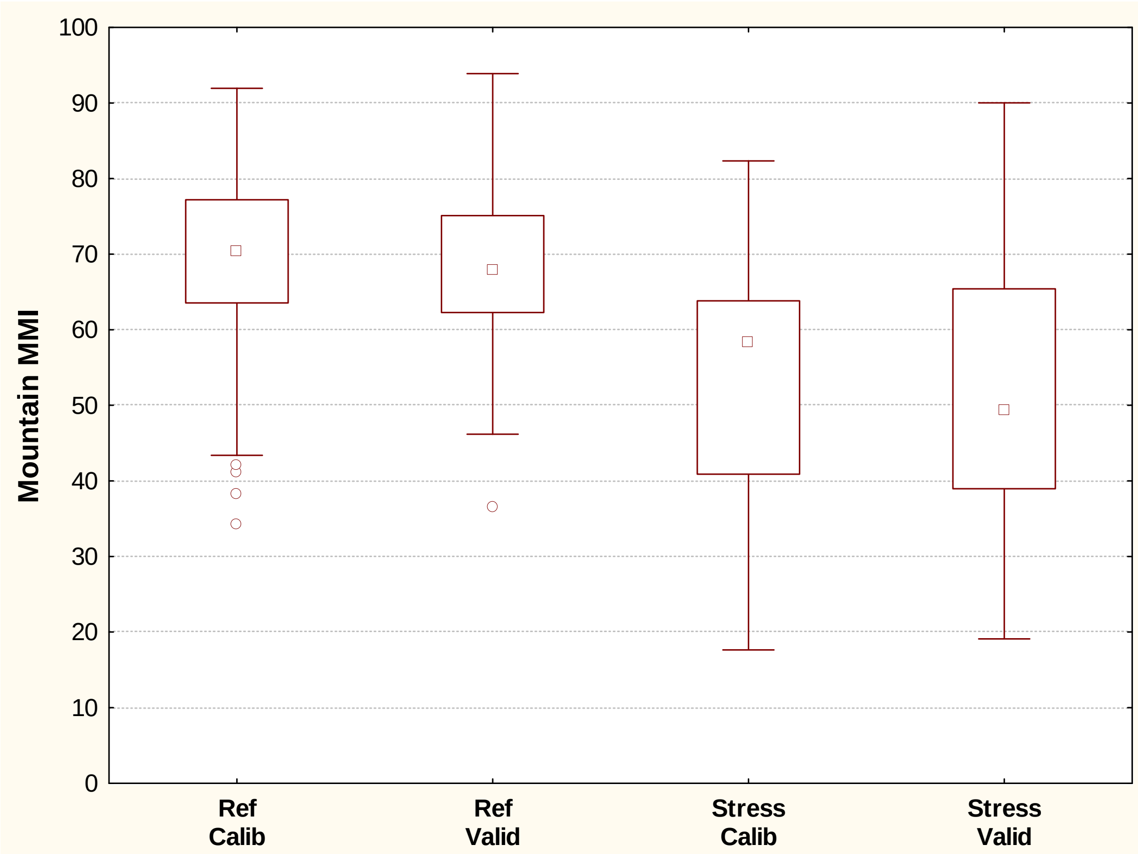

Figure 4-4. Index discrimination among reference and stressed conditions in Mountain streams, showing both calibration and validation data distributions (medians, interquartile ranges and ranges).

Foothills

Thirty-one (31) different metric combinations were tested to find the best index for the Foothill site class (**Appendix G**). Combinations were tested that included all six metric categories. The selected index included metrics from five of six metric categories (**Table 4-5**), had a calibration DE of 71%, and a *z*-score of 2.43. No voltinism metric was included because including one did not improve index performance. Discrimination of reference from stressed sites was adequate in calibration data (**Figure 4-5**) and was confirmed in validation data (validation DE = 100%). The index metrics were not redundant, with the highest correlations existing between EPT taxa and scraper taxa (**Table 4-6**).

Table 4-5. Stream MMI metrics for the Foothills site class.

Index Metrics	Metric Category	DE	Response
EPT taxa (adjusted)	Richness	64.3	decreaser
Non-insect % of taxa (adjusted)	Composition	50.0	increaser
% EPT, excluding Hydropsychidae	Composition	50.0	decreaser
Scraper taxa	Feeding group	50.0	decreaser
Tolerant taxa	Tolerance	71.4	increaser
Sprawler taxa (adjusted)	Habit	64.3	decreaser

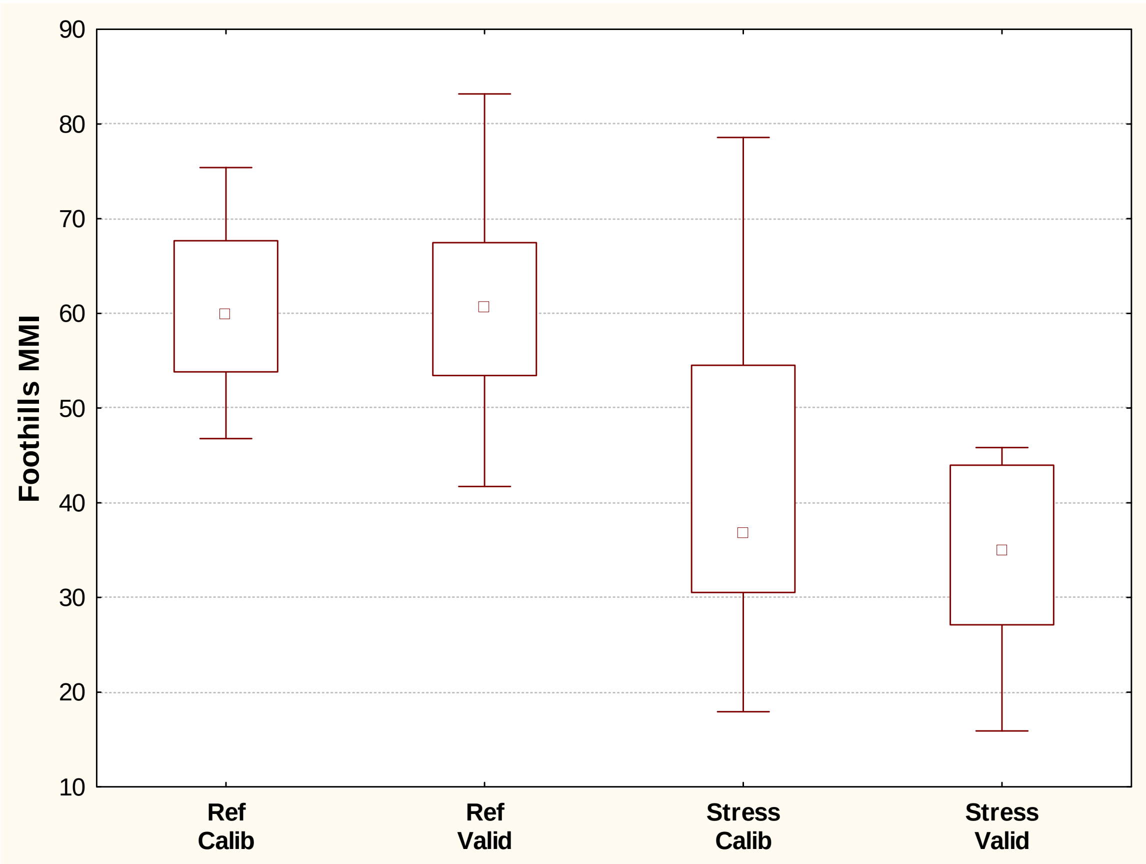

Figure 4-5. Index discrimination among reference and stressed conditions in Foothill streams, showing both calibration and validation data distributions (medians, interquartile ranges, and ranges).

Table 4-6. Correlations (Spearman r) among MMI metrics in the Foothills site class**.**

Index Metrics	Metric #	1	2	3	4	5
EPT taxa	1					
Non-insect % of taxa	2	-0.36				
% EPT, excl. Hydropsychidae	3	0.41	-0.30			
Scraper taxa	4	0.57	-0.21	0.24		
Tolerant taxa	5	-0.10	0.29	-0.41	0.04	
Sprawler taxa	6	0.18	0.11	-0.21	0.19	0.15

Plains, Plateaus, and Broad Valleys (PPBV)

Forty-two (42) different metric combinations were tested to find the best index for the PPBV site class (**Appendix G**). Combinations were tested that included all six metric categories. The selected index included metrics from five of six metric categories (**Table 4-7**), had a calibration DE of 85%, and a *z*-score of 2.63. No richness metric was included because including one did not improve index performance. However, Simpson's index includes richness as one term of the index. Discrimination of reference from stressed sites was adequate in calibration data (**Figure 4-6**) and was confirmed in validation data (validation DE = 100%). The index metrics were not redundant, with the highest correlations existing between % clingers and % non-insects (**Table 4-8**).

Table 4-7. Stream MMI metrics for the PPBV site class.

Index Metrics	Metric Category	DE	Response
Simpson's index	Composition	50.0	increaser
% non-insects	Composition	75.0	increaser
% filterers (adjusted)	Feeding group	67.5	decreaser
% tolerant (adjusted)	Tolerance	72.5	increaser
% clingers	Habit	65.0	decreaser
Semi-voltine taxa	Voltinism	67.5	decreaser

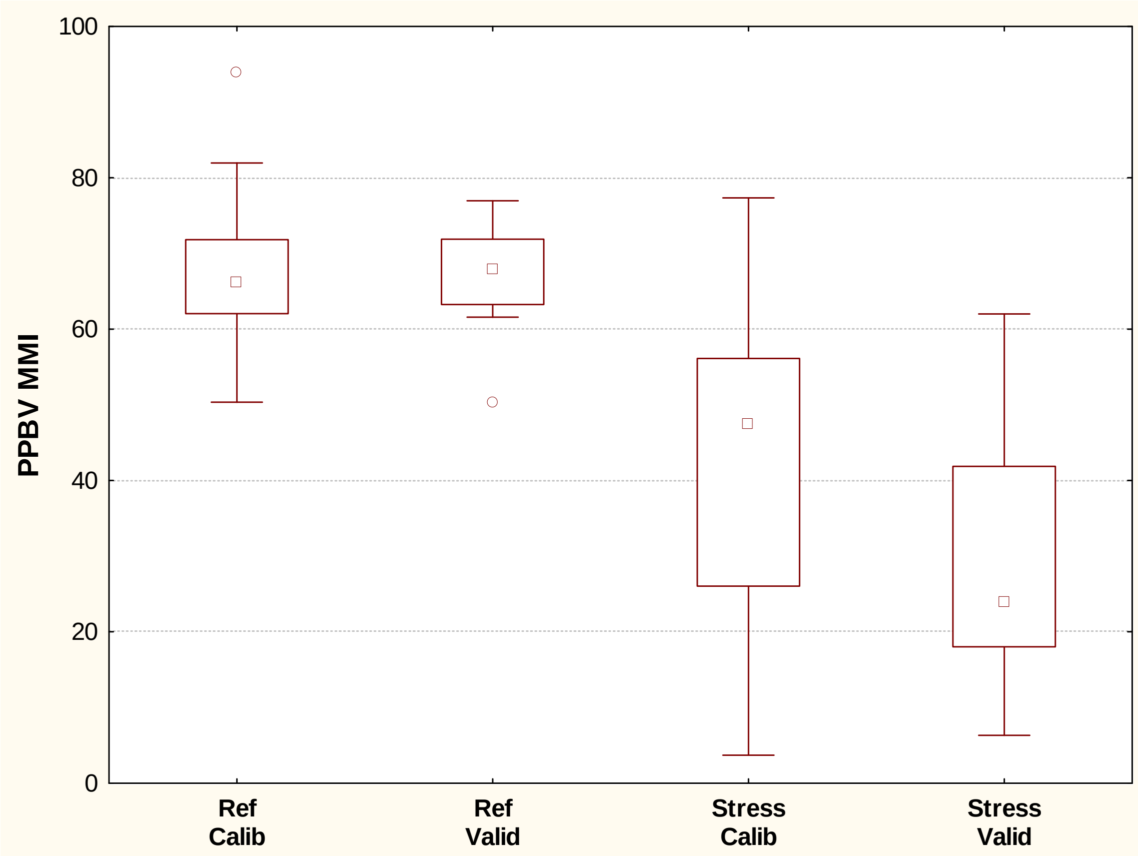

Figure 4-6. Index discrimination among reference and stressed conditions in PPBV streams, showing both calibration and validation data distributions (medians, interquartile ranges, and ranges).

Table 4-8. Correlations (Spearman r) among MMI metrics in the PPBV site class**.**

Index Metrics	Metric #	1	2	3	4	5
Simpson's Index	1					
% non-insects	2	0.07				
% filterers	3	-0.06	-0.13			
% tolerant	4	0.40	0.23	0.09		
% clingers	5	-0.01	-0.67	0.18	-0.09	
Semi-voltine taxa	6	-0.36	-0.28	-0.02	-0.35	0.43

4.1.6 Stream Benthic MMI Application

The Idaho stream benthic MMIs should be applied as follows.

1. Determine the appropriate site class for the site using **Table 3-3**.
2. Calculate appropriate MMI metrics.
   Use metric attributes approved by IDEQ (**Appendix H**).

Count mites as a single taxon.
Mark taxa to be excluded from richness metrics.

3. Score metrics based on formulae in **Table 4-9**.
   Reset scores above 100 or below 0 to 100 or 0, respectively.
4. Calculate the MMI as the average of the metric scores.
5. Report the results.
   Include the MMI scores and MMI DE
   Compare numeric results to impairment thresholds
   (IDEQ to decide on threshold values)

4.2 River Macroinvertebrate MMI

Large rivers are not as numerous in Idaho as are streams. The dataset for calibrating a river macroinvertebrate index reflects the smaller sample size. However, sample sizes were large enough for calibration and in some site types, for validation (**Table 4-10**). Validation with five and fewer sites can give spurious results, but nevertheless offer insights on the robustness of the calibration.

In each metric category, at least one metric had a DE of 50% or greater in both the Mountains and Non-mountains (**Table 4-11**). In general, responses were stronger in the Non-mountain dataset. In the Mountains, the richness metrics were not very strong. The highest richness DE (50%) was for total taxa, non-insect percent of taxa, and Plecoptera taxa. The highest DE overall was 70% in the Mountains for % Trichoptera and % Tanytarsini of Chironomidae. In the Non-mountain dataset, all categories had at least one meric of 67% or higher except for the habit metrics. The highest DE (83%) was for scraper taxa.

Table 4-9. Metric adjustment and scoring formulae for the Idaho stream MMIs**.**

Metrics	Formula
Mountains	
Total Taxa	100*(*metric value*)/58
EPT Taxa	100*(*metric value*)/31
% Ephem. and Plecoptera	100*(*metric value*)/74
% filterers	100*(30.6-(*metric value*))/30.3
HBI (adjustment)	(*metric value*) – (4.670+1.055*exp(-16.510/(dr_area[km^2]))) + 5.59
HBI (score)	100*(6.95-(*adjusted metric value*))/2.52
Clinger taxa (adjustment)	(*metric value*) – (14.175+16.337*exp(-0.965/(dr_area[km^2]))) + 30.3
Clinger taxa (score)	100*(*adjusted metric value*-18.6)/19.2
Semi-voltine taxa	100*(*metric value*)/13
Foothills	
EPT taxa (adjustment)	(*metric value*) – (20.345-14.934*(PropFinesRaw+0.01)) + 17.2
EPT taxa (score)	100*(*adjusted metric value*-6.60)/19.3
Non-insect % of taxa (adjustment)	(*metric value*) - (8.67+ 9.015*exp(-0.128/(PropFinesRaw+0.01)))+13.6
Non-insect % of taxa (score)	100*(26.6 - *adjusted metric value*)/21.6
% EPT, no Hydropsychidae	100*(*metric value*)/74
Scraper taxa	100*(*metric value*)/18
Tolerant taxa	100*(19 - *metric value*)/16
Sprawler taxa (adjustment)	*(metric value) –* (11.263+6.443*exp(-9.6/(%PoolHab+1))) + 15.3
Sprawler taxa (score)	100*(*adjusted metric value*-7.4)/13.7
PPBV	
Simpson's Index	100*(0.41 – (*metric value*))/0.35
% non-insects	100*(79.6 – (*metric value*))/78.5
% filterers (adjustment)	*(metric value)* – (34.09 - 40.24 * %Forests) + 14
% filterers (score)	100*(*adjusted metric value*+15.3)/58.8
% tolerant (adjustment)	*(metric value)* – (82.742-0.0065*Elev[m]) + 50.2
% tolerant (score)	100*(91 – *adjusted metric value*)/71
% clingers	100*(*metric value*)/92
Semi-voltine taxa	100*(*metric value*)/9

Note: if the score formula results in a value <0 or >100, re-set to the appropriate extreme of the scoring scale (0-100) before averaging in the MMI.

Table 4-10. River benthic sample size.

	Mountains		Non-mountains	
dataset	Calibration	Validation	Calibration	Validation
Reference	19	5	9	0
Stressed	10	3	12	3

Table 4-11. River benthic metric discrimination efficiency and trend with increasing stress. Metrics are as in Table 4-1.

Metric	Mtns	non-mtns	Metric	Mtns	non-mtns
TotalTax	50 (-)	41.7 (-)	BivalPct	30 (+)	50 (+)
InsectTax	40 (-)	58.3 (-)	CorbPct	NR	NR
NonInsPT	50 (+)	66.7 (+)	MitePct	30 (-)	41.7 (-)
EPTTax	40 (-)	58.3 (-)	CllctTax	40 (-)	58.3 (-)
EphemTax	40 (-)	58.3 (-)	FiltrTax	40 (+)	50 (+)
PlecoTax	50 (-)	NR	PredTax	30 (-)	NR
TrichTax	30 (+)	41.7 (-)	ScrapTax	40 (+)	83.3 (-)
ColeoTax	40 (+)	50 (-)	ShredTax	NR	NR
DipTax	NR	75 (-)	CllctPct	60 (+)	NR
ChiroTax	NR	58.3 (-)	FiltrPct	NR	NR
OrthoTax	40 (+)	66.7 (-)	PredPct	60 (+)	33.3 (+)
OligoTax	NR	NR	ScrapPct	30 (+)	50 (+)
CrMolTax	30 (+)	58.3 (+)	ShredPct	50 (-)	NR
TanytTax	30 (-)	NR	BrrwrTax	NR	NR
Dom01Pct	40 (-)	41.7 (-)	ClmbrTax	60 (+)	NR
Evenness	40 (+)	33.3 (-)	ClngrTax	50 (-)	58.3 (-)
D_Simp	40 (-)	NR	SprwlTax	30 (-)	58.3 (-)
D_Marg	60 (-)	66.7 (-)	SwmmrTax	40 (+)	33.3 (+)
Shan_base_2	30 (+)	33.3 (-)	SwmClmTax	50 (+)	NR
EPTPct	60 (-)	50 (-)	BrrwrPct	NR	50 (+)
EphemPct	50 (+)	75 (-)	ClmbrPct	30 (-)	41.7 (+)
PlecoPct	50 (-)	NR	ClngrPct	60 (-)	50 (-)
TrichPct	70 (-)	41.7 (+)	SprwlPct	50 (+)	41.7 (-)
NonInPct	40 (+)	66.7 (+)	SwmmrPct	40 (+)	41.7 (-)
ColeoPct	60 (-)	75 (-)	HBI	30 (+)	58.3 (+)
OdonPct	40 (+)	41.7 (+)	BeckBI	50 (-)	91.7 (-)
DipPct	60 (+)	58.3 (-)	Baet2EphPct	NR	NR
ChiroPct	60 (+)	50 (-)	Hyd2EPTPct	40 (+)	50 (-)
Orth2ChiPct	40 (+)	NR	Hyd2TriPct	50 (+)	58.3 (-)
CrCh2ChiPct	NR	50 (+)	IntolPct	60 (-)	NR
TanytPct	60 (-)	66.7 (-)	TolerPct	30 (+)	66.7 (+)
Tnyt2ChiPct	70 (-)	41.7 (-)	IntolTax	60 (-)	NR

Table 4-11. Continued.

Metric	Mtns	non-mtns	Metric	Mtns	non-mtns
OligoPct	50 (+)	50 (+)	InMolTax	NR	NR
IsoPct	NR	33.3 (+)	TolerTax	40 (+)	NR
CrMolPct	30 (+)	58.3 (+)	SemVolTax	50 (-)	50 (-)
AmphPct	NR	50 (+)	SemVolPct	50 (-)	58.3 (-)
GastrPct	NR	41.7 (+)	UniVolPct	50 (-)	75 (-)
			MltVolPct	50 (+)	50 (+)

4.2.1 River Macroinvertebrate MMI Results

Mountains

Forty-one (41) different metric combinations were tested to find the best index for river sites in the Mountain site class (**Appendix G**). The selected index included metrics from all six metric categories (**Table 4-12**), had a calibration DE of 70%, and a z-score of 1.59. Discrimination of reference from stressed sites was adequate in calibration data (**Figure 4-7**) and was confirmed in validation data (validation DE = 100%). The index metrics were not redundant, with the highest correlations existing between EPT taxa and semi-voltine taxa (**Table 4-13**).

Table 4-12. River MMI metrics for the Mountain site class.

Index Metrics	Metric Category	DE	Response
EPT Taxa	Richness	40.0	decreaser
% EPT	Composition	60.0	decreaser
% Chironomidae	Composition	60.0	increaser
% Predators	Feeding group	60.0	increaser
Swimmer & Climber Taxa	Habit	50.0	increaser
Becks Biotic index	Tolerance	50.0	decreaser
Semi-voltine Taxa	Voltinism	50.0	decreaser

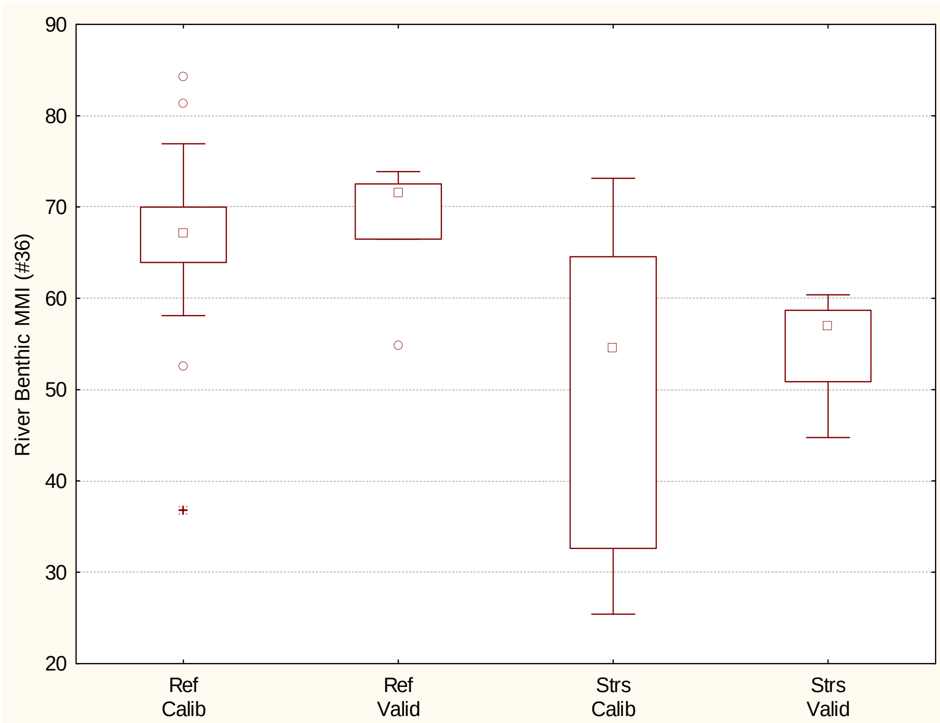

Figure 4-7. Index discrimination among reference and stressed conditions in the river Mountain site class, showing both calibration and validation data distributions (medians, interquartile ranges and ranges).

Table 4-13. Correlations (Spearman r) among river MMI metrics in the Mountain site class**.**

Index Metrics	Metric #	1	2	3	4	5	6
EPT Taxa	1						
% EPT	2	0.63					
% Chironomidae	3	-0.28	-0.57				
% Predators	4	0.28	0.11	0.02			
Swimmer & Climber Taxa	5	0.44	0.19	-0.03	0.38		
Becks Biotic index	6	0.56	0.34	-0.18	0.40	0.06	
Semi-voltine Taxa	7	0.66	0.56	-0.41	0.23	0.19	0.60

Non-mountains

Twenty-nine (29) different metric combinations were tested to find the best index for river sites in the Non-mountain site class (**Appendix G**). The selected index included metrics from all six metric categories (**Table 4-14**), had a calibration DE of 92%, and a z-score of 2.23. Discrimination of reference from stressed sites was adequate in calibration data (**Figure 4-8**) and was confirmed in validation data for stressed sites (validation DE = 100%). No reference sites were reserved for validation because all of the few reference samples were used in calibration.

The index metrics were not redundant, with the highest correlations existing between insect taxa and sprawler taxa (**Table 4-15**).

Table 4-14. River MMI metrics for the Non-mountain site class.

Index Metrics	Metric Category	DE	Response
Insect Taxa	Richness	58.3	decreaser
Non-insect % of Taxa	Richness	66.7	increaser
% Ephemeroptera	Composition	75.0	decreaser
% Scrapers	Feeding group	50.0	increaser
Sprawler Taxa	Habit	58.3	decreaser
% Tolerant	Tolerance	66.7	increaser
% Multivoltine	Voltinism	50.0	increaser

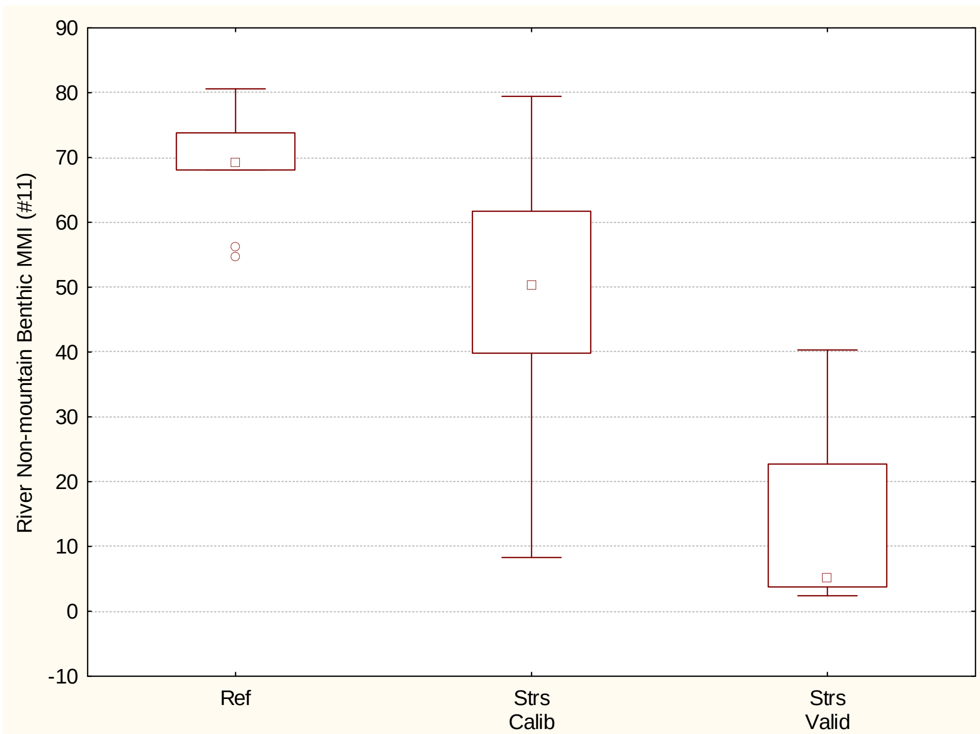

Figure 4-8. Index discrimination among reference and stressed conditions in the river Non-mountain site class, showing both calibration and validation data distributions (medians, interquartile ranges and ranges).

Table 4-15. Correlations (Spearman r) among river MMI metrics in the Non-mountain site class.

Index Metrics	Metric #	1	2	3	4	5	6
Insect Taxa	1						
Non-insect % of Taxa	2	-0.75					
% Ephemeroptera	3	0.46	-0.40				
% Scrapers	4	-0.23	0.48	-0.06			
Sprawler Taxa	5	0.80	-0.50	0.31	-0.19		
% Tolerant	6	-0.53	0.61	-0.21	0.26	-0.40	
% Multivoltine	7	-0.46	0.46	-0.35	0.22	-0.57	0.41

4.2.2 River Benthic MMI Application

The Idaho river benthic MMIs should be applied as follows.

1. Determine the appropriate site class for the site using **Table 3-3**.
2. Calculate appropriate MMI metrics.
   Use metric attributes approved by IDEQ (**Appendix H**).
   Count mites as a single taxon.
   Mark taxa to be excluded from richness metrics.
3. Score metrics based on formulae in **Table 4-16**.
   Reset scores above 100 or below 0 to 100 or 0, respectively.
4. Calculate the MMI as the average of the metric scores.
5. Report the results.
   Include the MMI scores and MMI DE
   Compare numeric results to impairment thresholds
   (IDEQ to decide on threshold values)

4.3 Idaho Predictive Model

Model background

The predictive modeling approach to bioassessment estimates the taxonomic richness of a biological assemblage expected at a site if it were in a minimally disturbed reference condition. The expectation is based on the taxa lists and environmental setting of each reference calibration site. The ratio of observed to expected taxa at a test site then indicates the departure of that site from the reference condition. Additional details of the procedures for developing and evaluating predictive models are documented elsewhere (Clarke et al. 2003, Hawkins et al. 2000, Van Sickle et al 2005).

Table 4-16. Metric adjustment and scoring formulae for the Idaho river benthic MMIs**.**

Metrics	Formula
Mountains	
EPT Taxa	100*(*metric value*) / 28
% EPT	100*(*metric value*) / 69.0
% Chironomidae	100*(59.5 - (*metric value*)) / 50.6
% Predators	100*(13.8 - (*metric value*)) / 11.5
Swimmer & Climber Taxa	100*(12 - (*metric value*)) / 7
Becks Biotic index	100*(*metric value*) / 16.1
Semi-voltine Taxa	(100*(*metric value*) / 9.55
Non-mountains	
Insect Taxa	100*(*metric value*) / 51.4
Non-insect % of Taxa	100*(60.5 - *metric value*) / 53.4
% Ephemeroptera	100*(*metric value*) / 63.9
% Scrapers	100*(81.6 - *metric value*) / 78.0
Sprawler Taxa	100*(*metric value*) / 20.5
% Tolerant	100*(88.6 - *metric value*) / 65.1
% Multivoltine	100*(89.7 - *metric value*) / 73.3

Note: If the score formula results in a value <0 or >100, re-set to the appropriate extreme of the scoring scale (0-100) before averaging in the MMI.

The predictive model output assigns an Observed to Expected ratio (O/E) for each sample. When the observed taxa are as numerous as those expected based on environmental characteristics of the site, the O/E value is 1.0. When taxa are not present when they are expected, the ratio drops below 1.0. The point at which the O/E ratio no longer represents reference conditions can be estimated from the precision in the reference O/E values, which are near 1.0 on average but have quantifiable variability. The O/E index primarily measures the loss of taxa found in the reference sites. Because the O/E index only measures the loss of reference taxa, taxa that appear only in non-reference sites have no effect on the index. This results in O/E models that are only indirectly sensitive to invasions of exotic taxa when such taxa replace reference taxa.

Model building proceeds in a series of steps, as follow:

1) Resolve taxonomic uncertainties with Operational Taxonomic Units (OTU)
2) Define clusters of taxonomically similar reference calibration sites
3) Relate site variables to clusters with Discriminant Function Analysis (DFA)
4) Develop expected taxa prediction and compare to observed taxa (O/E)
5) Evaluate model performance

Much of the procedure has been automated in statistical software, especially steps 3 and 4. So for each of these steps described below, the general intent of the procedure is presented, while extensive details provided elsewhere are referenced.

Predictive models were built for both stream and river macroinvertebrates. A predictive model for fish in streams was attempted, but was unsuccessful. There are too few fish taxa in reference streams of Idaho to build a reliable model of expected taxa. Presence and absence of these few taxa did not vary predictably with the environmental variables. In addition, the O/E model primarily indicates impairment when taxa are absent. This pattern does not always occur with fish in Idaho. Rather, streams stressed by increasing temperature or sediment can become suitable for opportunistic exotic taxa and don't necessarily eliminate the taxa found in reference sites.

4.3.1 Model Development

O/E Step 1: Operational Taxonomic Units (OTU)

Aggregation into OTUs and elimination of macroinvertebrate taxa from the analysis was necessary for two reasons, as also described for ordination during site classification (Section 3.1). First, rare taxa can influence model results to a degree greater than their actual significance in the ecological settings, and should therefore be removed from analysis. Exclusion of rare taxa increases O/E precision by a small amount (Van Sickle et al. 2007). Second, the model assumes that each taxonomic identification is unique when it may not be so. This taxonomic uncertainty can lead to meaningless assessment differences, and must be resolved. Aggregation and elimination of taxa was described for ordination and the same OTUs were used for predictive model development. The OTUs are static once identified. This is necessary for model algorithms and is meaningful because we are only interested in taxa expected to be in the reference sites that are either present as predicted or lost.

O/E Step 2: Define clusters of taxonomically similar reference sites

The predictive model recognizes natural variability based on groupings of reference sites with similar taxonomic components. The groups (also called clusters or site classes) are used in the model development and future applications. Sites were grouped based on taxonomic composition. That is, sites with similar taxa were grouped together and dissimilar sites were separated into different clusters.

After eliminating reference sites with no benthic samples, small benthic sample sizes, and sites redundant with close neighboring sites, 222 reference sites were available for O/E development. Sample target size was 500 organisms. The taxa lists of large samples were randomly re-sampled so that the electronic record showed a final taxa list with 500 organisms in it. Samples with less than 400 organisms (target – 20%) were not used in model development. The 222 reference stream samples were randomly partitioned into development (n = 212) and validation (n = 60) datasets. The development data set was used to calibrate the model. The validation dataset was used to evaluate model performance, to identify possible overfitting issues, and to guide selection of the best model among several alternatives. Overfitting occurs when a model is built that is specific to the calibration dataset, but that is not precise when applied to new data because of the high degree of specificity.

The clustering exercise was performed using taxonomic identifications at the OTU level and taxonomic presence/absence data. Clustering was performed in PC-ORD (McCune and Mefford 2006) using the Sorensen Index (a.k.a. Bray-Curtis) to measure similarities and the flexible-beta group linkage method with beta set at -0.50. Clusters were selected using professional judgment to prune the dendrogram into groups having maximum within group similarity and a minimum of five sites.

For this dataset, it was possible to use a single cut-line at about 45% information remaining for pruning the dendrogram into eleven groups with a minimum group size of nine sites (**Figure 4-9**). The placement of the cut-line and selection of the number of groups was somewhat arbitrary. With more groups, we may lack the predictor variables to robustly distinguish between all of them. With fewer, we may lose opportunities to predict expected taxa specific to the natural conditions. In the O/E model building procedure, definition of more groups can be accommodated and may (or may not) improve model precision. If we define fewer groups, we cannot model any environmental differences within the larger groups, whether or not we have the distinguishing predictor variables. Therefore, it is best to define more groups initially. The dendrogram had 0.46% chaining. When the flexible beta value was set at -0.25, the percent chaining increased and the dendrogram did not show as many distinct clusters.

O/E Steps 3 and 4: Relate site variables to clusters and calculate O/E

We expect the biological community to vary with changes in the environmental setting, regardless of stressor effects which may disrupt the natural gradients in taxonomic diversity. The biological groups identified in the cluster analysis were related to environmental conditions using Discriminant Function Analysis (DFA). Environmental variables that account for changes in the undisturbed macroinvertebrate assemblage but are not related to stressor influences are useful for DFA analysis. Simple and easily derived variables will likely be available and consistent in future data collection efforts while including variables that are difficult to measure or derive reduce the usefulness in the final model. Predictor variables for model development included 15 measures not related to anthropogenic influences (**Table 4-17**). Variables were either field measured or office generated (e.g., via GIS). Environmental variables that showed distinct distributions among cluster groups (**Figure 4-10**) were more likely to be included in the DFA and the final O/E model.

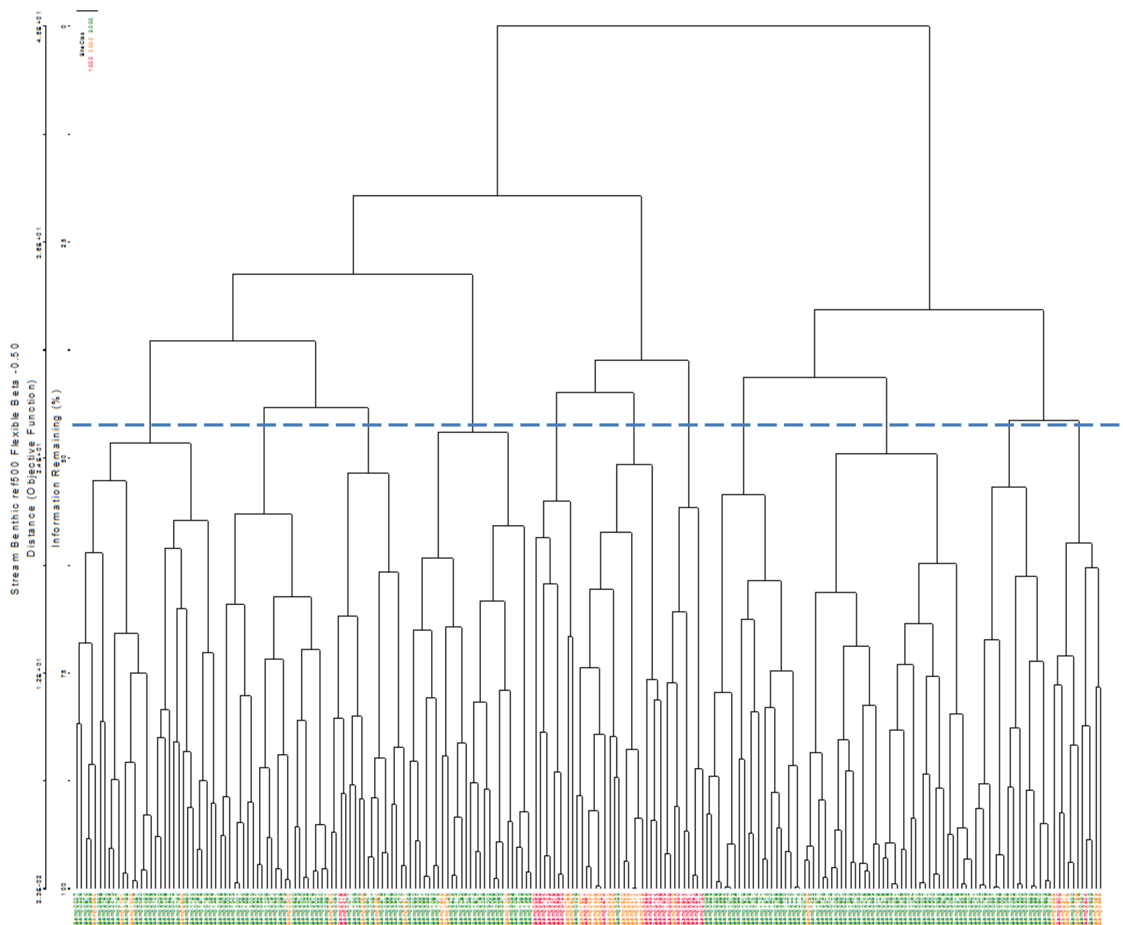

Figure 4-9. Clustering dendrogram of calibration stream reference sites, showing pruning levels for establishing eleven site groups. Color codes for site names relate to site classes: Mountains (green), Foothills (tan), and PPBV (pink).

Through automated software routines (R code, Van Sickle et al. 2005), multiple discriminant models with all possible subsets of the 15 environmental variables were generated. To evaluate each model, the ratio of observed to expected taxa (O/E) was calculated for each site. Expected taxa for a site are calculated as the product of the probability that a site is a member of a cluster and the probability of capture of the taxon in that group, summed for all groups and taxa. The O/E calculations were based on a probability of capture threshold of > 0.5, meaning that a taxon would not be expected (or counted among the observed) unless it occurred in more than half of the reference sites in a group. The exclusion of rare taxa in O/E models improves model precision (Van Sickle et al. 2007).

Table 4-17. Candidate stream predictor variables for RIVPACS development**.**

Abbreviation	Description
DD_LAT	Latitude (decimal degrees)
DD_LONG	Longitude (decimal degrees)
MELEV	Site elevation (ft)
GRADIENT	Gradient (field measured)
SlopeNHD	Gradient (GIS measured using NHD data)
power	Drainage area * GRADIENT * precipitation
PowerNHD	Drainage area * SlopeNHD * precipitation
ppt14_mm	Precipitation (mm)
tmax14_C	Maximum air temperature (°C)
LithErodPrelim	Erodibility of underlying lithology (10 point scale)
RiffRun	Percentage of riffle and run habitat in the stream reach
AvgOfBFWIDTH	Average of bankfull width
JulianDay	Day of the year (1-365) of the benthic sample collection date
StrmDen	Stream density
Log10_DrArea	Drainage area of sampling location (log-transformed)

Software output included the five best performing models for each of 1 to 15-order (predictors) models. Performance measures included the mean, standard deviation, and root mean square error (RMSE) of O/E values derived from reference samples. These measures were compared with the null model, which does not account for any environmental variability, and with the minimum error associated with replicate sampling. A final model was selected as the alternative with the appropriate number of predictor variables, high precision of the O/E values in calibration and validation data, and meaningful predictor variables. Also considered was discrimination among groups, measured as a high percent correct group prediction and low Wilks' lambda value (indicating separation of cluster groups in the DFA).

O/E Step 5: Evaluate model performance

The appropriate model order (number of predictor variables) was determined from model precision and evaluation of overfitting. Precision increases as more variables are included in the model, measured as decreasing RMSE. Overfitting occurs when the model is so specific to the calibration data that results cannot be replicated with validation data. Overfitting was determined using two indicators of correct site classification: resubstitution and cross validation. The resubstitution procedure classifies each site to a group using the final classification function and determines whether the predicted group is the same as the group identified through cluster analysis. We expect a low rate of resubstitution error because the same sites used in building the model were classified after model calibration. The cross validation procedure calculates the discriminant function model in the absence of one observation and then uses the model to classify the case that was removed, much like other statistical jackknife procedures. Overfitting can be indicated as the point at which correct classifications using resubstitution and cross-validation diverge.

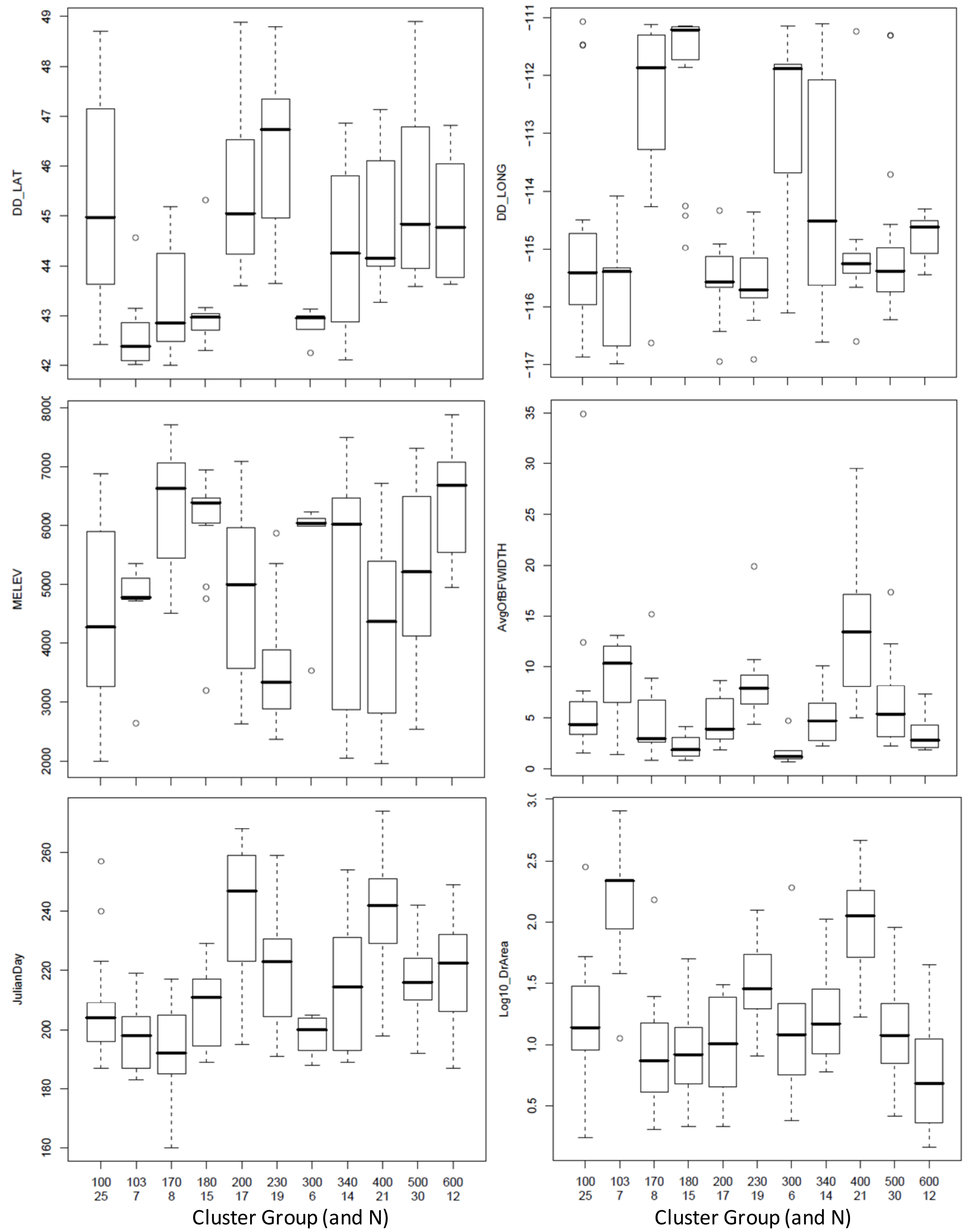

Figure 4-10. Distinguishing characteristics of biologically-defined reference clusters in streams.

Resubstitution classification accuracy of the discriminant function models increased consistently with model order, but cross-validated classification accuracy did not improve appreciably beyond sixth-order models, where it began to diverge from the resubstitution accuracy (**Figure 4-11**). A 5th order model would be most appropriate to increase model precision without overfitting.

Predictive model precision, measured by the RMSE of the O/E ratio, also improved steadily with model order up to the 5th or 6th order model. Higher order models did not show continually improving precision (**Figure 4-12**). The best performing 5th order model had the lowest RMSE in the validation dataset (0.175) and a calibration RMSE of 0.16, considerably less than the null model RMSE of 0.21. Mean O/E values for reference calibration and validation data were 1.02 and 1.00, respectively. Discrimination among cluster groups was adequate, with a Wilks' lambda value of 0.11, correct classification in 50.6% of sites with resubstitution and 42% with cross validation. This O/E model performed well, considering that models with RMSE values less than 0.20 are adequately precise and statistics for other models in western states are similar (**Table 4-18**).

The predictor variables in the selected O/E model included longitude, latitude, elevation, stream slope, Julian day, and bankfull width. These variables relate to location, physical habitat, and sample timing. While some groups tend to lie in distinct parts of the state (**Figure 4-13**), others are better defined by the physical habitat characteristics.

The legitimacy of the predictor variables in the selected model was confirmed in forward and backward stepwise DFA analyses with all variables and the 'all-subsets importance', which is the percentage of models using each variable among the five best models of all 15 model orders (**Table 4-19**). One variable that was important in both confirmatory analyses but was not in the 5th order model selected was the % riffle-run habitat in the stream reach. Conceptually, % riffle-run habitat could be partially explained by the stream slope variable, which remained in the model.

4.3.2 Post Model Analyses

While the precision of the model among reference sites is the primary tool for assessing O/E model performance, responsiveness of the index along a stressor gradient is also informative. To parallel evaluations of the MMI, we illustrate the discrimination efficiency of the O/E model in the stream site classes. The O/E index showed greatest response to stressors in the Foothills and PPBV site classes, where nearly 75% of stressed sites were below an O/E value of 0.8 and more than 50% were less than 0.6 (**Figure 4-14**). In the Mountains, fewer stressed sites showed O/E values responding to stress, with more than 50% of stressed sites greater than 0.85 O/E units.

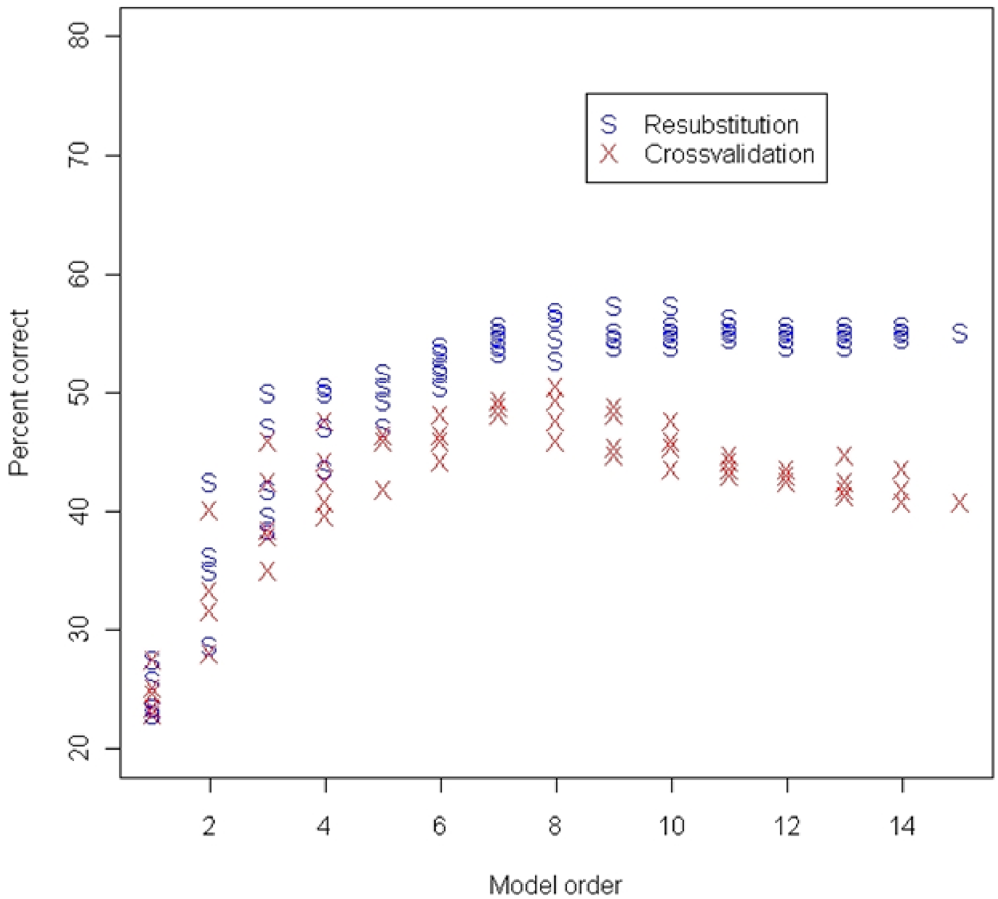

Figure 4-11. Resubstitution and cross validation classification accuracy for stream sites.

Table 4-18. Comparison of stream O/E models for western states.

Model	Number of Site Classes	Number of Predictor Variables	RMSE of O/E at calibration sites	
			Predictive Model	Null Model
Idaho 2010 (this study)	11	5	0.16	0.21
WSA (West) (U.S. EPA 2006)	31	7	0.19[a]	0.26[a]
Colorado (Hawkins 2009)	7	7	0.18	0.33
Montana (Jessup et al. 2006)	5	5	0.17[a]	0.38[a]
Oregon (Hubler 2008)	3 - 5[b]	2 - 4[b]	0.12 – 0.15[ab]	0.14 – 0.18[ab]
Wyoming (Hargett et al. 2005)	15	14	0.17[a]	0.29[a]

[a] Standard deviation reported instead of RMSE. The two measures are comparable.

[b] A range of values is presented because models were developed for multiple regions.

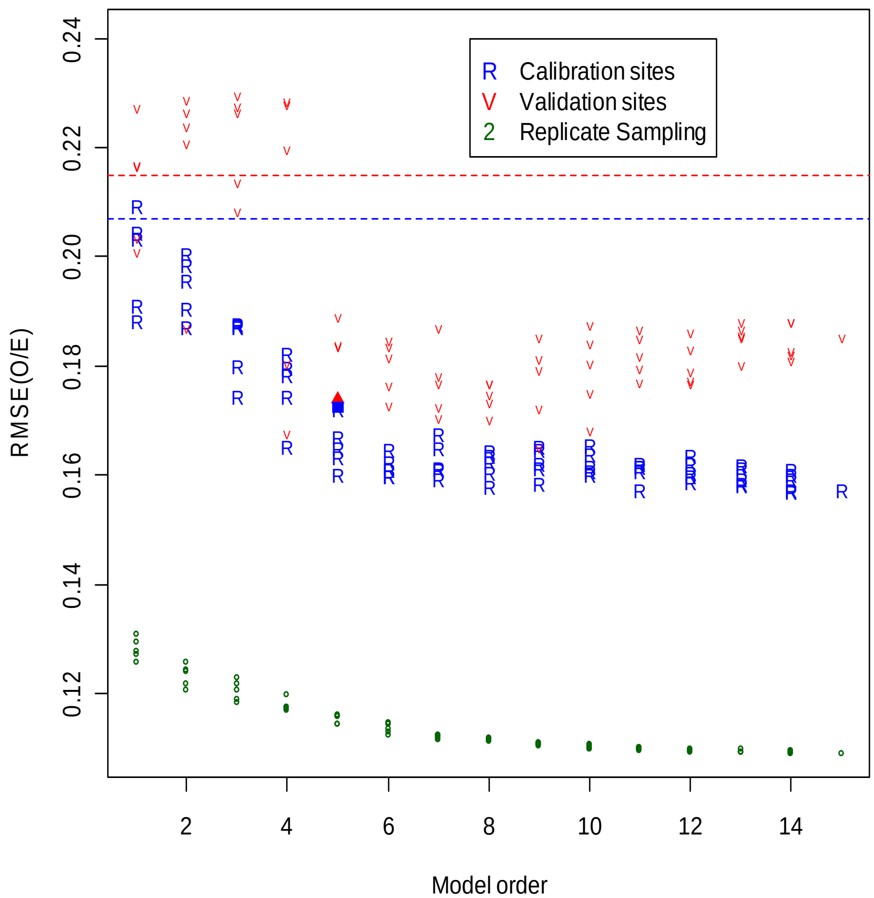

Figure 4-12. Relationship between model RMSE of stream reference samples and the number of predictor variables used in the models. Dashed lines are null models for calibration (blue) and validation (red) datasets. Green circles represent an estimate of random sampling error.

The O/E index can be applied across the state of Idaho without segregating sites by site class. The mean and RMSE of calibration data are typically used to define the range of O/E values that are similar to reference. For instance, the mean minus twice the RMSE could be used as a threshold (1.02 – 2*0.16 = 0.68). However, **Figure 4-14** illustrates that there are slight differences in the reference distributions. Accounting for site class differences might allow application of the O/E index to be more sensitive to stressors than application with a statewide assessment threshold.

Table 4-19. Predictor variable DFA steps and 'all-subsets importance'.

Predictor	Selected Model	All Subsets Importance	Forward F to Enter	Backward F to Remain
DD_LONG	X	87.3	8.25	7.93
JulianDay	X	87.3	8.79	8.95
DD_LAT	X	81.7	9.42	9.89
MELEV	X	76.1	9.82	10.26
Log10_DrArea		69	4.23	2.78
SlopeNHD		67.6	4.76	4.65
AvgOfBFWIDTH	X	60.6	2.44	2.44
PowerNHD		56.3	4.21	4.21
tmax14_C		43.7	2.36	2.36
ppt14_mm		42.3	3.06	3.06
RiffRun		31		
GRADIENT		15.5		
power		15.5		
StrmDen		15.5		
LithErodPrelim		11.3		

4.4 Development of an O/E model for river sites

The dataset of river sites was much smaller than the stream dataset, with 31 reference sites. There were obvious differences in reference criteria among Mountain and Non-mountain classes, so much so that we considered building separate models for the two classes. However, we proceeded building the model with all reference sites, expecting that the site classes would be evident in the clustering and predictive importance. Model building included the same steps described for streams above.

After establishing OTUs for rivers, cluster analysis revealed that three cluster groups could be defined, two of which were almost entirely Mountain sites (**Figure 4-15**). The third cluster group had a mix of Foothills and PPBV sites, as well as a single Mountain site.

Predictor variables included nine measures of location, climate, sample timing, and physical site characteristics (**Table 4-20**). Two variables, membership in the Mountains site class and river order were categorical. These two were among those that showed distinctions among the cluster groups (**Figure 4-16**).

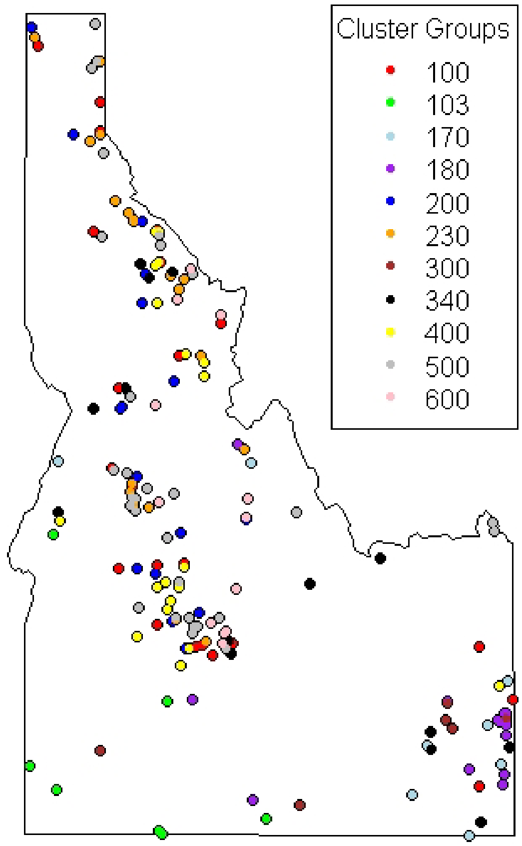

Figure 4-13. Reference calibration stream sites showing cluster memberships.

Resubstitution classification accuracy of the DFA models increased consistently up to the 4th or 5th model order, but cross-validated classification accuracy peaked in third- to sixth-order models, suggesting that a 4th-5th order model would be most appropriate (**Figure 4-17**). Predictive model precision, measured by the RMSE of the O/E ratio, improved slightly with model order up to the 6th order model (**Figure 4-18**). However, we focused on 5th order models based on limited improvements in correct classifications and precision between the 5th and 6th orders. The recommended model was selected based on model order (not overfit), RMSE in calibration and validation data (should be low), discrimination among groups (high percent correct group prediction and low Wilks' lambda value), and meaningful predictor variables.

The meaningfulness of predictor variables was evaluated based on forward and backward DFA analyses, as well as the percentage of potential models that included each variable (all subsets importance) (**Table 4-21**). In the forward DFA, only two variables entered into the model with significant F values, including mountain site class membership and Strahler order (both categorical predictors). In the backwards stepwise procedure, four variables remained in the model, including mountain site class membership, maximum temperature, wetted width, and longitude.

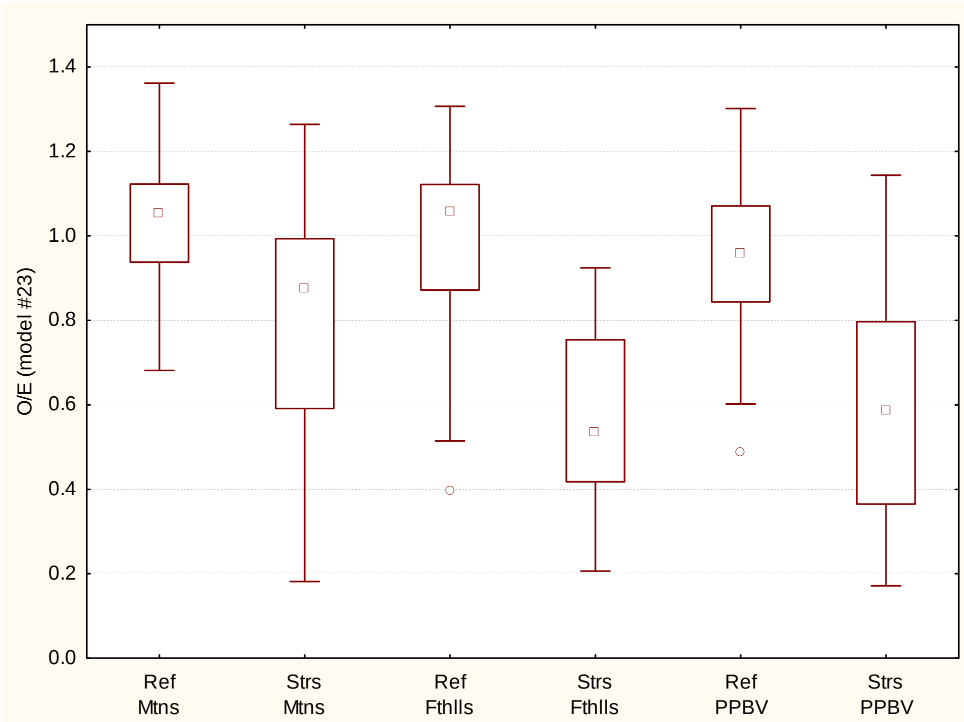

Figure 4-14. O/E values observed for samples taken from reference and stressed stream sites in the bioregions established for the MMI: Mountains, Foothills, and PPBV. Symbols represent the median, intraquartile ranges, non-outlier ranges, and outliers.

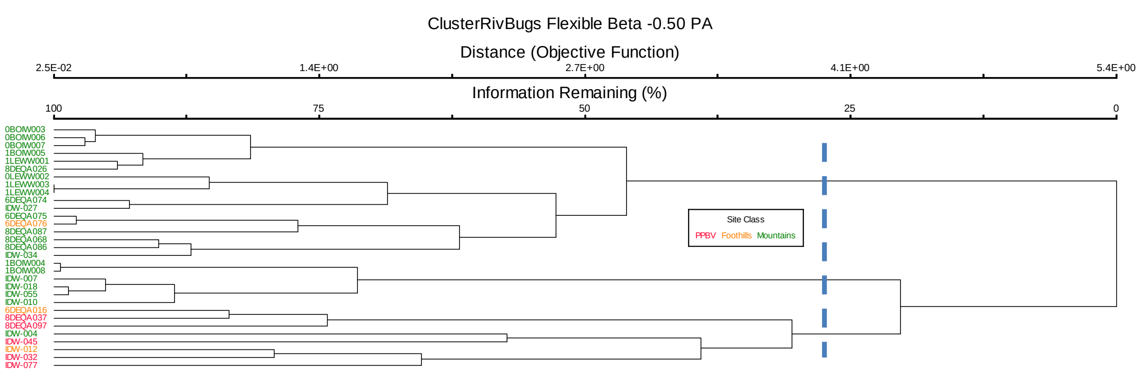

Figure 4-15. Clustering dendrogram of calibration river reference sites, showing pruning levels for establishing three site groups. Color codes for site names relate to site classes: Mountains (green), Foothills (tan), and PPBV (pink).

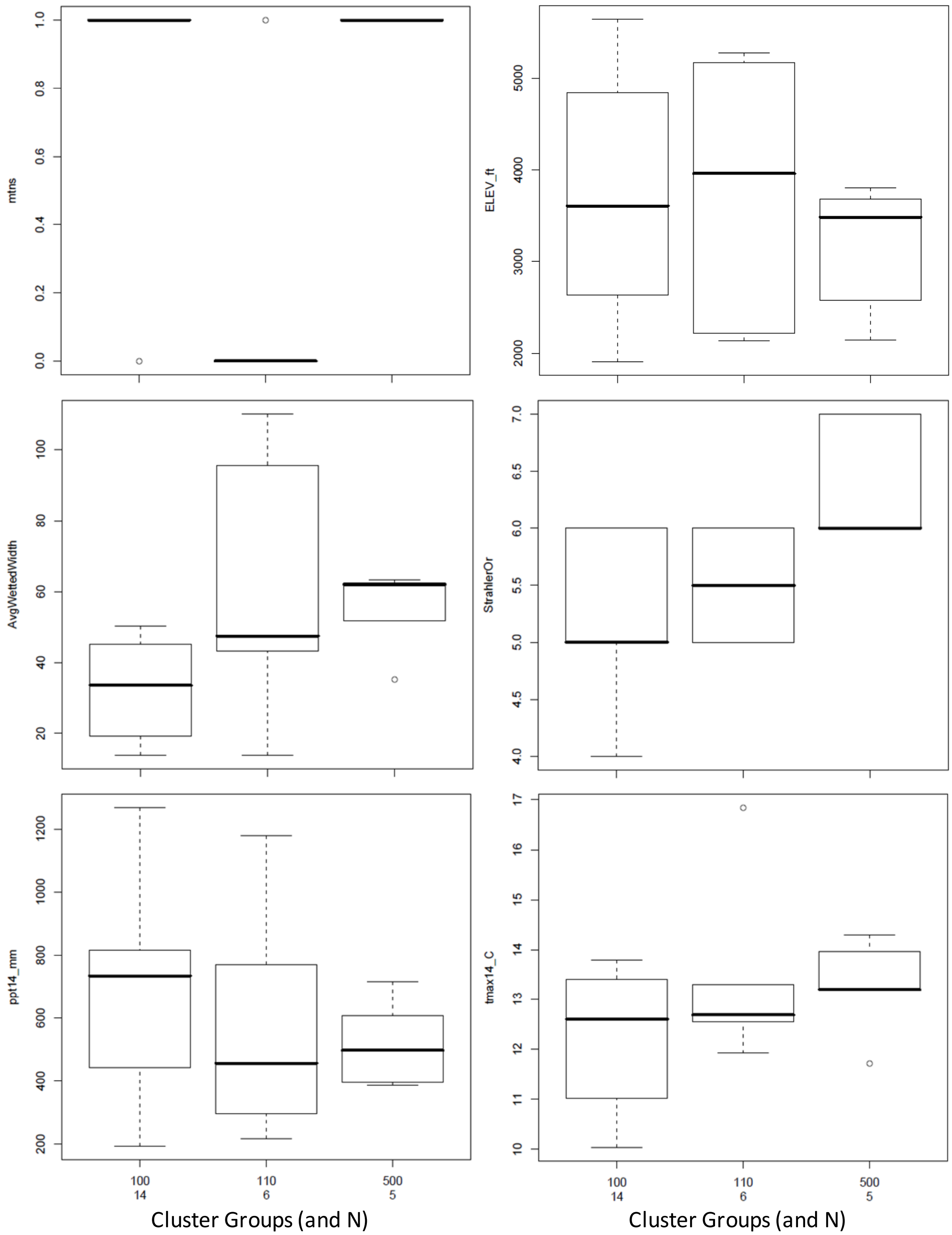

Figure 4-16. Distinguishing characteristics of biologically-defined reference clusters in rivers.

Table 4-20. Candidate river predictor variables for predictive model development.

Abbreviation	Description
LAT_DD	Latitude (decimal degrees)
LONG_DD	Longitude (decimal degrees)
ELEV_ft	Mean elevation (feet)
StrahlerOr	River order (Strahler 1957)
mtns	Membership in mountains site class (on/off variable)
ppt14_mm	Precipitation (mm)
tmax14_C	Temperature (°C)
AvgWettedWIDTH	Average of wetted width (m)
JulianDay	Day of the year (1-365) of the benthic sample collection date

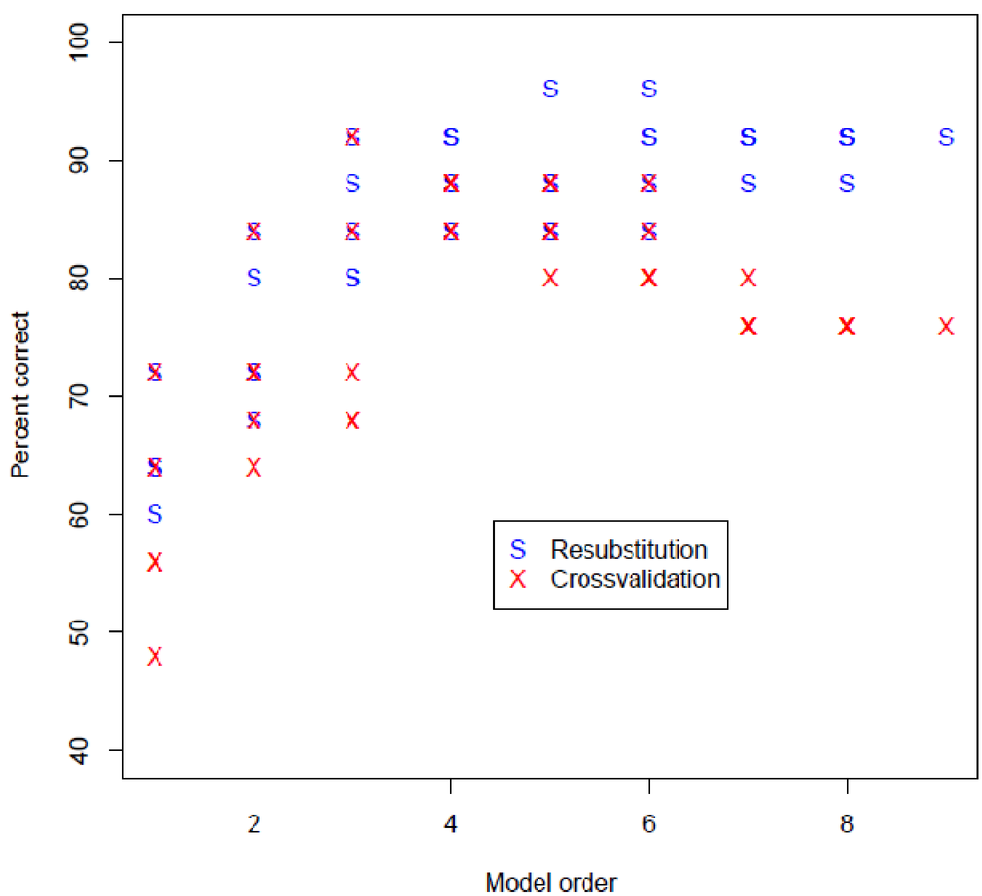

Figure 4-17. Resubstitution and cross validation classification accuracy for river sites.

Table 4-21. Predictor variable DFA steps and 'all-subsets importance'.

Predictor	Selected Model	All Subsets Importance	Forward F to Remain	Backward F to Remain
mtns	X	90.2	19.6	22.5
StrahlerOr	X	73.2	9.0	
ppt14_mm	X	68.3		8.7
AvgWettedWIDTH	X	56.1		9.8
tmax14_C	X	51.2		
LONG_DD		41.5		5.2
ELEV_ft		34.1		
LAT_DD		26.8		
JulianDay		19.5		

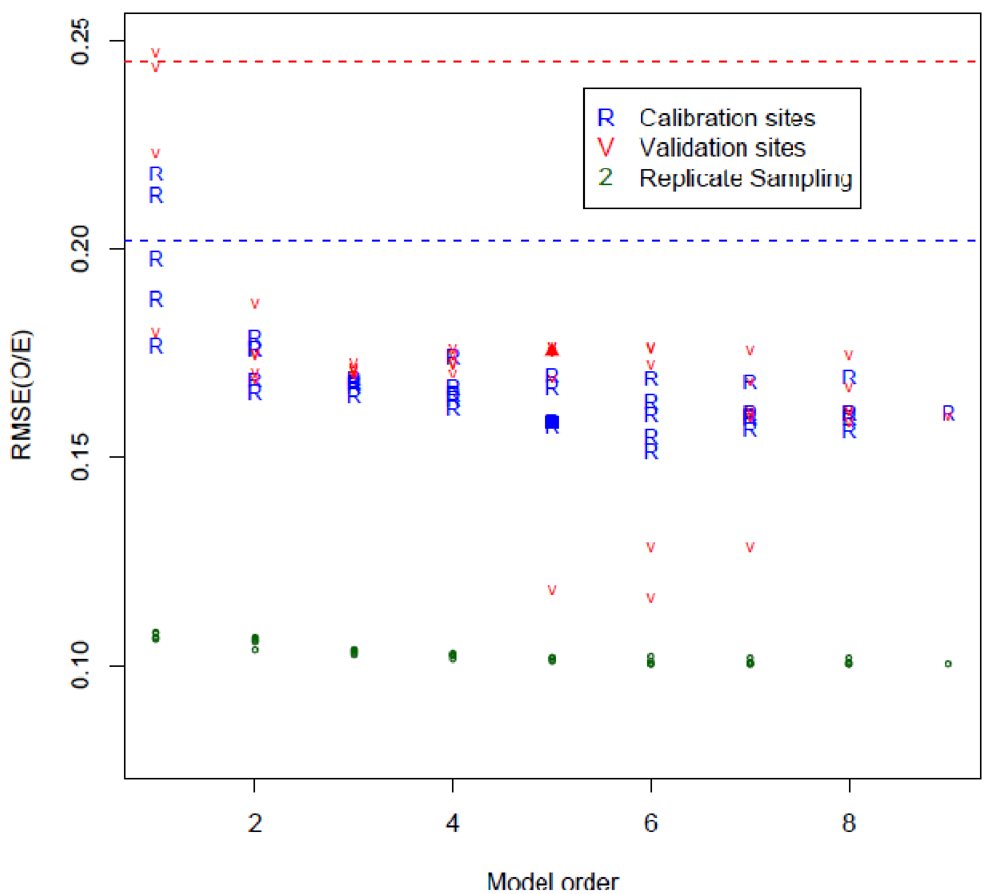

Figure 4-18. Relationship between model RMSE of river reference samples and the number of predictor variables used in the models. Dashed lines are null models for calibration (blue) and validation (red) datasets. Green circles represent an estimate of random sampling error.

The fifth order model that was selected included the five variables that were most often in the best performing models: mountain site class membership, Strahler order, maximum air temperature, wetted width, and precipitation. These variables relate to ecoregion, river size, and climate. Longitude was a candidate for inclusion, but was not used because sites within groups were either dispersed east and west or clumped in the middle (**Figure 4-19**).

The fifth order model had a calibration RMSE of 0.16, which was considerably less than the null model RMSE of 0.20. The means of calibration and validation data were 1.0 and 0.89, respectively, and the validation RMSE was 0.175. The validation mean was considerably lower than 1.0 in the selected model, as it was for all other potential models (the highest validation mean was 0.92). The classification accuracy was high in resubstitution (96%) and reasonably high in cross validation (80%), with a Wilks' lambda of 0.11.

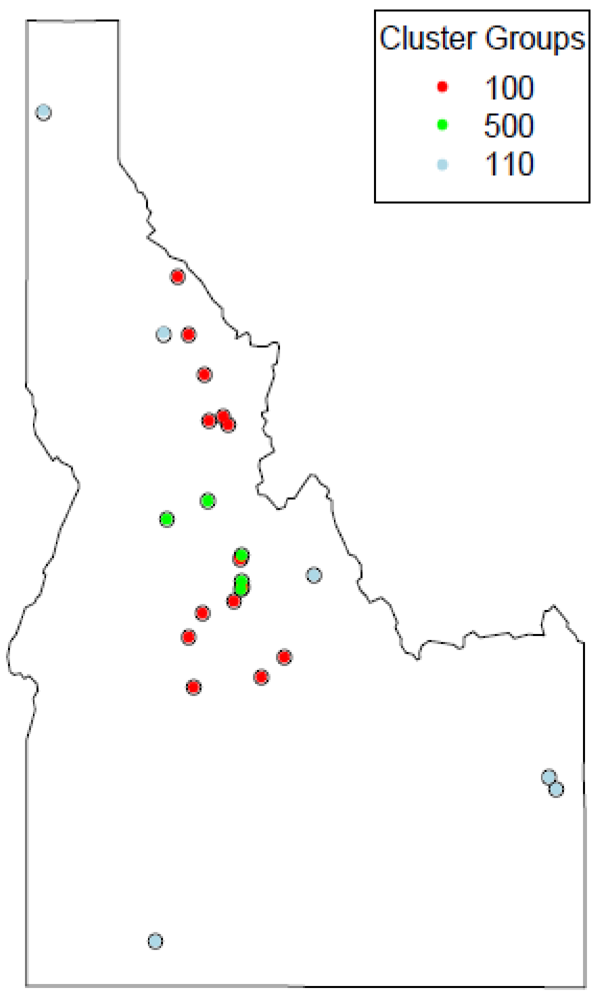

Figure 4-19. Reference calibration river sites showing cluster memberships.

In the site classes, the O/E index was less precise and more responsive in the non-mountains compared to the mountains (**Figure 4-20**). A potential threshold of impairment based on the mean minus twice the RMSE of calibration data would be 0.68 O/E units. If applied statewide to this data set, only one reference site of the mountain rivers would assess as impaired, while more than 50% of the non-mountain rivers would be impaired. However, most of the non-mountains stressed sites were outside the experience of the model, considered outliers, and assessment results should be considered tentative. The distributions of predictor variables in stressed sites of the non-mountains show that, on average, stressed sites are warmer, drier, and larger than the reference sites used to build the model (**Figure 4-21**). Of the non-mountain sites that were within the experience of the model, all had O/E values between 0.42 and 0.64.

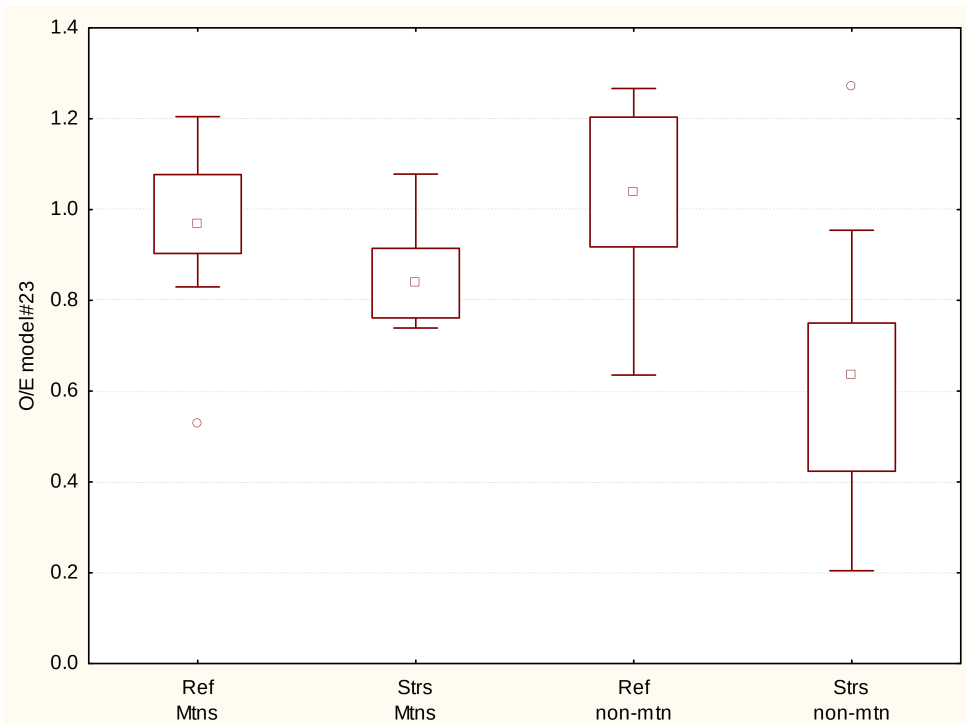

Figure 4-20. O/E values observed for samples taken from reference and stressed river sites in the bioregions established for the MMI.

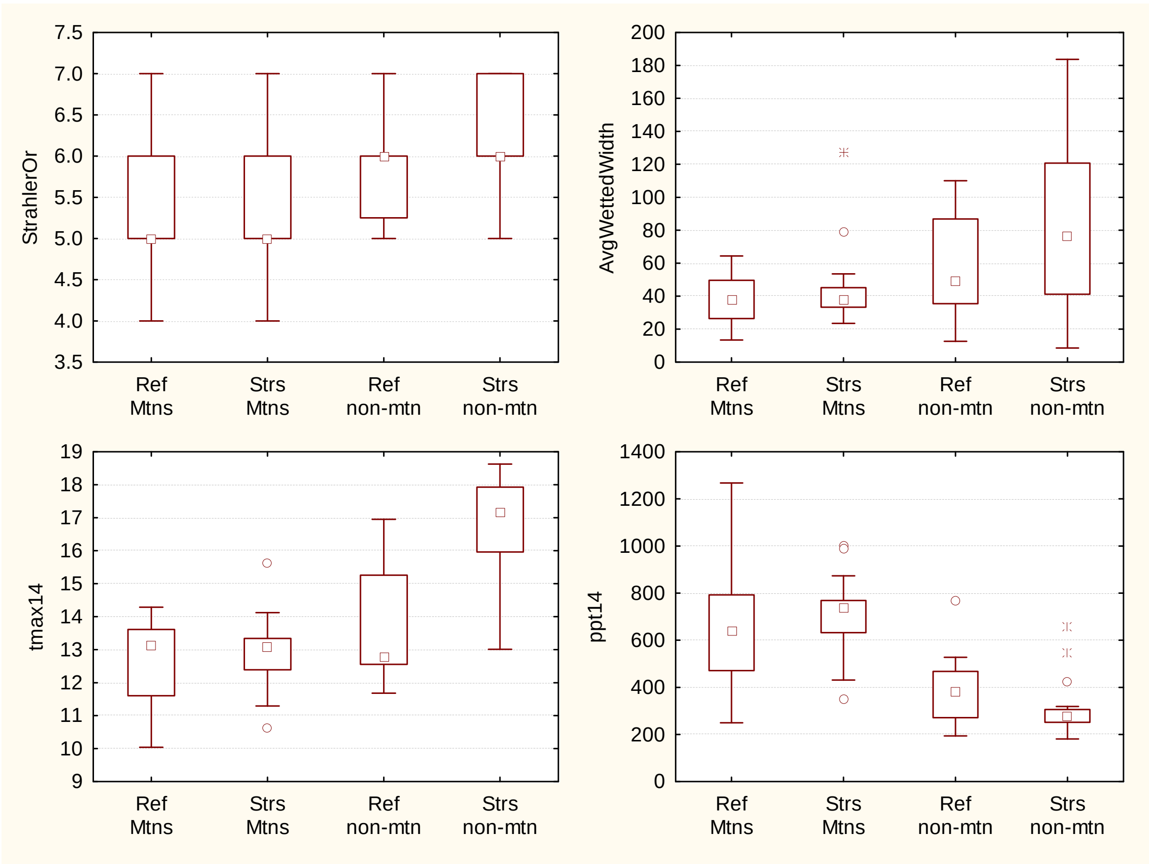

Figure 4-21. Distributions of continuous river O/E predictor variables in reference and site class categories.

5.0 Fish Indicators

Multimetric indices for fish were developed using the same general procedure described for benthic macroinvertebrates. Reference and stressed streams were used to describe the stressor gradient against which to measure responsiveness of fish metrics and indices. Responsiveness was tested within the individual site classes: Mountains, Foothills and PPBV for streams and Mountains and Non-mountains for rivers. Where there were different responses among classes, index formulations were recommended that were specific to each class.

The fish assemblage is an important ecological indicator in Idaho as well as a commercial and recreational resource. Many of the state's streams and rivers are cold-water habitats that support salmonids and other game fish. A healthy cold-water fish assemblage is not necessarily diverse, with some cold mountain streams and rivers supporting only trout and sculpin. The metrics that are candidates for inclusion in fish indices therefore rely heavily on attributes of the taxa and to a lesser extent on richness and diversity measures.

5.1 Metric Descriptions

Forty-three (43) fish metrics in five metric categories were calculated (**Table 5-1**). The categories included richness, composition, trophic guild, reproductive strategies, and tolerance to pollution. Each category addresses aspects of the sample that are expected to change with general or specific stressors. It was mentioned that richness can be low in cold mountains streams. It can be high either when stressors appear in those coldwater systems or when stressors are absent from more productive systems. Because of the variable response patterns, there was no requirement to include richness metrics in final indices. Composition of taxa, numbers of individuals in various groups, can vary with stressor intensity depending on the tolerances or opportunistic abilities of each group. Trophic guild metrics exhibit patterns when food resource quality or type becomes altered due to stresses. Reproductive strategies can be dependent on habitat quality, which can be degraded with increasing stress. Tolerance metrics are based on four levels of tolerance to generalized pollutants. Metric calculations were performed in a Microsoft Access relational database that allowed calculations based on sample taxonomic lists and taxa attributes.

The attributes of the taxa that were used in the calculations were either provided entirely by IDEQ or provided in part and augmented with designations from the Western EMAP database (provided by U.S. EPA). All calculations were based on the level of taxonomy recorded in the IDEQ database. All taxa in each sample were counted towards richness measures, without an attempt to exclude ambiguous taxa because most identifications were at the species level.

Table 5-1 (continuous). Fish metrics used in index development.

Type	MetricCode	Metric Name	Description
Richness	TotalTax	Total Taxa	Total number of taxa
	NatTax	Native Taxa	Number of taxa having a native range that includes any part of Idaho
	SalmTax	Salmonid Taxa	Number of taxa in the family Salmonidae
	SlmSclpPT	Salmon & Sculpin % of Taxa	Percent of taxa that are either salmonids or cottids
	BullTrtInd	Bull Trout Individuals	Number of Bull Trout, an indicator species (Tested in all samples, not just July and August)
	DartTax	Darter Taxa	Number of taxa in the family Percidae
	MinnTax	Minnow Taxa	Number of taxa in the family Cyprinidae
	NatMinTax	Native Minnow Taxa	Number of native taxa in the family Cyprinidae
	SucTax	Sucker Taxa	Number of taxa in the family Catostomidae
	SunTaxa	Sunfish Taxa	Number of taxa in the family Centrarchidae
Composition	TotalInd	Total Individuals	Number of individuals in the sample
	MinnPct	% Minnow Individuals	Percent of individuals in the sample in the family Cyprinidae
	DacePct	% Dace Individuals	Percent of individuals in the sample in the genus Rhinichthys
	SuckerPct	% Sucker Individuals	Percent of individuals in the sample in the family Catostomidae
	LNDacePct	% Longnose Dace	Percent of individuals in the sample that are longnose dace
	LND2Minn	% Longnose Dace of Minnows	Percent of individuals that are longnose dace of all minnows
	IndPUEArea	Individuals per Reach Area	Number of individuals per square meter of reach area (length x width) (IDEQ expressed low confidence in measurement consistency)
	IndPUEtime	Individuals per Shock Time	Number of individuals per second of active electrofishing (IDEQ expressed low confidence in measurement consistency)
	Dom01Pct	% Individuals in Dominant Taxon	Percent of individuals in the sample of the most dominant taxon
	IndpNatTax	Individuals per Native Taxon	Total individuals divided by the number of native taxa (+1) in the sample
Trophic	BenTax	Benthic Taxa	Total number of taxa that live/forage on the stream bottom (Partially from EMAP)
	InvrtPct	% Invertivore Individuals	Percent of individuals in the sample in the invertivore trophic guild
	PiscPct	% Piscivore Individuals	Percent of individuals in the sample in the piscivore or invertivore-piscivore guilds

Table 5-1 (continuous). Fish metrics used in index development.

Type	MetricCode	Metric Name	Description
	FOHPct	% Filterer/Omnivore/Herbivore Individuals	Percent of individuals in the sample in the filterer, omnivore, or herbivore guilds
	PiscTax	Piscivore Taxa	Total number of taxa in the piscivore or invertivore-piscivore guild
Reproduction	HiderTaxa	Hider Taxa	Number of taxa that hide eggs without protection (Partially from EMAP)
Reproduction	LithTax	Lithophil Taxa	Number of taxa that spawn in gravel; lithophil brood hiders and lithopelagophils (Partially from EMAP)
Reproduction	LithPct	% Lithophilic Individuals	Percent of individuals in the sample that spawn in gravel; lithophil brood hiders and lithopelagophils (Partially from EMAP)
Reproduction	AnadPct	% Anadromous Individuals	Percent of individuals in the sample that require sea-residence (Partially from EMAP)
Reproduction	CotNumSiz	Number of Sculpin Size Classes	Number of size classes represented by Cottidae (<40, 40-80, >80) (Size classes are based on data distribution)
Reproduction	CypNumSiz	Number of Minnow Size Classes	Number of size classes represented by Cyprinidae (<40, 40-80, >80) (Size classes are based on data distribution)
Reproduction	SalNumSiz	Number of Salmonid Size Classes	Number of size classes represented by Salmonidae (<100, 80-180, >180) (Size classes are based on data distribution)
Tolerance	NatIntTax	Native Intolerant Taxa	Number of taxa designated as "II" and that are native of Idaho (Partially from EMAP)
Tolerance	NatIntPct	% Native Intolerant Individuals	Percent of individuals in the sample designated as "II" and that are native of Idaho (Partially from EMAP)
Tolerance	CldWtrPct	% Cold-water Individuals	Percent of individuals in the sample that require cold temperatures
Tolerance	ExoticPT	Non-Native % of Taxa	Percent of taxa that are not native to Idaho
Tolerance	ExoticPct	% Non-Native Individuals	Percent of individuals in the sample that are not native to Idaho
Tolerance	LngLivTax	Long-lived Taxa	Number of taxa that have a life span >= 8 years (Partially from EMAP)
Tolerance	LngLivPct	% Long-lived Individuals	Percent of individuals in the sample that have a life span >= 8 years (Partially from EMAP)
Tolerance	AnomPct	% Individuals with Anomalies	Percent of individuals in the sample that show physical signs of stress (Typically DELT anomalies)

Table 5-1 (continuous). Fish metrics used in index development.

Type	MetricCode	Metric Name	Description
	ModTolerPct	% Moderately Tolerant Individuals	Percent of individuals in the sample designated as "TT" or "MT" (Partially from EMAP)
	TolerPct	% Tolerant Individuals	Percent of individuals in the sample designated as "TT" (Partially from EMAP)
	IntolTax	Intolerant Taxa	Number of taxa designated as "II" (Partially from EMAP)

5.2 Stream MMI Development

Reference and stressed sites were identified to optimize sample sizes for the benthic macroinvertebrate analyses. Fish sampling in Idaho was not as intensive as benthic macroinvertebrate sampling, so the sample sizes in reference and stressed sites are smaller (**Table 5-2**). This resulted in adequate data sets for calibration of the MMIs, but meager and possibly inadequate validation datasets in the Foothills and PPBV.

Table 5-2. Stream fish sample sizes by site class, reference status, and calibration designation.

Site Class	Mountains		Foothills		PPBV	
Dataset	Calib.	Valid.	Calib.	Valid.	Calib.	Valid.
Reference N	96	25	13	4	10	2
Stressed N	18	9	13	4	15	5

5.2.1 Metric adjustments

Though site classes could account for much of the variability observed in the fish assemblage, remaining variability was investigated using correlation analysis relating metrics to environmental factors. Spearman rank correlations were calculated for fish metrics and environmental measures that were not subject to human disturbance. The correlations were specific to site class and included only reference sites so that variability due to stressors would be reduced.

Strong ($r > 0.50$) and consistent relationships were observed for many metrics and drainage areas. Other variables that were often strongly related to the metrics included total stream length in the catchment and stream power, both of which are related to catchment size. Other relationships were observed with stream gradient and in the PPBV, elevation and lithologic erodibility. We decided to adjust correlated metrics to catchment sizes because these relationships were most consistent across classes and because such adjustments have proven useful in other studies (McCormick et al. 2001). The adjustments were based on regressions using reference sites in all site classes because there were too few reference sites in some classes to produce robust regressions. The regression equations predicted the appropriate catchment size-specific metric values and residuals of the observed metric values to the predicted values were assessed for responsiveness to the stressor gradient. A constant was added to the regression equation to standardize each metric to a 100 square kilometer catchment.

5.2.2 Metric Evaluation

Metric responsiveness to the stressor gradient was evaluated using the DE of calibration data within site classes, as was used for evaluating benthic macroinvertebrate metrics. At least one metric had DEs greater than 50% in every metric category and site class except in the PPBV (**Table 5-3**). In the PPBV, neither richness nor tolerance metrics had highly discriminating metrics and in general, other metrics were not strongly responsive to stress. The Foothills metrics discriminated well, with DEs over 75% in each metric category.

Table 5-3. Stream fish metric discrimination efficiency (DE) and adjustments to drainage area (DA). The trends of metrics to increasing stress are shown as positive (+), negative (-), or not responsive (NR). Metric codes are as in Table 5-1.

MetricCode	Mountains	Foothills	PPBV	Adjustment
TotTax	55.6 (-)	46.2 (+)	46.7 (+)	Metric - (0.58+1.44*log10(DA))+3.46
NatTax	72.2 (-)	69.2 (+)	33.3 (-)	Metric - (0.25+1.51*log10(DA))+3.28
SalmTax	NR	61.5 (-)	NR	
SlmSclpPT	NR	92.3 (-)	26.7 (+)	
BullTrtInd	NR	NR	NR	
DartTax	NR	NR	NR	
MinnTax	38.9 (-)	84.6 (+)	33.3 (+)	Metric - (-0.62+0.62*log10(DA)) + 0.63
NatMinTax	44.4 (-)	92.3 (+)	33.3 (+)	Metric - (-0.54+0.55*log10(DA))+0.57
SucTax	NR	46.2 (+)	NR	
SunTaxa	NR	NR	NR	
TotalInd	50 (+)	69.2 (+)	40 (+)	
MinnPct	38.9 (-)	76.9 (+)	46.7 (+)	Metric - (-14.85+14.76*log10(DA))+14.67
DacePct	38.9 (-)	46.2 (+)	40 (-)	Metric - (-10.88+10.94*log10(DA)) + 10.99
SuckerPct	NR	46.2 (+)	33.3 (+)	
LNDacePct	NR	NR	NR	
LND2Minn	NR	69.2 (-)	NR	
IndPUEArea	55.6 (+)	53.8 (+)	26.7 (+)	
IndPUEtime	55.6 (+)	84.6 (+)	26.7 (-)	
Dom01Pct	55.6 (+)	53.8 (-)	26.7 (-)	Metric - (100.42-19.20*log10(DA))+62.03
IndpNatTax	66.7 (+)	46.2 (+)	66.7 (+)	
BenTax	38.9 (-)	69.2 (+)	46.7 (+)	Metric - (-0.95+1.36*log10(DA))+1.77
InvrtPct	50 (-)	NR	46.7 (+)	Metric - (-14.65+35.87*log10(DA))+57.08
PiscPct	55.6 (+)	30.8 (-)	46.7 (-)	Metric - (109.44-35.63*log10(DA))+38.18
FOHPct	NR	46.2 (+)	26.7 (+)	
PiscTax	NR	NR	53.3 (-)	

Table 5-3. Continued.

MetricCode	Mountains	Foothills	PPBV	Adjustment
HiderTaxa	NR	61.5 (+)	NR	
LithTax	27.8 (+)	NR	66.7 (-)	
LithPct	50 (+)	30.8 (+)	60 (-)	Metric - (105.15-26.31*log10(DA))+52.52
AnadPct	NR	NR	NR	
CotNumSiz	NR	NR	46.7 (+)	
CypNumSiz	38.9 (-)	76.9 (+)	26.7 (+)	Metric - (-0.68+0.68*log10(DA))+0.69
SalNumSiz	NR	61.5 (-)	26.7 (+)	
NatIntTax	NR	NR	NR	
NatIntPct	50 (-)	NR	NR	
CldWtrPct	38.9 (+)	84.6 (-)	46.7 (-)	Metric - (119.29-19.24*log10(DA)) +80.82
ExoticPct	61.1 (+)	NR	33.3 (+)	
ExoticPT	61.1 (+)	NR	33.3 (+)	
LngLivTax	NR	30.8 (+)	33.3 (-)	
LngLivPct	50 (+)	30.8 (-)	46.7 (-)	Metric - (115.99-37.23*log10(DA))+41.52
AnomPct	NR	NR	NR	
ModTolerPct	NR	76.9 (+)	26.7 (+)	
TolerPct	NR	38.5 (+)	26.7 (+)	
IntolTax	NR	NR	NR	

DA = drainage area in square kilometers

5.2.3 Metric scoring

Metrics were scored on a common scale prior to combination (as an average of scores) in an index. The scale ranges from 0 to 100 (as in Hughes et al. 1998, and Barbour et al. 1999). The optimal score is determined by the distribution of metric values, but not as calculated for benthic macroinvertebrates. For metrics that decrease with increasing stress, the median of reference metric values within the site class was considered optimal. This scoring scheme assumes a plateau in metric values in the best conditions and maximizes the scoring range in variation below the optimum (McCormick et al. 2001). The scoring equation on a 100 point scale is as follows:

$$MetricScore = 100 \times \frac{MetricValue - 10^{th}\ Percentile_{Stressed}}{50^{th}\ Percentile_{reference} - 10^{th}\ Percentile_{Stressed}}$$

Metrics that increase with increasing stress (reverse metrics) were scored using the 10th percentile of stressed values as the optimal, receiving a score of 100. Decreasing scores were calculated as metric values increased to the 90th percentile using the equation:

$$MetricScore = 100 \times \frac{90^{th}\ Percentile_{Stressed} - MetricValue}{90^{th}\ Percentile_{Stressed} - 10^{th}\ Percentile_{Stressed}}$$

The metric scoring range was from 0 to 100. Scores outside of this range were re-set to the nearest extreme before the index was calculated.

Validation data sets were small in the Foothills and PPBV, with only four and five stressed sites each. In the mountains, there were nine stressed samples for validation.

Non-fish vertebrates were collected in four samples. They were inconsequential in metric calculations because they were rare and were not given taxa attributes. In each case, samples contained only one vertebrate taxon and only one or two individuals.

5.2.4 Fish MMIs in Mountain Streams

Thirty-four (34) different metric combinations were tested to find the best index for the mountain site class (**Appendix I**). The selected index included metrics from all five metric categories (**Table 5-4**), had a calibration DE of 78%, and a z-score of 2.1. Discrimination of reference from stressed sites was adequate in calibration data (**Figure 5-1**) and was confirmed in validation data (validation DE = 67%). In general, the index metrics were not redundant, with the highest correlations existing between % invertivores and % lithophilic spawners (**Table 5-5**). Both of these metrics were retained because they represent different attributes of the fish assemblage (feeding and reproduction).

Table 5-4. Stream fish MMI metrics for the mountain site class.

Index Metrics	Metric Category	DE	Response
Native Taxa	Richness	72.2	Decreaser
Individuals per native taxon	Composition	66.7	Increaser
% invertivores	Trophic guild	50.0	Decreaser
% lithophilic spawners	Reproduction	50.0	Increaser
% native intolerant individuals	Tolerance	50.0	Decreaser

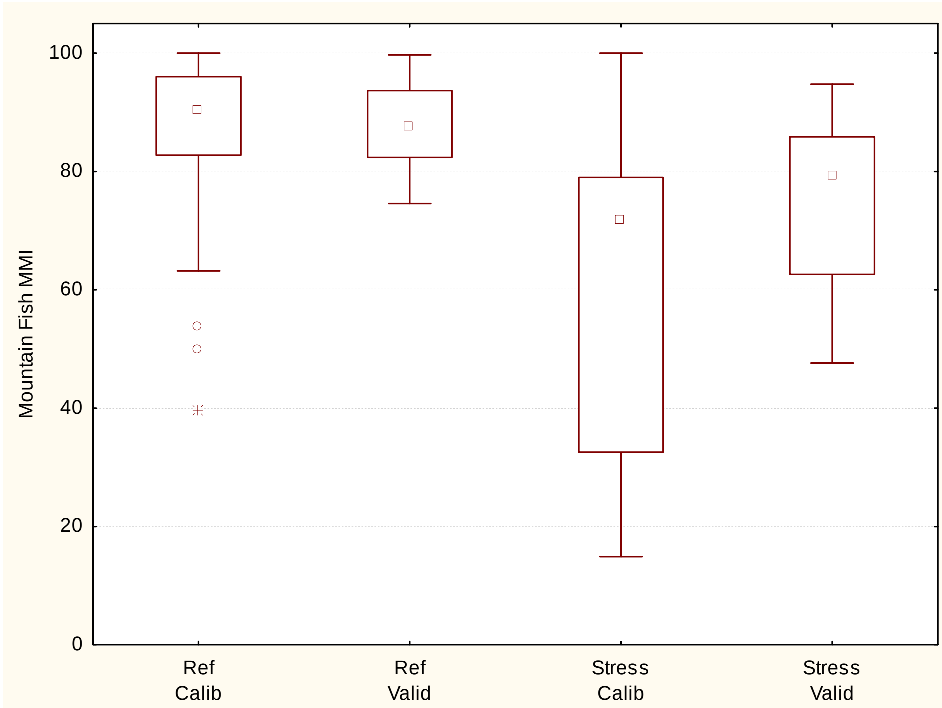

Figure 5-1. Fish index discrimination among reference and stressed conditions in Mountain streams, showing both calibration and validation data distributions (medians, interquartile ranges and ranges).

Table 5-5. Correlations (Spearman r) among fish MMI metrics in the mountain site class**.**

Index Metrics	Metric #	1	2	3	4
Native Taxa	1				
Individuals per native taxon	2	0.01			
% invertivores	3	0.51	0.14		
% lithophilic spawners	4	-0.47	-0.17	-0.90	
% native intolerant individuals	5	0.06	-0.12	-0.09	0.09

5.2.5 Fish MMIs in Foothills Streams

Twenty-four (24) different metric combinations were tested to find the best index for the Foothills site class (**Appendix I**). The selected index included metrics from four of five metric categories (**Table 5-6**), had a calibration DE of 84.6%, and a z-score of 3.1. There was no metric representing reproductive attributes of fish. Discrimination of reference from stressed sites was adequate in calibration data (**Figure 5-2**) and was confirmed in validation data (validation DE = 75%). In general, the index metrics were not redundant, with the highest correlations existing between minnow taxa and percent minnows and between salmon and sculpin percent of taxa and percent moderately tolerant (**Table 5-7**). These sets of metrics were retained because they represent different attributes of the fish assemblage.

Table 5-6. Stream fish MMI metrics for the Foothills site class.

Index Metrics	Metric Category	DE	Response
Minnow Taxa	Richness	84.6	Increaser
Salmon & Sculpin % of Taxa	Richness	92.3	Decreaser
Benthic Taxa	Richness	69.2	Increaser
% Minnow Individuals	Composition	76.9	Increaser
% Moderately Tolerant	Tolerance	76.9	Increaser
% filterers, omnivores, herbivores	Trophic guild	46.2	Increaser

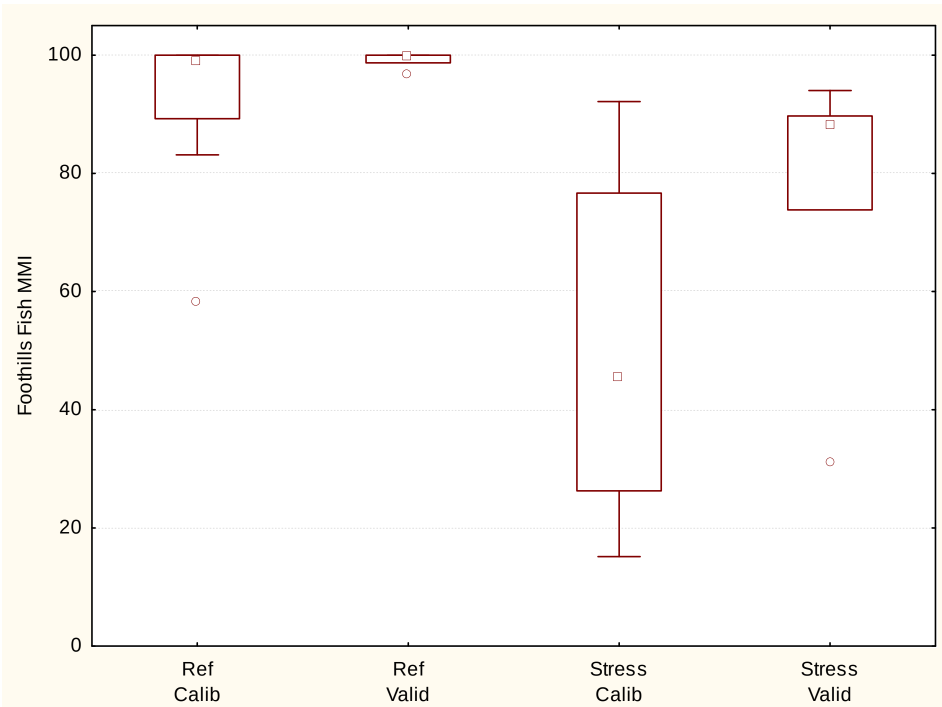

Figure 5-2. Fish index discrimination among reference and stressed conditions in Foothills streams, showing both calibration and validation data distributions (medians, interquartile ranges and ranges).

Table 5-7. Correlations (Spearman r) among fish MMI metrics in the Foothills site class**.**

Index Metrics	Metric #	1	2	3	4	5
Native Minnow Taxa	1					
Salmon & Sculpin % of Taxa	2	-0.61				
Benthic Taxa	3	0.68	-0.54			
% Minnow Individuals	4	0.89	-0.54	0.60		
% Moderately Tolerant	5	0.53	-0.87	0.47	0.53	
% FOH	6	0.33	-0.55	0.38	0.29	0.58

5.2.6 Fish MMIs in PPBV Streams

Twenty-three (23) different metric combinations were tested to find the best index for the PPBV site class (**Appendix I**). The selected index included metrics from all five metric categories (**Table 5-8**), had a calibration DE of 86.7%, and a z-score of 1.6. Discrimination of reference from stressed sites was adequate in calibration data (**Figure 5-3**). Both of the reference validation samples and two of five stressed samples had values above and below (respectively) the 25th percentile of reference calibration values. These results are satisfactory, given the small validation dataset. In general, the index metrics were not redundant, with the highest correlation between % piscivores and % invertivores (**Table 5-9**). Both of these metrics were retained because they represent different attributes of the fish assemblage (richness and composition).

Table 5-8. Stream fish MMI metrics for the PPBV site class.

Index Metrics	Metric Category	DE	Response
Native Taxa	Richness	33.3	Decreaser
Non-native % of Taxa	Tolerance	33.3	Increaser
% Minnow Individuals	Composition	53.3	Increaser
% Lithophilic Spawners	Reproduction	53.3	Decreaser
% Invertivores	Trophic Guild	46.6	Increaser
% Piscivores	Trophic Guild	46.6	Decreaser

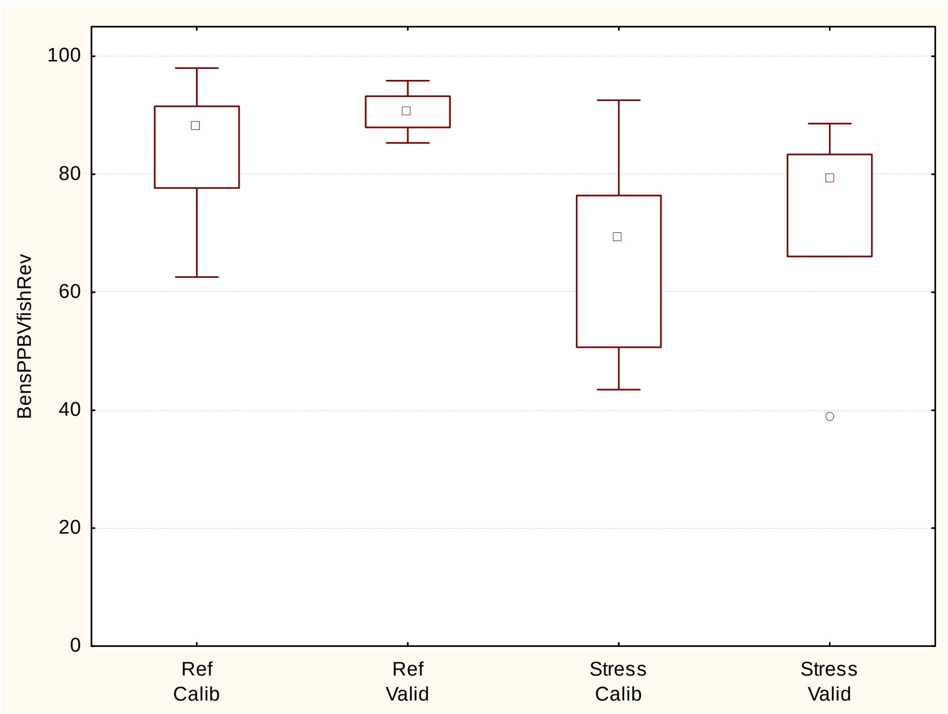

Figure 5-3. Fish index discrimination among reference and stressed conditions in PPBV streams, showing both calibration and validation data distributions (medians, interquartile ranges and ranges).

Table 5-9. Correlations (Spearman r) among fish MMI metrics in the PPBV site class**.**

Index Metrics	Metric #	1	2	3	4	5
Native Taxa	1					
Non-native % of Taxa	2	-0.16				
% Minnow Individuals	3	0.44	-0.14			
% Lithophilic Spawners	4	-0.11	0.01	0.35		
% Invertivores	5	0.33	-0.19	0.50	-0.19	
% Piscivores	6	-0.35	0.24	-0.53	0.37	-0.83

5.3 Stream Fish MMI Application

The Idaho stream fish MMIs should be applied as follows.

1. Determine the appropriate site class for the site using **Table 3-3**.
2. Calculate appropriate MMI metrics.
   Use metric attributes approved by IDEQ (**Appendix J**).
   Adjust metric values to drainage area as in **Table 5-3**.
3. Score metrics based on formulae in **Table 5-10**.
   Reset scores above 100 or below 0 to 100 or 0, respectively.
4. Calculate the MMI as the average of the metric scores.
5. Report the results.
   Include the MMI scores and MMI DE
   Compare numeric results to impairment thresholds
      (IDEQ to decide on threshold values)

5.4 River Fish MMI Development

The river fish samples were not numerous, preventing adequate validation of MMIs (**Table 5-11**). With only three validation samples randomly selected from each stressed dataset, validation results are uncertain. In addition, the few samples were not enough for adjusting metrics to natural conditions other than the site classes. It appeared that the samples collected during the EMAP efforts contained more taxa than those collected by IDEQ, but this was not expected to cause major bias in the index development because both types of sites were evenly represented in each site class and reference type.

Table 5-10. Fish metric scoring formulae for the Idaho stream MMIs**.**

Metrics	Formula
Mountains	
Native Taxa (adjusted to DA)	100*((*adj. metric value*) - 0.52) / 2.8
Individuals per native taxon	100*(53.34 - (*metric value*)) / 48.79
% invertivores (adjusted to DA)	100*((*adj. metric value*) + 17.55) / 64.82
% lithophilic spawners (adjusted to DA)	100*(112.88 - (*adj. metric value*)) / 48.85
% native intolerant individuals	100*(*metric value*) / 100
Foothills	
Minnow Taxa (adjusted to DA)	100*(3.57 - (*adj. metric value*)) / 3.05
Salmon & Sculpin % of Taxa	100*(*metric value*) / 100
Benthic Taxa (adjusted to DA)	100*(4.08 - (*adj. metric value*)) / 2.59
% Minnow Individuals (adjusted to DA)	100*(93.06 - (*adj. metric value*)) / 80.71
% Moderately Tolerant	100*(100 - (*metric value*)) / 100
% filterers, omnivores, herbivores	100*(32.74 - (*metric value*)) / 32.74
PPBV	
Native Taxa (adjusted to DA)	100*((*adj. metric value*) – 1.33) / 1.82
Non-native % of Taxa	100*(40 - (*metric value*)) / 40
% Minnow Individuals (adjusted to DA)	100*(110.50 - (*adj. metric value*)) / 66.22
% Lithophilic Spawners (adjusted to DA)	100*((*adj. metric value*) + 2.61) / 80.27
% Invertivores (adjusted to DA)	100*(138.15 - (*adj. metric value*)) / 73.71
% Piscivores (adjusted to DA)	100*((*adj. metric value*) + 37.9) / 54.86

Note: If the score formula results in a value <0 or >100, re-set to the appropriate extreme of the scoring scale (0-100) before averaging in the MMI.

Table 5-11. River fish sample sizes by site class, reference status, and calibration designation.

Site Class	Mountains		Non-mountains	
Dataset	Calibration	Validation	Calibration	Validation
Reference N	9	0	10	0
Stressed N	9	3	13	3

5.4.1 Metric Evaluation

Using the DE to find metrics that respond to the general stressor gradient showed that at least one metric in each metric category discriminated well (DE > 50%) (**Table 5-12**). More metrics in the mountains had DEs greater than 75%, but the metric with the highest DE (ExoticPT) was in the non-mountains. Except in a few cases, the metrics were not strongly correlated with each other.

Table 5-12. River fish metric discrimination efficiency (DE). The trends of metrics to increasing stress is shown as positive (+) or negative (-). Metric codes are as in Table 5-1.

Metric	Mountain	Non-Mountain	Metric	Mountain	Non-Mountain
TotalTax	44.4 (+)	53.8 (-)	BenTax	44.4 (+)	NR
NatTax	33.3 (+)	61.5 (-)	InvrtPct	77.8 (-)	53.8 (-)
ExoticPT	55.6 (+)	92.3 (+)	PisciTaxa	NR	53.8 (-)
SalmTax	33.3 (-)	53.8 (-)	PiscPct	33.3 (-)	NR
BullTrtInd	NR	NR	FOHPct	77.8 (+)	38.5 (+)
DartTax	NR	NR	HiderTaxa	NR	46.2 (-)
MinnTax	44.4 (+)	30.8 (+)	LithTaxa	NR	61.5 (-)
NatMinTax	NR	53.8 (-)	LithPct	55.6 (-)	53.8 (-)
SucTax	77.8 (+)	NR	LngLivPct	66.7 (+)	61.5 (+)
SunTaxa	NR	69.2 (+)	AnadPct	NR	NR
fTotalInd	55.6 (+)	53.8 (-)	CotNumSiz	33.3 (+)	NR
ExoticPct	44.4 (+)	46.2 (+)	CypNumSiz	77.8 (+)	NR
MinnPct	NR	30.8 (+)	SalNumSiz	44.4 (-)	53.8 (-)
DacePct	44.4 (+)	NR	IntolTax	55.6 (-)	69.2 (-)
SuckerPct	77.8 (+)	46.2 (+)	NatIntTax	55.6 (-)	69.2 (-)
IndPUEArea	77.8 (-)	NR	NatIntPct	55.6 (-)	69.2 (-)
IndPUEtime	44.4 (+)	53.8 (-)	TolerPct	66.7 (+)	53.8 (+)
Dom01Pct	88.9 (-)	46.2 (+)	ModTolerPct	NR	53.8 (+)
			AnomPct	NR	NR
			CldWtrPct	55.6 (-)	46.2 (-)
			LngLivTax	NR	NR

5.4.2 Fish MMIs in Mountain Rivers

Several index alternatives gave very strong indications of stress in the mountain rivers. Of 19 alternatives, 15 had DEs of 100%. The selection of the best index (**Table 5-13**) was therefore based on the *z*-score and preferences for the component metrics. The selected index had a DE of 100 and a *z*-score of 3.59 (**Figure 5-4**). There were no redundant metrics (Pearson $r < 0.85$) and all stressed validation scores were below the 25th percentile of reference scores.

Table 5-13. River fish MMI metrics for the mountain site class.

Index Metrics	Metric Category	DE	Response
Non-native % of Taxa	Richness	55.6	Increaser
% Suckers	Composition	77.8	Increaser
% Filterers, Omnivores, and Herbivores	Trophic guild	77.8	Increaser
Number Cyprinid Size Classes	Reproduction	77.8	Increaser
% Lithophils	Reproduction	55.6	Decreaser
Intolerant Taxa	Tolerance	55.6	Decreaser

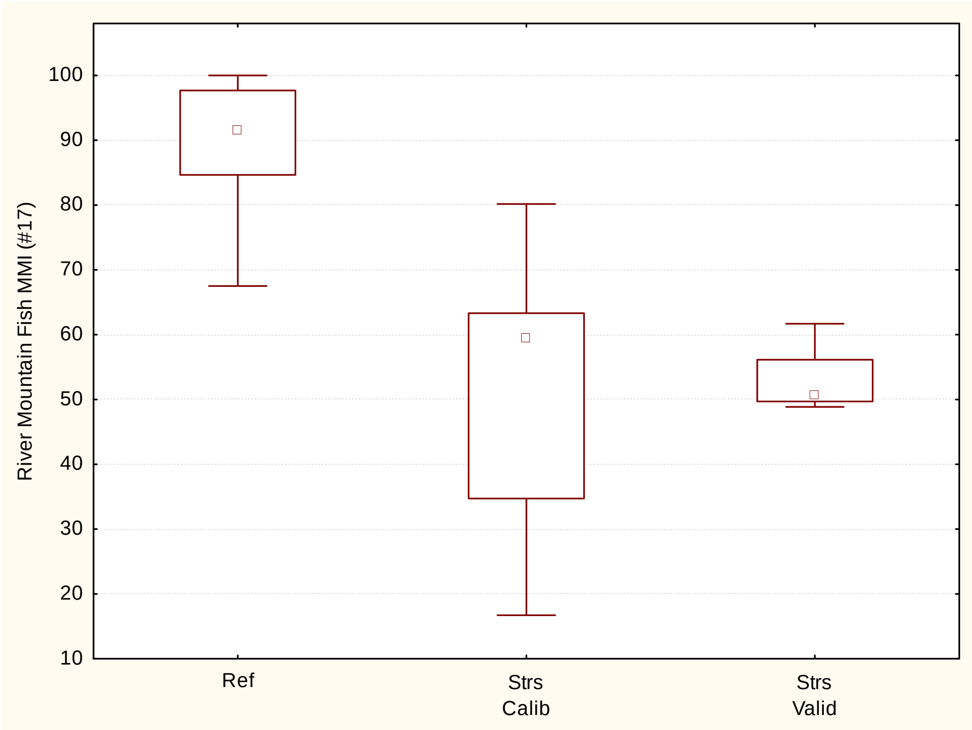

Figure 5-4. River fish index discrimination among reference and stressed conditions in the mountain site class, showing both calibration and validation data distributions (medians, interquartile ranges and ranges).

5.4.3 Fish MMIs in Non-mountain Rivers

Although there were several metrics with strong DEs, their combination in an index did not strengthen the overall indication of stress by much. Several index alternatives gave very strong indications of stress in the Mountain rivers. Of 30 alternatives, those with the highest DEs contained the sunfish taxa metric, which was not selected because it has a low range of values (only one calibration site had more than one taxon). The selected index (**Table 5-14**) had a DE of 76.9 and a *z*-score of 1.61 (**Figure 5-5**). There were no redundant metrics (Pearson r < 0.85).

Only one of three validation stressed sites had an index score lower than the 25th percentile of reference.

Table 5-14. River fish MMI metrics for the non-mountain site class.

Index Metrics	Metric Category	DE	Response
Native Taxa	Richness	61.5	Decreaser
Non-native % of Taxa	Richness	92.3	Increaser
Native Minnow Taxa	Richness	53.8	Decreaser
Piscivore Taxa	Trophic guild	53.8	Decreaser
% Lithophils	Reproduction	53.8	Decreaser
Intolerant Taxa	Tolerance	69.2	Decreaser

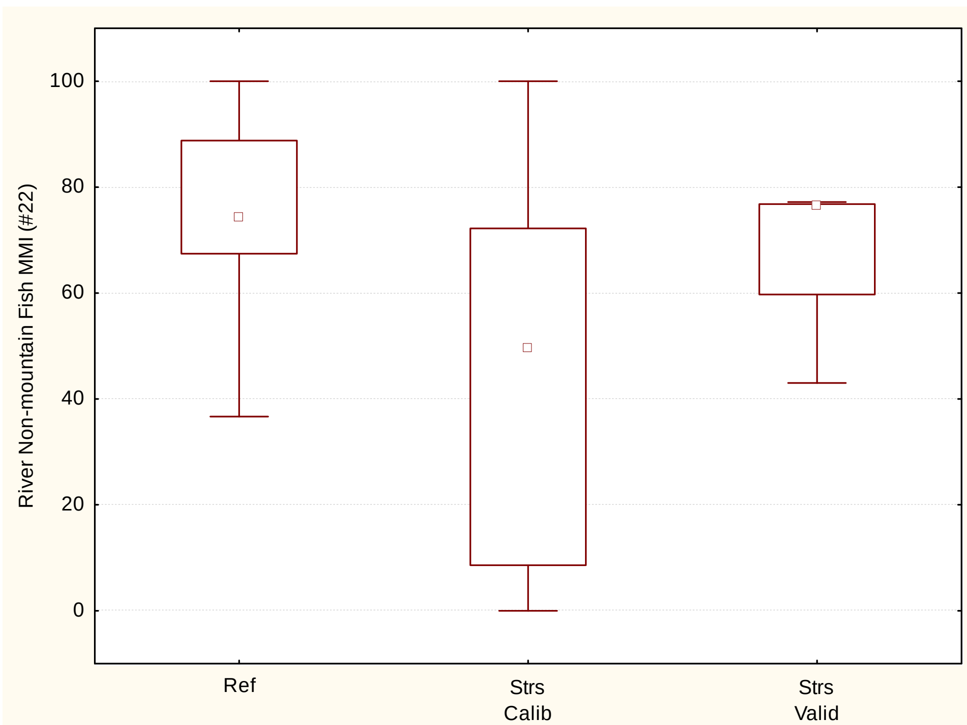

Figure 5-5. River fish index discrimination among reference and stressed conditions in the non-mountain site class, showing both calibration and validation data distributions (medians, interquartile ranges and ranges).

5.5 River Fish MMI Application

The Idaho river fish MMIs should be applied as follows.

1. Determine the appropriate site class for the site using **Table 3-3**.
2. Calculate appropriate MMI metrics.
   Use metric attributes approved by IDEQ (**Appendix J**).
3. Score metrics based on formulae in **Table 5-15**.

Reset scores above 100 or below 0 to 100 or 0, respectively.

4. Calculate the MMI as the average of the metric scores.
5. Report the results.

    Include the MMI scores and MMI DE

    Compare numeric results to impairment thresholds

        (IDEQ to decide on threshold values)

Table 5-15. Fish metric scoring formulae for the Idaho river MMIs**.**

Metrics	Formula
Mountains	
Non-native % of Taxa	100*(44.3 - (*metric value*)) / 44.3
% Suckers	100*(52.1 - (*metric value*)) / 52.1
% Filterers, Omnivores, and Herbivores	100*(70.6 - (*metric value*)) / 70.6
Number Cyprinid Size Classes	100*(3 - (*metric value*)) / 2.2
% Lithophils	100*((*metric value*) – 1.5) / 43.5
Intolerant Taxa	100*((*metric value*)) / 2
Non-mountains	
Native Taxa	100*(*metric value*) / 6
Non-native % of Taxa	100*(95 - (*metric value*)) / 74.4
Native Minnow Taxa	100*(*metric value*) / 1.8
Piscivore Taxa	100*((*metric value*) – 1) / 2.7
% Lithophils	100*(*metric value*) / 24.0
Intolerant Taxa	100*(*metric value*) / 1.3

In the non-mountains, the strongest single metric had a higher DE than the index and could be used to add interpretive value to assessments. The non-native percent of taxa was less than 20% in 75% of reference sites and more than 20% in 90% of stressed sites. Sites with high percentages of non-native taxa are likely stressed. If the index does not concur, assessments may be tentative and the site fish assemblage would deserve further scrutiny.

Some river metrics included in the indices have low ranges of values. These metrics include the number of cyprinid size classes, intolerant taxa, native minnow taxa, and piscivore taxa. This was not preferable, but was acceptable because of limited numbers of responsive metric alternatives.

6.0 Idaho Stream Habitat

The habitats of the streams and rivers in Idaho can be degraded through intensive human activities that alter flows, channels, or sediment supplies. Aquatic biota often occupy specialized habitat niches and they are therefore sensitive to reductions in habitat complexity. The habitat index was developed in parallel with the biological indices, using many of the same analytical techniques and some common analytical results. For instance, reference site criteria were as defined for the biological indices. Site classification was re-examined for habitat types and only slightly modified from the stream biological classes to include a new class; systems dominated by pool-glide channel morphology.

Index development proceeded for riffle-run dominated sites (RR), subsets of RR sites (Mountains, Foothills, and PPBV), and for pool-glide dominated sites (PG), as discussed under site classification (Section 3.6). The small RR sites (wetted width <0.7m) were not used in index calibration. Each group was divided into calibration and validation data sets, with validation reserved as an independent measure of index performance. Sample sizes were as listed in **Table 6-1**.

Table 6-1. Reference/stressed and calibration/validation samples used for habitat index development.

Dataset	Ref - Cal	Ref - Val	Stressed - Cal	Stressed - Val
Riffle/Run (All)	285	71	91	22
RR-Mountains	221	56	38	9
RR-Foothills	34	9	18	4
RR-PPBV	29	7	35	9
Pool/Glide	15	4	24	6

6.1 Data preparation

Based on the same reference criteria used in stream biological assessments (Section 2.1), sites with valid data for habitat analysis included 381 reference, 154 stressed, and 2663 other sites. Most of the habitat variables used in this exercise were the same as those considered during development of the SHI (Fore and Bollman 2002). The definition of fine substrates changed slightly (<2.5 mm, previously <2 mm), but the other measurements were consistently reported. Habitat variables specific to pools were also considered, which were not used in the SHI calculations. The initial list of 40 habitat variables was reduced to 29 variables after checking for redundancy (**Table 6-2**). Eleven (11) of the variables were considered redundant because they were reported first as a 'raw' value (which was either the direct measurement or a subjective habitat assessment score), and second as the score (typically on a scale of 0-10) based on the raw value and the SHI scoring criteria. In these situations, we only used the raw value (e.g., WolmanRaw), instead of the adjusted score (e.g., WolmanScore) so that the more objective measurements were analyzed.

The habitat variables were categorized into seven types of measures, including streambanks, canopy cover, hiding cover, channel shape, pool measures, riparian condition, and substrates. Each variable was examined for trends with increasing impairment and in most cases the trend was decreasing habitat variable values with increasing site disturbance. The substrate measures of percent fines increased with increasing stress. Variable scoring followed methods described for biological metrics, with the 95th percentile of all data defining the best possible score on a 0 to 100 scale. The percent fines variables were scored in an opposite fashion, with the 5th percentile set as optimal and the 95th percentile as the worst.

6.2 Habitat Variable Discrimination

Habitat variables discriminated reference and stressed sites to variable degrees, depending on the data subset (**Table 6-3**). Many variables discriminated well in pool-glide sites, with at least one variable in each category having a DE greater than 50% (except for the pool variables). In all riffle-run sites, half of the variable categories had at least one highly discriminating variable, while no variables in the banks, canopy, or channel shape categories had DE > 50%. In the individual site classes, the Foothills variables performed worst, with the percent fines variables responding opposite of expectations.

6.3 Index Trials and Evaluation

The first combinations of variables used the best performing variable from each variable category. Variable scores were averaged to arrive at an index value for each site. Subsequent index alternatives were calculated by substituting, adding, or removing variables to make new combinations. Each index was evaluated using the DE and z-score of the index. The variables included in the SHI were used in one index alternative for each data set.

Table 6-2. Habitat variables used in the analysis. Variables in the existing SHI are shown in bold-type.

Variable	Description	Variable Type	Units	Derivation
TOTPOOLS	Total number of pools	Pools	#	Measured
AvPoCOVER	Overhead cover (averaged across 1-4 pools in the sampling reach)	Pools	%	Estimated
AvPoLENGTH	Pool length (averaged across 1-4 pools in the sampling reach)	Pools	m	Measured
AvPoMAXDEPTH	Maximum pool depth (averaged across 1-4 pools in the sampling reach)	Pools	m	Measured
AvPoMAXWIDTH	Maximum pool width (averaged across 1-4 pools in the sampling reach)	Pools	m	Measured
AvPoPTOUT	Pool tail out depth (averaged across 1-4 pools in the sampling reach)	Pools	m	Measured
AvPoRESDEPTH	Residual depth (averaged across 1-4 pools in the sampling reach)	Pools	m	Measured
AvPoSUBCOVER	Submerged cover (averaged across 1-4 pools in the sampling reach)	Pools	%	Estimated
AvPoSUBSIZE	Predominant substrate size (averaged across 1-4 pools in the sampling reach)	Pools	mm	Measured
AvPoUCBANK	Undercut banks (averaged across 1-4 pools in the sampling reach)	Pools	%	Estimated
AvUndercutBanks	Horizontal distance of undercut banks (averaged across left and right banks at 3 locations)	Pools	Proportion	Measured
BankCoverPercent	Bank vegetation cover (sum of covered stable and unstable, averaged across left and right banks)	Banks	%	Estimated
BankStabPercent	Bank stability (sum of covered and uncovered stable, averaged across left and right banks)	Banks	Proportion	Estimated
CanopyRaw	Canopy closure, averaged across 4 measurements (left bank, center up, center down, right bank) taken at 3 riffles	Canopy	%	Measured
CSHAPERaw	Channel shape. Scored on a scale of 0-15, based on predominant channel shape and mean bank angle as illustrated in the habitat assessment data sheet.	Channel shape	Score	Subjective scoring

Variable	Description	Variable Type	Units	Derivation
EMBEDRaw	Embeddedness (in riffles), scored on a scale of 0-20. Sites with low embeddedness (<25%of gravel, cobble and boulder particles are surrounded by fine sediment (particles less than 6.5 mm) = highest score, >75% surrounded by fine sediment, or sand, clay or bedrock bottom =lowest score). See habitat assessment data sheet for more guidance.	Substrate	Score	Subjective scoring
LODRaw	Number of large organic debris pieces > 10 cm in diameter and 1 m in length, within bankful	Cover	#	Measured
PctFinesBF	Percent fines (<2.5 mm) within bankful width (derived from Wolman pebble count averaged across 3 riffles)	Substrate	%	Measured
PctFinesWW	Percent fines (<2.5 mm) within wetted width (derived from Wolman pebble count averaged across 3 riffles)	Substrate	%	Measured
PoolRiffleRatio	Pool:riffle ratio, the ratio of lengths of summed pool and glide habitats to length of riffle and run habitats	Channel shape	ratio	Measured
POOLSUB	Pool substrate characteristics, scored on a scale of 0-20. Sites with mixtures of substrate materials and prevalent gravel and firm sand, root mats and submerged vegetation common=highest score; hard-pan clay or bedrock, no root mats or submerged vegetation=lowest score.	Pools	Score	Subjective scoring
POOLVAR	Pool variability, scored on a scale of 0-20. Even mix of deep, shallow, large and small pools=highest score; majority of pools small and shallow, or pools absent=lowest score.	Pools	Score	Subjective scoring
SinuScore	Sinuosity. Categorical, scored on a scale of 0-14 (low=2; braided=6; moderate=10; high=14)	Channel shape	Score	Subjective

Variable	Description	Variable Type	Units	Derivation
STREAMCORaw	Instream cover (for fish). Greater than 50% mix of cobble, gravel, woody debris, undercut banks, or other stable fish cover=highest score; less than 10% coble, gravel or other stable fish cover, lack of cover is obvious=lowest score.	Cover	Score	Subjective scoring
VelDepScore	Velocity and depth ratio. Scored on a scale of 0-18.	Channel shape	Score	Measured
WDRatio	Ratio of average width to average depth (averaged across 3 locations along stream reach; for depth, 3-7 measurements are taken at each location, depending on wetted width). As channels became wider and shallower, the ratio increases; as they become narrower and deeper, it decreases.	Channel shape	ratio	Measured
WolmanRaw	Number of Wolman size classes, averaged across 3 riffles. Derived from Wolman pebble counts.	Substrate	#	Measured
DISPRES	Disruptive pressures (on streambank, immediately adjacent to stream), scored on a scale of 0-10. Highest score=minimal vegetative disruption, almost all potential plant biomass at present state of development remains; lowest score=disruption of streambank vegetation is very high, less than 30% of the potential plant biomass remains.	Riparian	Score	Subjective scoring
ZONEINFL	Zone of influence (width of riparian vegetative zone, least buffered side), scored on a scale of 0-10. Highest score=width of riparian vegetative zone (on each side) is at least 4 times the width of the stream, with no impacts from human activities; lowest score=little or no riparian vegetation due to man induced activities.	Riparian	Score	Subjective scoring

Table 6-3. Discrimination efficiency (DE) of habitat variables in data subsets. Variable codes are as in Table 6-2.

Variable	Riffle-run	Mtns	FtHlls	PPBV	Pool-glide
TOTPOOLS	0.0	0.0	0.0	67.9	0.0
AvPoMAXDEPTH	52.7	57.1	17.6	39.3	23.3
AvPoMAXWIDTH	47.3	37.1	17.6	42.9	26.7
AvPoPTOUT	46.2	42.9	29.4	25.0	23.3
AvPoRESDEPTH	50.5	40.0	17.6	60.7	30.0
AvPoSUBSIZE	64.8	54.3	41.2	42.9	33.3
AvPoCOVER	49.5	42.9	58.8	42.9	20.0
AvPoUCBANK	30.8	22.9	47.1	35.7	30.0
AvPoSUBCOVER	38.5	37.1	23.5	46.4	33.3
AvPoLENGTH	36.3	31.4	17.6	32.1	26.7
AvUndercutBanks	0.0	0.0	0.0	40.0	50.0
BankCoverPercent	41.8	31.6	27.8	68.6	13.3
BankStabPercent	44.0	31.6	33.3	60.0	60.0
CanopyRaw	47.3	39.5	44.4	51.4	50.0
CSHAPERaw	36.3	44.7	66.7	14.3	56.7
EMBEDRaw	54.9	36.8	44.4	51.4	0.0
LODRaw	63.7	63.2	33.3	0.0	76.7
PctFinesBF	61.5	42.1	16.7	68.6	83.3
PctFinesWW	61.5	39.5	16.7	71.4	83.3
PoolRiffleRatio	38.5	42.1	27.8	34.3	40.0
POOLSUB	0.0	0.0	0.0	0.0	83.3
POOLVAR	0.0	0.0	0.0	0.0	56.7
SinuScore	0.0	0.0	0.0	0.0	40.0
STREAMCORaw	70.3	52.6	61.1	80.0	76.7
VelDepScore	30.8	31.6	27.8	31.4	80.0
WDRatio	44.0	42.1	27.8	31.4	53.3
WolmanRaw	47.3	39.5	27.8	37.1	53.3
DISPRES	65.9	76.3	44.4	68.6	90.0
ZONEINFL	62.6	65.8	61.1	65.7	86.7

The indices were also evaluated for ease of application, variety of metrics, and correlation to the biological indices. For ease of application, the recommended indices were selected after consideration of the trade-offs between the simplicity of fewer index formulations and incremental improvements in the index performance when using site-class-specific index f ormulations. We assume that a great variety of metrics will result in an index that is responsive to many types of habitat degradation. However, some of the index alternatives that were most responsive to stress had relatively few metrics.

Correlations of candidate indices and the biological indices was conducted to determine whether the habitat measures were associated with biological conditions. The strengths of these correlations were used to select indices. The association of biological and habitat conditions was informative regarding effects of habitat and other stressors in the systems, but these correlations were only in reference and stressed sites, not in all sites. Therefore, the greater value in the correlation analysis is the comparison among indices to guide index selection.

Correlation analysis among habitat variables revealed that redundancy among variables was not an issue in selecting index alternatives. The only redundant variables (Spearman r >0.80) were also conceptually redundant and would not be selected for use within the same index trial. For instance, percent fines measured in the wetted channel were highly correlated with percent fines measured in the bankfull channel. These two variables are conceptually equivalent and would not be used in any single index alternative. Similar redundancy was observed among variables within the pool category.

Habitat Index Results

With each set of data, 22-45 different combinations of habitat variables were tested (**Appendix K**). The combinations included between 4 and 10 variables each. The best DEs in the datasets ranged from 88-100% and the best z-scores were from 2.3 to 4.1 units. When selecting index alternatives that would be best for application in Idaho streams, the following characteristics were considered; DE, z-score, representation of variable categories, common responses among regions, and relationships with biological indices. Some of the index alternatives that were best at discriminating reference and stressed sites were not necessarily those with representation of all variable categories or those with the strongest relationships with the macroinvertebrate and fish indices.

The index alternative that includes all the variables in the existing SHI (but scored on a 0-100 scale) was most strongly and consistently related to the currently recommended biological indices in the riffle-run site classes (**Table 6-4**). Correlations to the PPBV fish index were all insignificant. Correlations in the pool-glide streams were not significant for any of the habitat or biological indices, possibly due to a low sample size.

Table 6-4. Correlations (Pearson r) between five possible habitat indices and the currently recommended macroinvertebrate and fish MMIs. Significance of the correlation is as follows; p<0.001 (***), p<0.01 (**), p< 0.05 (*).

Biological Index	SHI	BestOfCat	PPBVbest	MtnBest	FHbest
BenthicMMI-Mtns	0.51***	0.49***	0.47***	0.53***	0.40***
BenthicMMI-FtHlls	0.59***	0.50***	0.33*	0.50***	0.56***
BenthicMMI-PPBV	0.69***	0.66***	0.60***	0.69***	0.51***
FishMMI-Mtns	0.40***	0.23**	0.35***	0.38***	0.41***
FishMMI-FtHlls	0.50**	0.58**	0.43*	0.43*	0.54**
FishMMI-PPBV	0.18	0.19	0.09	0.17	0.02

The SHI and other indices were responsive to stress when evaluated in all riffle-run sites. However, when sites are categorized by site class, the expectations for reference are different among the site classes (**Figure 6-1**). This suggests that the refined classification could give more accurate assessment results.

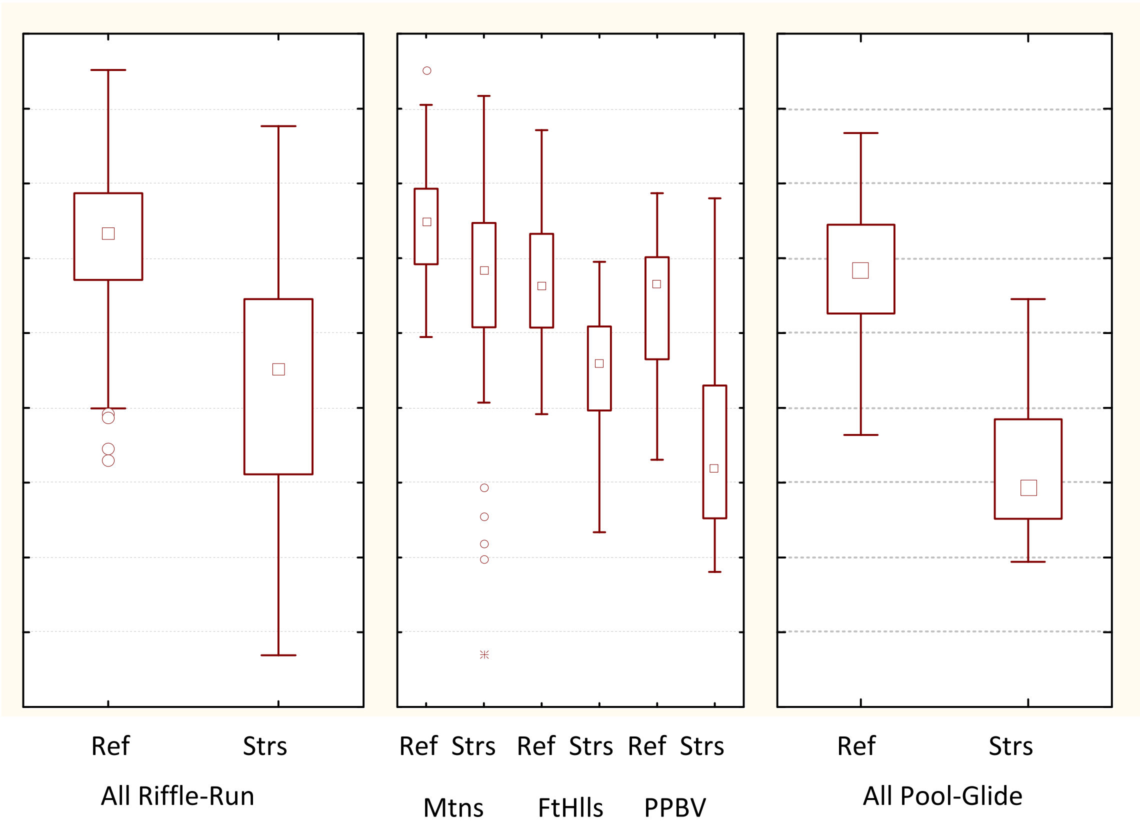

Figure 6-1. SHI values in subsets of calibration data.

The SHI and indices that performed best in each site class were compared across all site classes to determine whether selection of a single set of habitat measures would perform well in all site classes (**Table 6-5, Appendix K**). The combination first identified as an excellent performer in the PPBV had the highest z-score in all but the Foothills site class. It included stream cover, percent fines in the wetted channel, percent bank cover, disturbance pressure, and zone of influence. In the Foothills, the PPBV combination performed much worse than the best Foothills alternative, which included stream cover, channel shape, disturbance pressure, and zone of influence.

Table 6-5. Index combinations including SHI measures and the best performers in each site class (riffle-run sites only).

Habitat Measure		SHI	MtnBest	FHbest	PPBVbest	RRbest
Instream cover		X	X	X	X	X
Large organic debris		X	X			
Percent fines in wetted channel		X	X		X	X
Embeddedness		X	X			
WolmanRaw		X	X			
Percent Bank Cover		X	X		X	X
Pool substrate size						X
Channel shape		X		X		X
Canopy closure		X	X			X
Disruptive pressures		X	X	X	X	X
Zone of influence		X	X	X	X	
Region	**Remarks**	**SHI**	**MtnBest**	**FHbest**	**PPBVbest**	**RRbest**
Riffle-Run	DE25	83.5	81.3	76.9	**86.8**	85.7
	z-score	2.16	2.22	2.19	**2.74**	2.15
Mountains	DE25	81.6	**86.80**	73.7	84.2	77.4
	z-score	2.19	2.28	2.26	**2.59**	1.73
Foothills	DE25	72.2	55.6	**88.90**	61.1	55.6
	z-score	1.25	0.98	**2.01**	1.27	0.98
PPBV	DE25	80.0	82.9	80.0	85.7	**92.9**
	z-score	1.88	2.11	1.85	**2.77**	2.02
Pool-Glide	DE25	95.8	95.8	95.8	**100.0**	91.7
	z-score	3.00	2.96	3.14	**4.72**	3.24

A potential habitat index application option would be to consider two indices in each site class. One would be most responsive to the reference/stressed gradient and the second would be most correlated to the biological indices. The newly developed indices in each site class would give an indication of general agreement with site reference status. These would include the PPBV (Habitat 1) index for all site classes but the Foothills, where the Foothills index would be applied. The SHI is related to the biological indices, performs adequately with respect to DE and z-score in all site classes, includes measures of many aspects and scales of aquatic habitat influences, and offers continuity with past assessments.

Habitat measures were scored as described for benthic macroinvertebrates, where the 95th percentile of distributions for each measure was considered optimal and scored as 100 points. Though indices are common among site classes, they are presumed to be more sensitive when scored specifically for each class, as in **Table 6-6**. The SHI could be scored as currently formulated (see Fore and Bollman 2002). The current SHI formulation performs almost identically to the SHI scored as in Table 6-6 in the Mountains and the PPBV. Compared to the new formulation, the old SHI formulation has a higher DE in the Foothills and a lower DE in Pool-Glide sites.

Table 6-6. Habitat index measures and scoring formulae.

	Mountains	Foothills	PPBV	Pool-Glide
Hab Index 1				
STREAMCORaw	X/19	NA	X/18	X/18
PctFinesWW	(33.8-X)/33.8	NA	(86.2-X)/77.4	(100-X)/90.5
BankCoverPercent	X/100	NA	X/100	X/100
DISPRES	X/10	NA	X/9	X/10
ZONEINFL	X/10	NA	X/8	X/9
Hab Index 2				
STREAMCORaw	NA	X/19	NA	NA
CSHAPERaw	NA	X/12	NA	NA
DISPRES	NA	X/10	NA	NA
ZONEINFL	NA	X/10	NA	NA
SHI				
STREAMCORaw	X/19	X/19	X/18	X/18
PctFinesWW	(33.8-X)/33.8	(42.6-X)/42.6	(86.2-X)/77.4	(100-X)/90.5
BankCoverPercent	X/100	X/100	X/100	X/100
LODRaw	X/124	X/76	X/48	X/85.6
CSHAPERaw	X/13	X/12	X/9	X/12
CanopyRaw	X/92.5	X/96.5	X/96	X/66.5
WolmanRaw	X/11	X/11	X/10	X/10
EMBEDRaw	X/19	X/18	X/18	X/16
DISPRES	X/10	X/10	X/9	X/10
ZONEINFL	X/10	X/10	X/8	X/9

Notes: "X" represents the observed value for the metric being scored. Formulae results should be expressed as percentages (multiplied by 100). Scores outside of the 0-100 range should be re-set to the nearest extreme of the range before being averaged into the index.

Riffle-Run Mountains

In Riffle-Run Mountain sites 31 different metric combinations were tested. Validation data performed as expected to confirm that the five measure habitat index 1 was robust (validation DE = 77.8%) (**Figure 6-2**). Validation for the SHI was more than adequate for reference sites, but only 55% of validation stressed sites had SHI index values below the 25th percentile of reference.

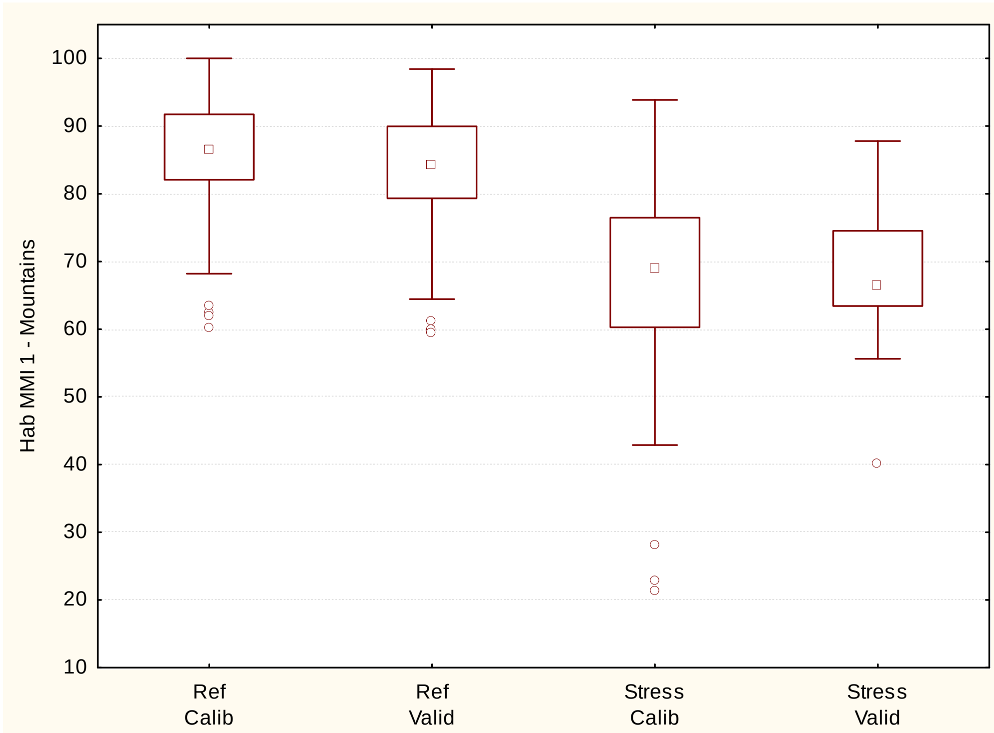

Figure 6-2. Index values in reference and stressed calibration and validation sites in the Mountain Riffle-Run sites.

Riffle-Run Foothills

In Riffle-Run Foothills sites 47 different metric combinations were tested. Validation data performed as expected to confirm that the four measure habitat index 2 was robust (validation DE = 75%) (**Figure 6-3**). Validation for the SHI was adequate for reference sites, but only 44% of validation stressed sites had SHI index values below the 25th percentile of reference.

Riffle-Run PPBV

In Riffle-Run PPBV sites 32 different metric combinations were tested. Validation data performed as expected to confirm that the five measure habitat index 1 was robust (validation DE = 88.9%) (**Figure 6-4**). Validation for the SHI was more than adequate for reference and stressed sites.

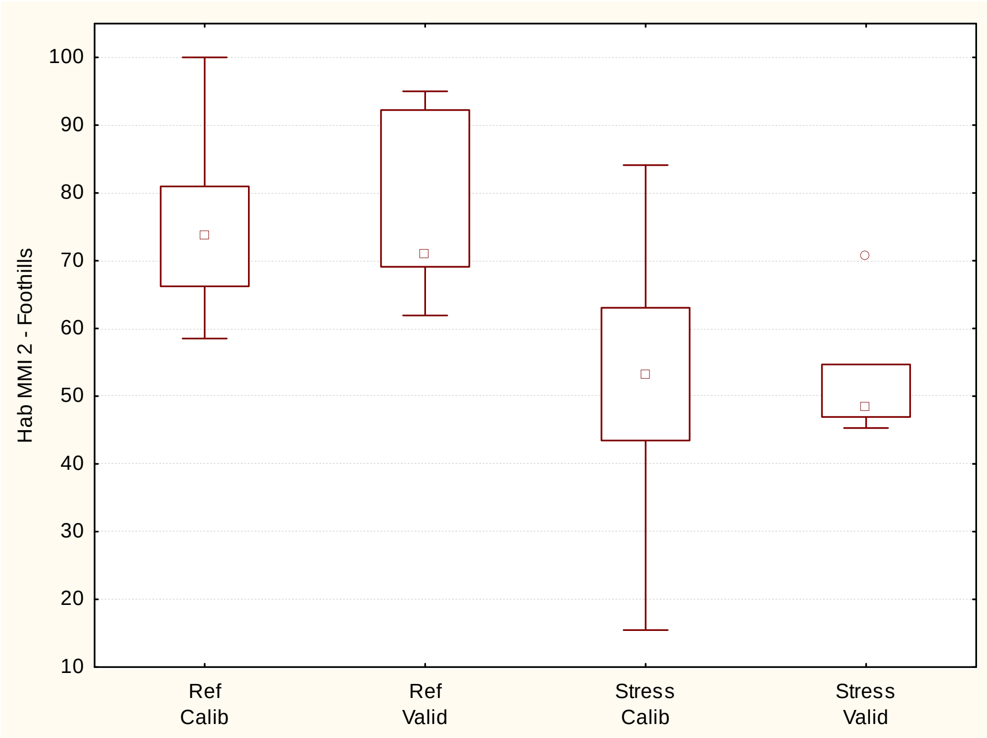

Figure 6-3. Index values in reference and stressed calibration and validation sites in the Foothills Riffle-Run sites.

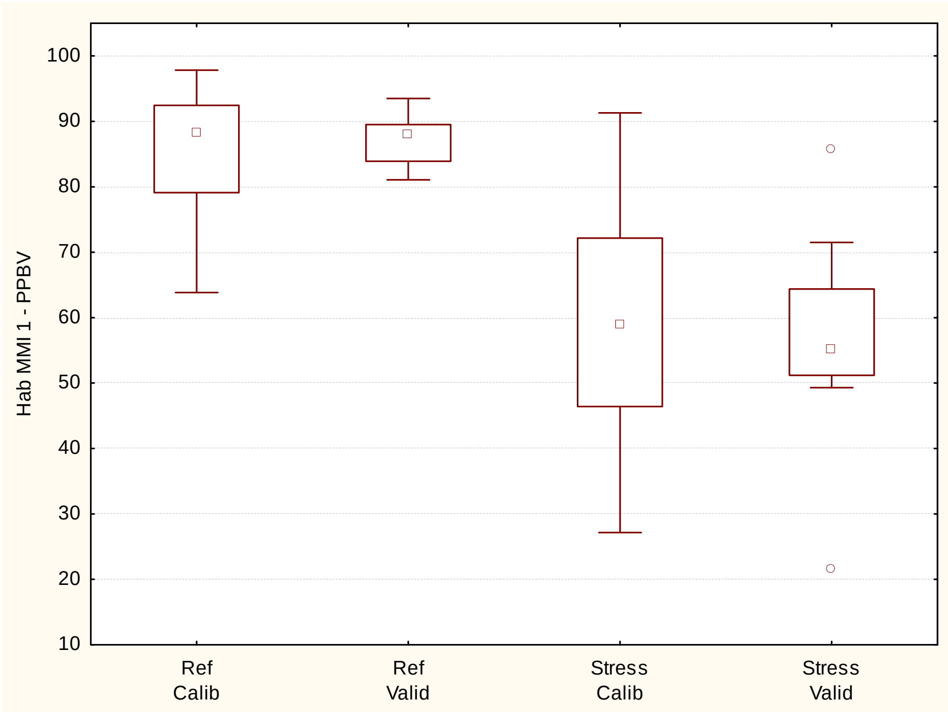

Figure 6-4. Index values in reference and stressed calibration and validation sites in the Foothills Riffle-Run sites.

Pool-Glide

In Pool-Glide sites 36 different metric combinations were tested. Validation data performed as expected to confirm that the five measure habitat index 1 was robust (validation DE = 100%) (**Figure 6-5**). Only one of four reference validation sites were greater than the 25th percentile of reference, but these were still higher than most of the stressed site values. Validation for the SHI was more than adequate for reference and stressed sites.

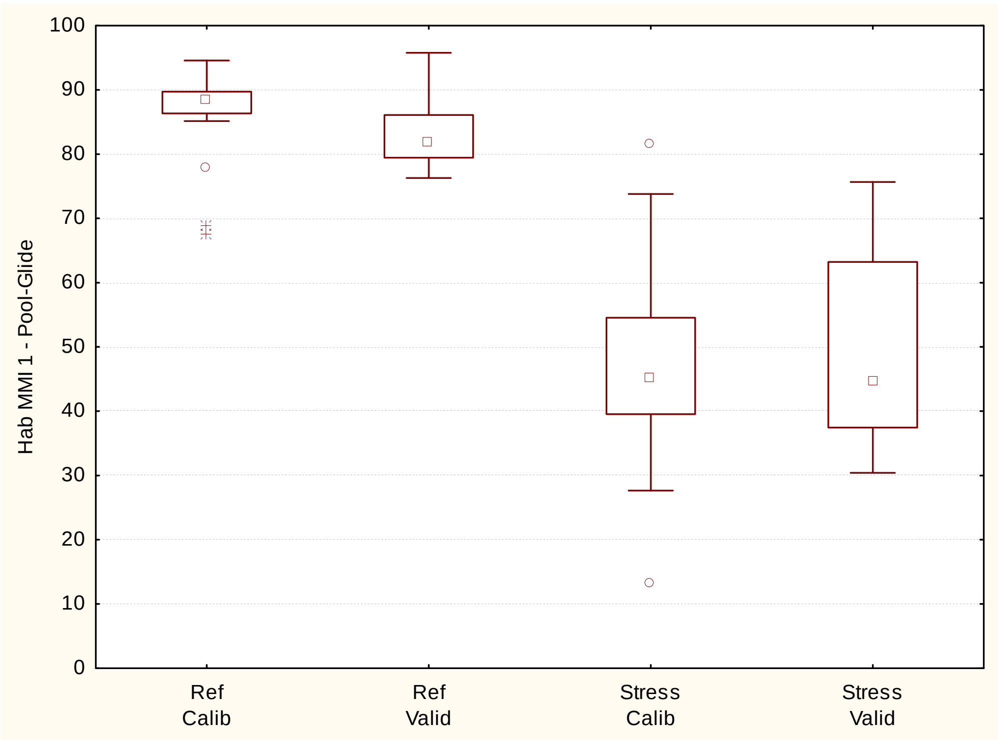

Figure 6-5. Index values in reference and stressed calibration and validation sites in the Pool-Glide sites.

7.0 Discussion and Conclusions

The preceding analyses resulted in multiple indices for assessing biological and habitat conditions in streams and rivers in Idaho. The indices provide tools for assessing streams and rivers throughout Idaho for reporting ecological integrity as required in the Clean Water Act sections 305(b) and 303(d). Performance characteristics of the indices reveal that most had an acceptable level of error in discriminating reference from non-reference conditions. The manner in which the indices are translated into impairment ratings and combined for waterbody assessments was not determined. Threshold analyses are recommended to identify break-points in the biological indicators that would be potential thresholds. Such analyses might include plots of indices along the gradients of individual stressors, change-point analyses, or quantile regression.

In the index summary (**Table 7-1**), the 25th percentile of reference is listed as one possible threshold. At this threshold, 75% of reference sites are correctly assessed above the threshold and the DE is the number of stressed sites assessed correctly below the 25th percentile of reference. Because of the differences in reference criteria (generally accepting more intensive land uses in reference sites of the plains ecoregions), the same threshold may not be appropriate in all regions.

Table 7-1. Index Summary.

Benthic Macroinvertebrates		
MMI – Streams		
Mountains	*Foothills*	*PPBV*
DE: 73%	DE: 71%	DE: 85%
Reference 25th %ile: 63.6	Reference 25th %ile: 53.8	Reference 25th %ile: 62.1
Metrics:	Metrics:	Metrics:
Total Taxa	EPT taxa	Simpson's index
EPT Taxa	Non-insect % of taxa	% non-insects
% Ephem. & Plecoptera	% EPT, excl. Hydropsych.	% filterers
% filterers	Scraper taxa	% tolerant
HBI	Tolerant taxa	% clingers
Clinger taxa	Sprawler taxa	Semi-voltine taxa
Semi-voltine taxa		

Table 7-1. Continued.

Benthic Macroinvertebrates	
MMI – Rivers	
Mountains	*Non-mountains*
DE: 70%	DE: 92.7%
Reference 25th %ile: 63.9	Reference 25th %ile: 68.1
Metrics:	Metrics:
EPT Taxa	Insect Taxa
% EPT	Non-insect % of Taxa
% Chironomidae	% Ephemeroptera
% Predators	% Scrapers
Swimmer & Climber Taxa	Sprawler Taxa
Becks Biotic Index	% Tolerant
Semi-voltine Taxa	% Multivoltine
O/E – Streams	**O/E – Rivers**
Reference RMSE: 0.16 index units	Reference RMSE: 0.16 index units
Number of cluster groups: 11	Number of cluster groups: 3
Predictors:	Predictors:
Longitude	Mountain site class
Latitude	River order
Julian day	Precipitation
Elevation	Average wetted width
Average bankfull width	Maximum air temperature

Fish		
MMI – Streams		
Mountains	*Foothills*	*PPBV*
DE: 78%	DE: 84.6%	DE: 86.7%
Reference 25th %ile: 82.8	Reference 25th %ile: 89.2	Reference 25th %ile: 77.7
Metrics:	Metrics:	Metrics:
Native Taxa	Minnow Taxa	Native Taxa
Individuals per native taxon	Salmon & Sculpin % of Taxa	Non-native % of Taxa
% invertivores	Benthic Taxa	% Minnow Individuals
% lithophilic spawners	% Minnow Individuals	% Lithophilic Spawners
% native intolerants	% Moderately Tolerant	% Invertivores
	% filterer/omnivore/herbivore	% Piscivores

Table 7-1. Continued.

Fish		
MMI – Rivers		
Mountains DE: 100% Reference 25th percentile:84.6 Metrics: Non-native % of Taxa % Suckers % filterer/omnivore/herbivore Number Cyprinid Size Classes % Lithophils Intolerant Taxa		*Non-mountains* DE: 76.9% Reference 25th percentile: 67.4 Metrics: Native Taxa Non-native % of Taxa Native Minnow Taxa Piscivore Taxa % Lithophils Intolerant Taxa
Habitat		
MMI – Streams		
All Classes – SHI DE: 72.2-95.8% Reference 25th %ile: Metrics: STREAMCORaw PctFinesWW BankCoverPercent LODRaw CSHAPERaw	 CanopyRaw WolmanRaw EMBEDRaw DISPRES ZONEINFL	*Pool-Glide* DE: 100% Reference 25th %ile: Metrics: STREAMCORaw PctFinesWW BankCoverPercent DISPRES ZONEINFL
Mountains (Riffle-Run) DE: 84.2% Reference 25th %ile: 80.8 Metrics: STREAMCORaw PctFinesWW BankCoverPercent DISPRES ZONEINFL	*Foothills (Riffle-Run)* DE: 88.9 Reference 25th %ile: 66.2 Metrics: STREAMCORaw CSHAPERaw DISPRES ZONEINFL	*PPBV (Riffle-Run)* DE: 85.7% Reference 25th %ile: 79.1 Metrics: STREAMCORaw PctFinesWW BankCoverPercent DISPRES ZONEINFL

The data provided by IDEQ and the EPA EMAP were of high integrity. Gathering the multiple layers of data in a relational database for this study was an intensive effort for reformatting and combining data from multiple assemblages, multiple sampling programs, and new GIS analyses. While this data management task is never simple, there may be ways to streamline the process in the future. A relational database that has capacity for multiple data types and functionality for data manipulation (metric and index calculation) would be ideal. Querying, outputting, and reporting all data pertaining to biological assessments could be accomplished in a relational database. Having all the data in one place would also simplify application of quality controls. This centrally organized database should also include remotely sensed data (GIS).

Quality control for data processing was not evaluated, so the following comments may already have been addressed in the IDEQ programs. Data entry should be as complete as possible. In some cases, data were apparently missing. In other cases, values of zero were suspected of displacing missing data. The habitat pool data were apparently incomplete and suspect. Quality controls should be in place for field sheet completeness, data entry accuracy and completeness, and database maintenance. IDEQ expressed uncertainty in the some of the fish sampling variables, especially those pertaining to effort expended on sample collection. These aspects of fish sampling should be performed and recorded consistently and accurately. Many of the habitat variables are ratings based on site observations. These qualitative measurements require frequent trainings and cross validation among sampling crews to ensure precise ratings. The benthic macroinvertebrate target sub-sample size was frequently missed. Picking individuals from the sampling residue should be performed with greater attention to the target size and with improved methods for attaining the target.

Precision of an index is affected by error in sampling and variability over time or seasons. Through this study, the indices were associated with performance statistics regarding accuracy of the index values relative to the site reference status (the DE) for the MMIs and precision among reference calibration sites for the O/E. These statistics are valuable in communicating expectations for accuracy in future assessments, where accuracy is expressed as the agreement between index results and reference or stressed status. However, index precision over sampling events in the same waterbody should be determined through replicate sampling analysis. The expectation for arriving at the same results repeatedly at a site would give a performance statistic that could be used to interpret single or multiple index results. For instance, difference in index results over time at the same site could be attributed to real community changes or sampling error if the magnitude of sampling error was known. This would be valuable for evaluating restoration effectiveness after a TMDL implementation.

An attempt was made to identify reference sites throughout Idaho so that assessed waterbodies would be in relatively close proximity to the reference sites that generate the reference conditions to which they are compared. Human disturbance intensity varies among the ecoregions of Idaho, which was recognized in this analysis by varying the reference and stressed site criteria across regions. This approach is justified if the reference conditions are adequately communicated as representing the best available conditions (Stoddard et al. 2006). The concept of best available conditions should be well understood when establishing thresholds for any of the indicators. In those regions where the best available conditions are close to true ecological integrity, establishment of thresholds for comparison to reference should consider that a large proportion of the sites are true reference. In areas where the best available conditions have minimal or greater disturbance, thresholds may result in greater Type 1 error (where sites are assessed as impaired when they are categorized as reference). The Biological Condition Gradient (BCG; Davies and Jackson 2006) is a standardized scale to which the reference conditions in Idaho could be calibrated, which would add interpretive value to any biological thresholds established for the indices.

Future sampling could be planned to target areas that are not well represented by reference or stressed sites. In the more developed plains, plateaus, and broad valleys, reference sites could be targeted through GIS analysis or other means to identify sites with minimal disturbance. In the rugged and inaccessible mountain areas, true stressed sites are less common and could be targeted. Sampling to better characterize the extremes of conditions in all site types will allow more comprehensive interpretation of existing indices and better calibration of new indices.

Taxonomic identifications and attributes are the basis of metric calculations. Quality controls for field and laboratory sample processing should be in place so that the accuracy of macroinvertebrate and fish identifications can be quantified. In addition, the attributes associated with the taxa should receive attention. These attributes have been established through consensus of multiple taxonomists, literature, and databases. Because the fish community is not necessarily diverse even in the best streams in Idaho, it is important to assess aspects of the community other than community richness. Therefore, the taxa attributes take on greater importance. The western EMAP fish attributes that were consulted for augmenting IDEQ attributes were shown to provide effective assessments (Pont et al. 2009, Whittier et al. 2007). Other sources and other attributes could be incorporated into Idaho's taxa lists to allow accurate calibration of metrics.

The rivers dataset was collected by two agencies with distinct protocols for habitat measures. Therefore, there were few habitat variables that were collected at sufficient numbers of sites for calibrating a river habitat index. Future river sampling should include either the universal list of habitat variables or a large part of it.

Small reference streams were apparently different than larger streams in their habitat characteristics. However, there was some question regarding the reference quality of some of the small streams. There were not enough small reference streams to calibrate a habitat index specific to them. Small streams should be targeted in the future to compile a dataset large enough to first determine their uniqueness, then to calibrate a habitat index if needed.

Pool variables in streams were not consistently recorded in our analytical dataset. There were missing data for several of the pool variables. In addition, IDEQ was not confident that an average of some of the pool variables would result in meaningful characterizations of the pools in a reach. This is partly due to the protocol for selecting pools to sample, which encourages selection of varied pool types. In future sampling, pool variables should be completely recorded, checked after data entry, and summarized meaningfully for the reach. For instance, the maximum of maximum pool depth might be more meaningful than the average of maximum pool depths.

Sediment measures in streams were based on Wolman pebble counts. While these are accurate and informative regarding the observed sediments, more detailed measures would allow calculation of expected sediment conditions. The Relative Bed Stability (RBS) index has proven an effective tool for determining impairment due to excessive sediment (Kauffman et al. 2008, Jessup et al. 2010). The more detailed measurements required for calculating RBS are incorporated into standard EMAP sampling protocols (Lazorchak et al. 1998). IDEQ should weigh the cost of additional field sampling (one half to one hour increased sampling time per site) against the value of the information (for causal assessments related to sediments).

There are two ways to score the SHI: as previously formulated (Fore and Bollman 2002) and as suggested in Table 6-6 of this report. The advantage of using the earlier formulation would be continuity in habitat assessments over time. The advantage of switching to the new formulation would be better calibration to the site classes. In addition, compared to the old formulation, the new formulation results in a higher DE in the Pool-Glide sites and a lower DE in Foothills.

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Appendix A
Analytical Datasets
(electronic copy only)

Appendix B

GIS Data

Appendix B
GIS Data Layers

Table B-1. Site-specific and catchment-wide variables analyzed using GIS.

Category	Site-specific	Description	Source
SiteID	BURPID	Station ID	ID DEQ
Location	DD_LONG	Longitude in decimal degrees	ID DEQ
	DD_LAT	Latitude in decimal degrees	ID DEQ
	In_Idaho	yes=lat/longs place the site within the Idaho boundary. no=site is located outside the state boundary.	Tetra Tech analysis
	Caution_Canada	Blank=sites entirely within the US. Yes=sites with substantial portions of the catchment in Canada. Maybe=sites mostly in the US.	Tetra Tech analysis
Hydrography	Dr_Area	Upstream catchment area (km2)	ID DEQ
	STREAM	Stream name	ID DEQ
	BASIN	Basin	ID DEQ
	ORDER	Strahler Order	ID DEQ
Elevation	MELEV	Elevation	ID DEQ
Ecoregion	LEVEL4	EPA Level 4 Ecoregion (number)	ID DEQ
	LEVEL4_NAM	EPA Level 4 Ecoregion (text)	ID DEQ
	LEVEL3	EPA Level 3 Ecoregion (number). There are 10 level 3 ecoregions.	ID DEQ
	LEVEL3_NAM	EPA Level 3 Ecoregion (text)	ID DEQ
	FEOW_Name	Freshwater ecoregions of the world (FEOW).	http://www.feow.org.
Climate	ISO_VAL	Mean annual precipitation (in inches) from 1961-1990	ID DEQ
	PRISM_ppt14_mm	PRISM average annual precipitation (1971-2000). Units = mm.	http://www.prism.oregonstate.edu/
	PRISM_tmin14_C	PRISM average annual minimum air temperature (1971-2000). Units = deg C.	http://www.prism.oregonstate.edu/

	PRISM_tmax14_C	PRISM average annual maximum air temperature (1971-2000). Units = deg C.	http://www.prism.oregonstate.edu/
Population Density	POP04_SQMI	The 2004 estimated population of the block group per square mile. Value represents the US Census block group that the site is located in. A block group is a combination of census blocks that is a subdivision of a census tract. A block group consists of all blocks whose numbers begin with the same digit in a given census tract. The block group is the lowest level of geography for which the Census Bureau has tabulated sample data in the 2000 census.	ID DEQ
Geology	Maj_Lith	Major bedrock lithologic unit that the site is located in. I entered 'NA' for sites that were located too far outside the state boundary of the shapefile to extrapolate.	http://www.idwr.idaho.gov/GeographicInfo/GISdata/geology.htm
	Formation	Geologic formation that the site is located in. I entered 'NA' for sites that were located too far outside the boundary of the shapefile to extrapolate. See Geology pdf for more info.	ID DEQ
Protected	Site_ProtectedArea	I included 3 different types of info: 1. Name of Wild and Scenic watershed that the site is located in; 2. if site is located within 50 m of a state protected river; 3. if site is located within 50 m of a federal wild river.	http://www.idwr.idaho.gov/GeographicInfo/GISdata/hydrography.htm
Category	**Catchment**	**Description**	**Source**
Land use	Land use land cover	proportion land use land cover categories in catchment area (NLCD 2001). Some catchments extended outside the land use layer provided by ID DEQ so I had to supplement it with the data off the nlcd website (http://www.mrlc.gov/nlcd_multizone_map.php#).	Tetra Tech analysis
Roads	Road Density	Ratio: total length of road in catchment (km)/upstream catchment area (km2). I also have the data broken down by road type (4WD, local road, highway, etc.) if we decide to pursue that further.	Tetra Tech analysis
	Stream Road Xing	Ratio: number of stream-road xings in the upstream catchment area/upstream catchment area	Tetra Tech analysis

	StreamWithin100mRoad	Ratio of Length of stream within 100 meters of roads : Total length of stream in upstream catchment area. NOTE: I tried a 50 meter buffer as well but couldn't get it to run.	Tetra Tech analysis
	Stream100m4WDRoad	Ratio of Length of stream within 100 meters of 4WDroads : Total length of stream in upstream catchment area. This is of interest because the 4WD roads are likely dirt roads that seem more likely to be contributing to sedimentation. NOTE: I tried a 50 meter buffer as well but couldn't get it to run.	Tetra Tech analysis
Streams	StreamLength	total length of streams and rivers in upstream catchment area (km)	Tetra Tech analysis
Ecoregion	LEVEL3	Proportion of upstream catchment area in each level 3 ecoregion. Also includes a column with a 'majority' ecoregion value = the ecoregion that the majority of the catchment area is located in. I noted which catchments were missing data (=catchments that extend outside the ecoregion layer boundary).	Tetra Tech analysis
	LEVEL4	Proportion of upstream catchment area in each level 4 ecoregion. I noted which catchments were missing data (=catchments that extend outside the ecoregion layer boundary).	Tetra Tech analysis
Census	POP04_SQMI	Weighted average of 2004 population per square mile within the upstream catchment area. I noted which catchments were missing data (=catchments that extend outside the state boundary).	Tetra Tech analysis
Geology	Maj_Lith	Proportion of upstream catchment area comprised of each Major Lithologic Unit. I noted which catchments were missing data (=catchments that extend outside the state boundary).	Tetra Tech analysis
Water Diversion	Div_Num	Ratio of # of Water Diversion Right ID's in each upstream catchment area: upstream catchment area	Tetra Tech analysis
	Div_SumMaxDivRate	Ratio of the sum of Max Diversion Rates in each upstream catchment area: upstream catchment area. MaxDivRate=The maximum instantaneous overall diversion rate for all uses of the right (cfs).	Tetra Tech analysis

	Div_SumMaxDivVol	Ratio of the sum of Max Diversion Volume in each upstream catchment area: upstream catchment area. MaxDivVol=the maximum annual diversion volume for all uses of the right (acre feet).	Tetra Tech analysis
Mines	Mines_Num	Ratio of the number of mines in the upstream catchment area: upstream catchment area (based on the original mines layer provided by ID DEQ)	Tetra Tech analysis
	Lmines_Num	Ratio of number of SIZPROD 'L' (this is believed to mean that the mines are large in size) mines in upstream catchment area: upstream catchment area (based on the original mines layer provided by ID DEQ).	Tetra Tech analysis
	NumMinePlant	Ratio of number of mines and/or plants in upstream catchment area: upstream catchment area. This is based on the USGS 'Active mines and mineral plants in the US' layer (http://tin.er.usgs.gov/mineplant/).	Tetra Tech analysis
NPDES	NPDES_Num	Ratio of # of NPDES permits in upstream catchment area: upstream catchment area. Based on NPDES layer provided by ID DEQ.	Tetra Tech analysis
	NPDES_MajorNum	# of Major NPDES permits in upstream catchment area: upstream catchment area. Based on NPDES layer provided by ID DEQ.	Tetra Tech analysis
Dams	Dams_Num	ratio of number of dams in the upstream catchment area:upstream catchment area. Based on dams layer provided by ID DEQ.	Tetra Tech analysis
Dairy	Dairy_Num	Ratio of number of dairy farms in upstream catchment area:upstream catchment area. Based on dairies layer from the IDWR website: http://www.idwr.idaho.gov/GeographicInfo/GISdata/dairies.htm	Tetra Tech analysis
Canals	Canals	Ratio of total length of canals or ditches in upstream catchment area : total length of streams and rivers in upstream catchment area (based on canals layer provided by ID DEQ).	Tetra Tech analysis

Appendix C

LDI

Appendix C
Landscape Disturbance Index (LDI) for Idaho

In defining reference sites across Idaho, we intended to recognize overarching land use intensity and to use such intensity to set reference criteria. Land use analysis (GIS) in the catchments of each site was used to assign all portions of the catchments into broad land use categories. To simplify interpretation of the land uses, the multiple (16) categories were agglomerated by similar stressor intensities and through calculation of a landscape disturbance index (LDI). The LDI is similar to the one introduced by Brown and Vivas (2005), in which numeric degrees of stressor intensity were assigned to each land use category and then a weighted index was calculated for each catchment. The disturbance ranks specific to this data set (**Table C-1**) were assigned using professional judgment. The LDI is the average disturbance rank, weighted by the percent coverage of each land use category in the catchments (see example, **Table C-2**).

Table C-1. Landscape Disturbance Index for Idaho

Narrative Category	Short Description	Disturbance Rank
Natural	Open Water	0
Natural	Woody Wetlands	0
Natural	Emergent Herbaceous Wetlands	0
Natural	Perennial Ice/Snow	0
Natural	Deciduous Forest	0
Natural	Evergreen Forest	0
Natural	Mixed Forest	0
Natural	Shrub/Scrub	0
Natural	Grassland/Herbaceous	0
Natural	Barren Land	0
Some Stress	Developed, Open Space	1
Some Stress	Developed, Low Intensity	2
Some Stress	Pasture/Hay	2
More Stress	Developed, Medium Intensity	3
More Stress	Cultivated Crops	3
Stressed	Developed, High Intensity	4

Table C-2. Example calculation of the LDI for a single catchment.

Catchment land uses:	**Percent Cover**	**Disturbance Rank**	**LDI partial**
Mixed Forest	55%	0	0
Emergent Wetlands	7%	0	0
Grassland/Herbaceous	12%	0	0
Pasture/Hay	8%	2	0.16
Developed, Medium Intensity	8%	3	0.24
LDI			**0.40**

Appendix D

Lithology

Appendix D
Lithologic Erodibility

Lithologic units in and around Idaho were determined using state-specific GIS data sets (accessible at: http://www.idwr.idaho.gov/GeographicInfo/GISdata/geology.htm). The units were narrative descriptions of the lithologic rock types. Similar lithologic types were found in the USGS Open-File Report 2005-1351.

A review of the listings of rock hardnesses and types allowed expert rating of the erodibility of each rock type on a scale of 1 (highly resistant to degradation) to 10 (likely to generate fine sediments during weathering or disturbance) (**Table D-1**). The experts who assigned the ratings included Ben Jessup and Nick Jokay of Tetra Tech. The 10 point erodibility scale was also converted to three categories of erodibility/resistance.

Table D-1. Fine sediment generation index and sediment rating for major lithologies in Idaho

Major Lithology	Fine Sediment Generation Index	Rating
dune sand	10	HighlyErodible
alluvium	9	HighlyErodible
loess	8	HighlyErodible
glacial drift	7	HighlyErodible
lake sediment and playa	7	HighlyErodible
sandstone	5	SomewhatResistant
meta-siltstone	5	SomewhatResistant
siltstone	5	SomewhatResistant
mixed miogeosynclinal	5	SomewhatResistant
shale and mudstone	5	SomewhatResistant
interlayered meta-sedimentary	5	SomewhatResistant
carbonate	4	SomewhatResistant
mixed carbonate and shale	4	SomewhatResistant
conglomerate	4	SomewhatResistant
mafic volcanic flow	3	Resistant
argillite and slate	3	Resistant
mafic meta-volcanic	3	Resistant
mafic intrusive	3	Resistant
calc-alkaline intrusive	3	Resistant
metamorphosed carbonate and shale	3	Resistant
mafic gneiss	3	Resistant
mixed eugeosynclinal	3	Resistant
felsic pyroclastic	2	Resistant
felsic volcanic flow	2	Resistant
granite	2	Resistant
granitic gneiss	2	Resistant
quartzite	2	Resistant
calc-alkaline meta-volcanic	2	Resistant
calc-alkaline volcanoclastic	2	Resistant
open water	0	NA
NA	0	NA

Appendix E

Reference Distributions

Appendix E

Stressor variable distributions for establishment of reference site criteria

In the following graphs, box and whisker plots show median, quartile, and non-outlier minima and maxima. Outliers are shown as individual circles or asterisks. Some extreme outliers have been cropped from the displays to emphasize distributions in the common ranges.

Reference and stressed criteria are displayed as blue and red dashed lines. These correspond to values in **Table 2-1** of the report.

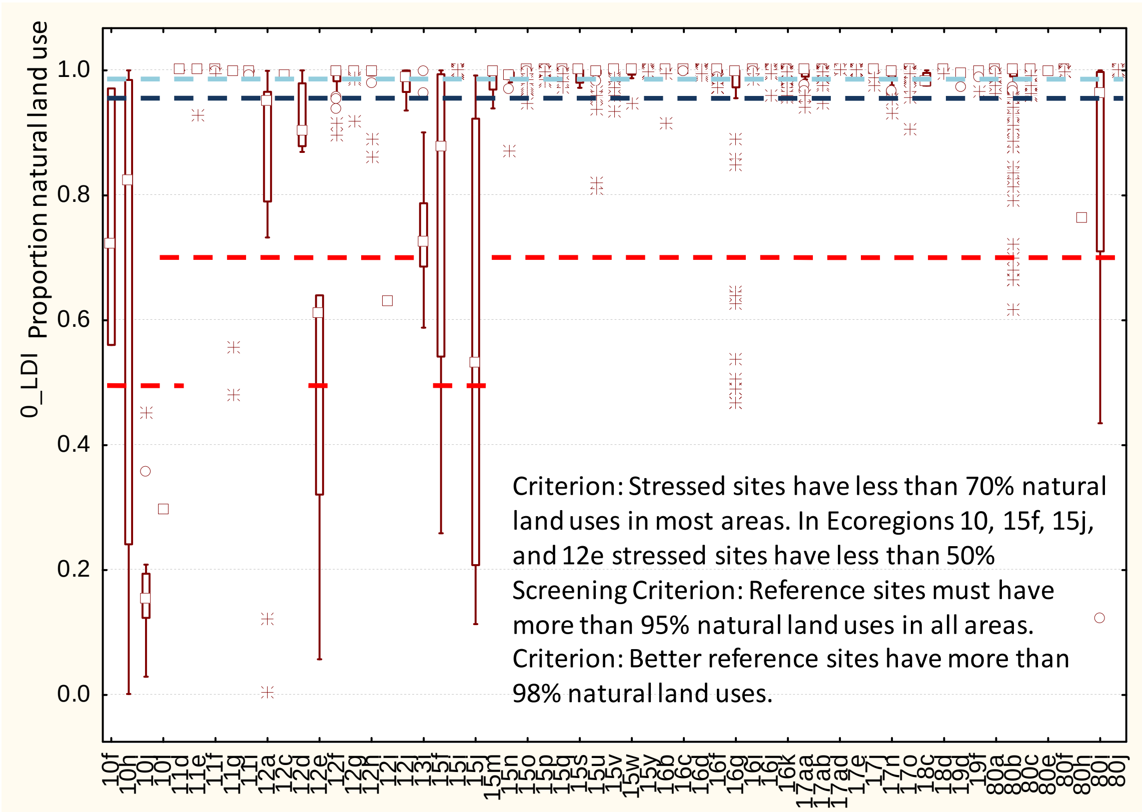


Figure E-1. Proportion natural land uses in stream sites by level 4 ecoregion.

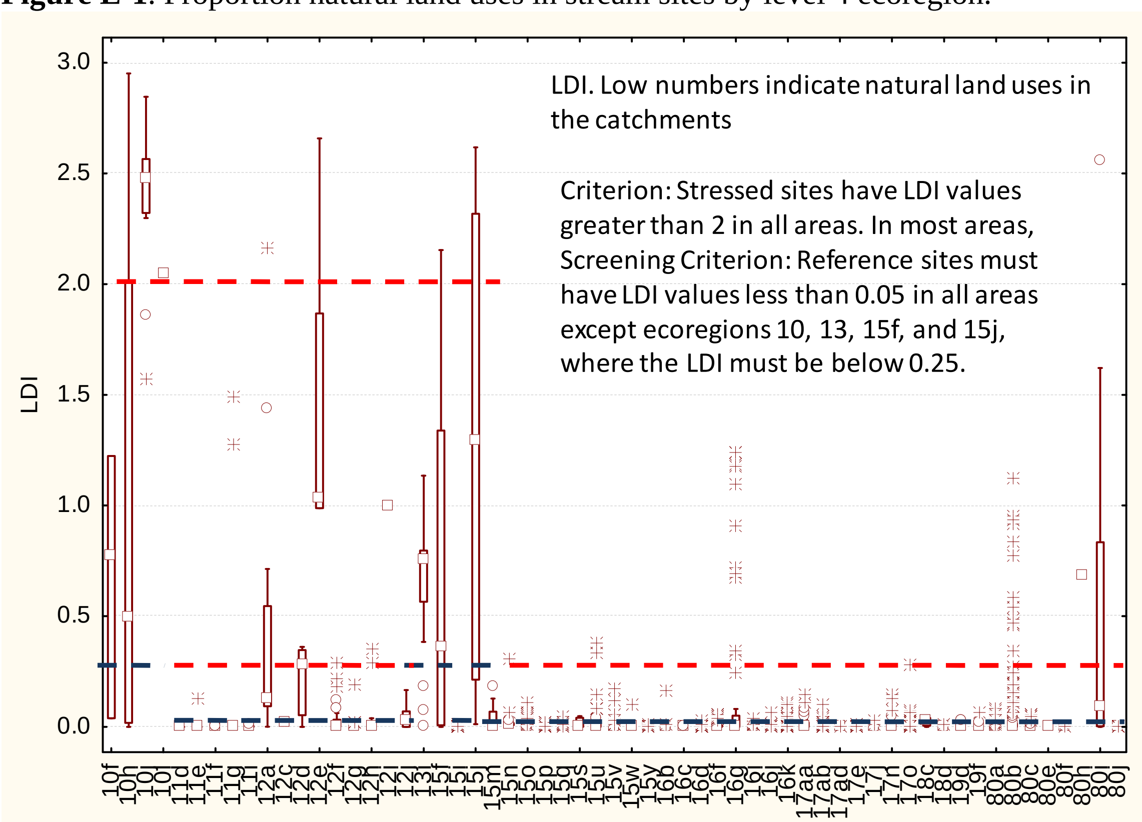


Figure E-2. LDI values in stream sites by level 4 ecoregion.

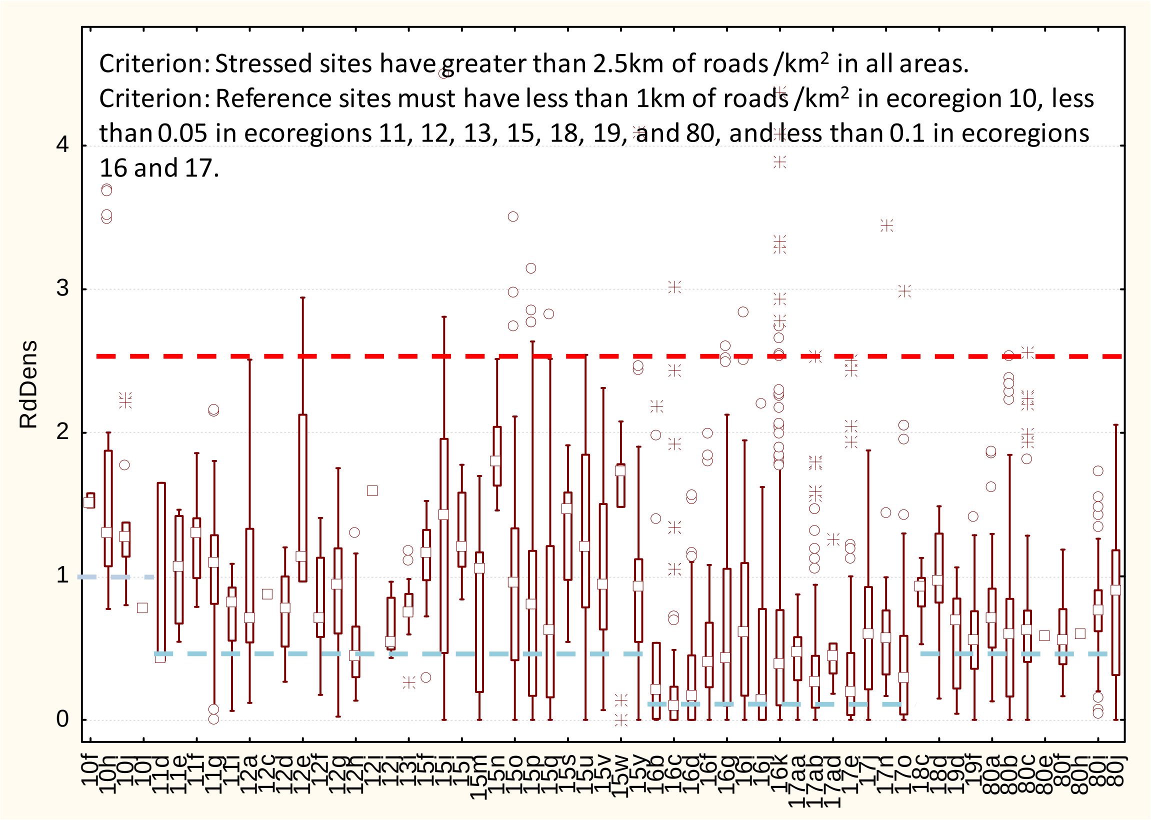


Figure E-3. Road density in stream sites by level 4 ecoregion.

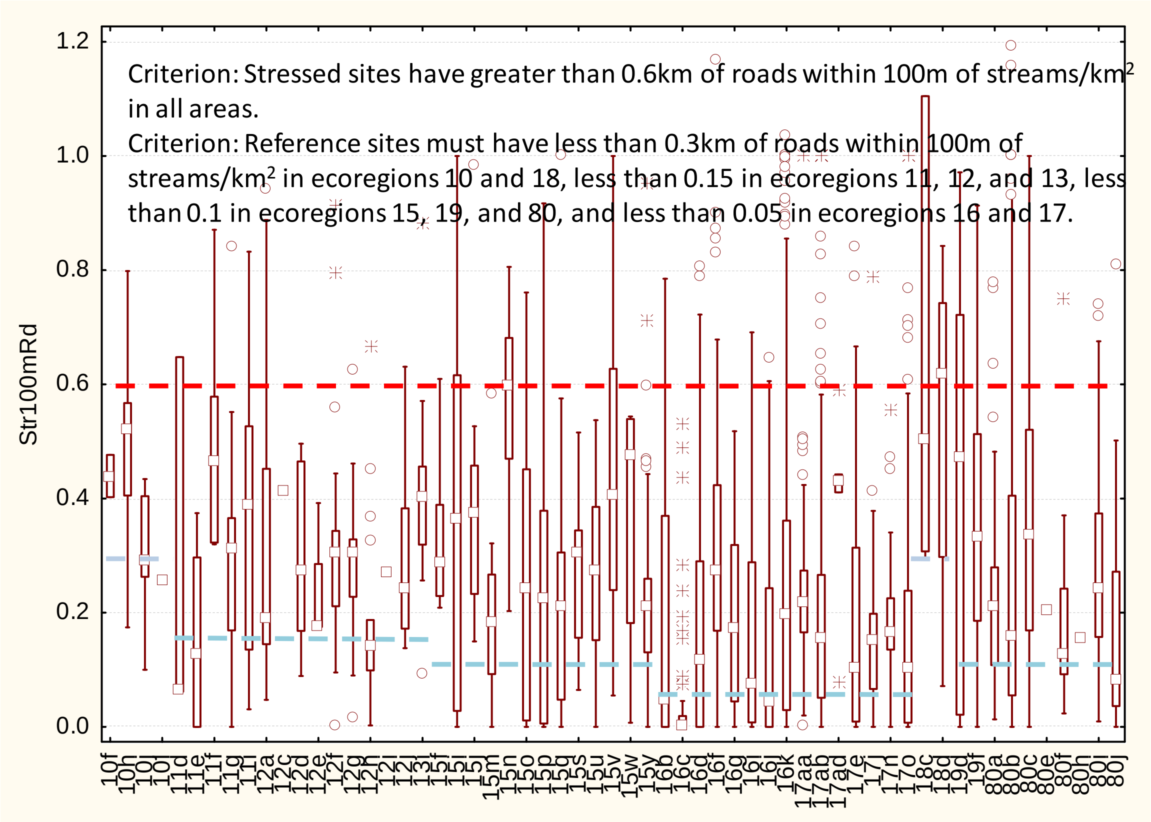


Figure E-4. Roads near streams in stream sites by level 4 ecoregion.

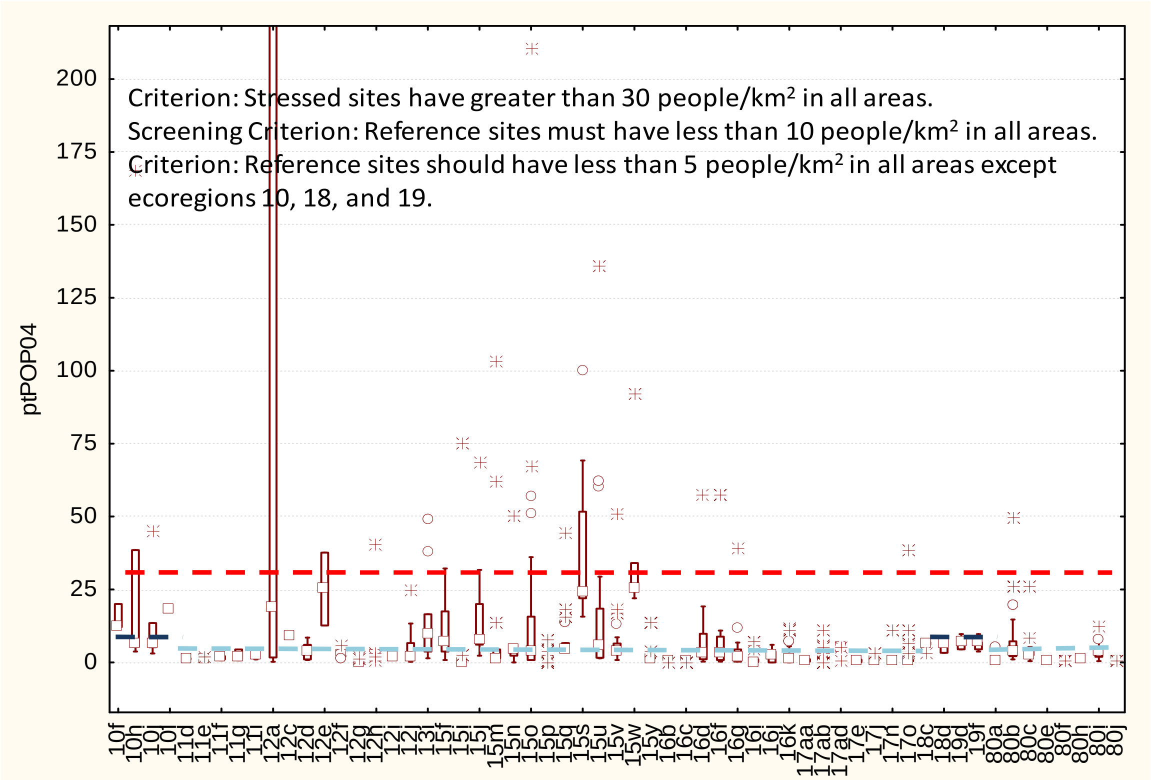


Figure E-5. Population density at stream sites by level 4 ecoregion.

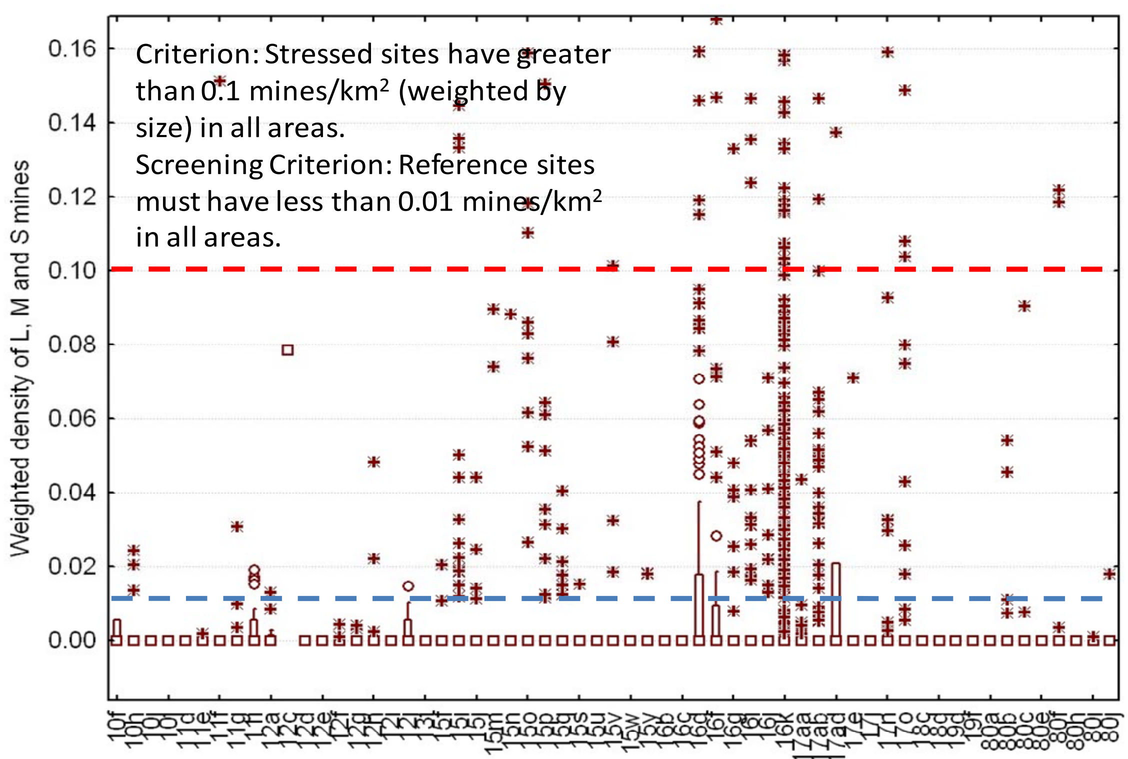


Figure E-6. Weighted density of mines at stream sites by level 4 ecoregion. Weighted Density = (3*density of large mines)+(2*density of medium mines)+(1*density of small mines). Stress occurs with 1 small mine in 10 km^2 or 1 large mine in 30 km^2.

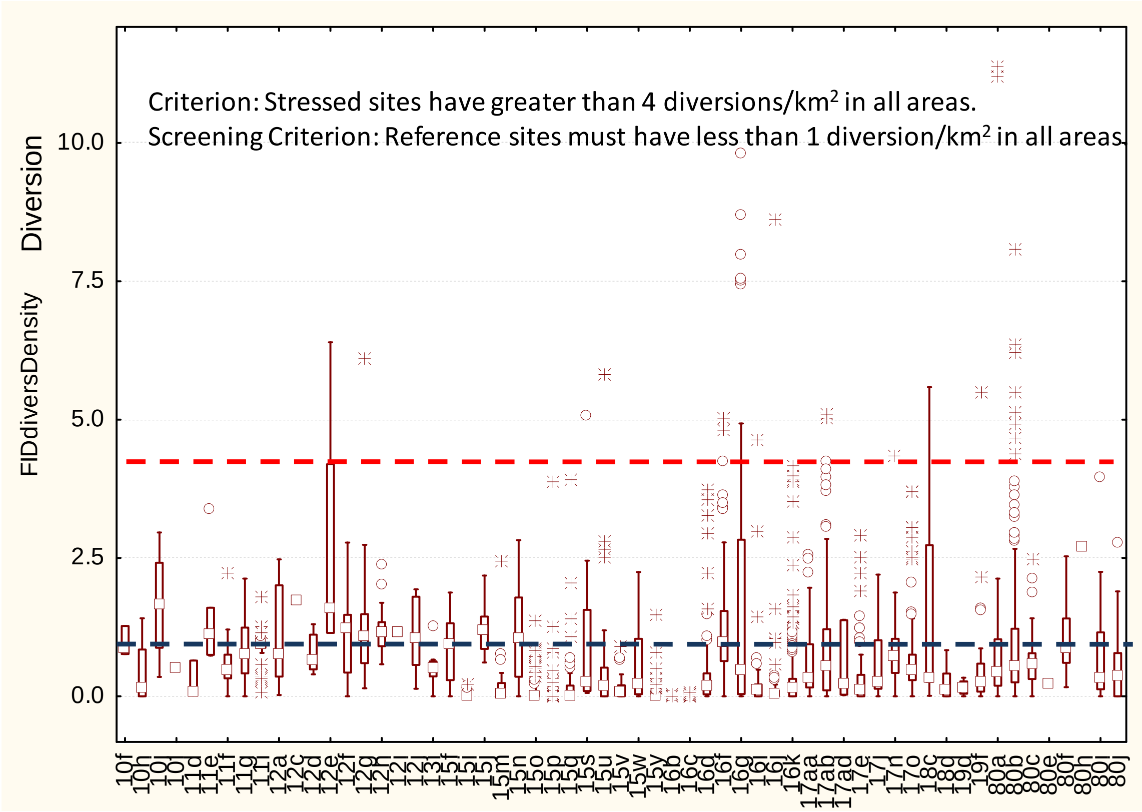


Figure E-7. Diversion density at stream sites by level 4 ecoregion.

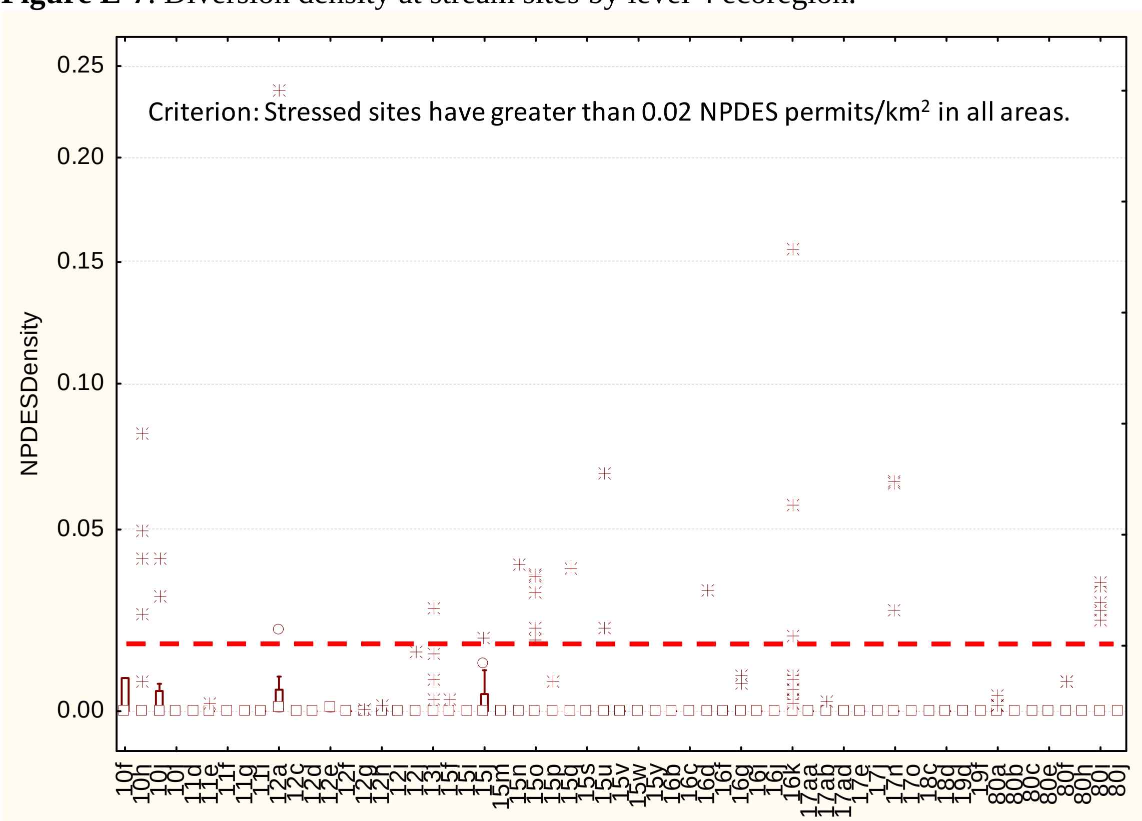


Figure E-8. NPDES permit density at stream sites by level 4 ecoregion.

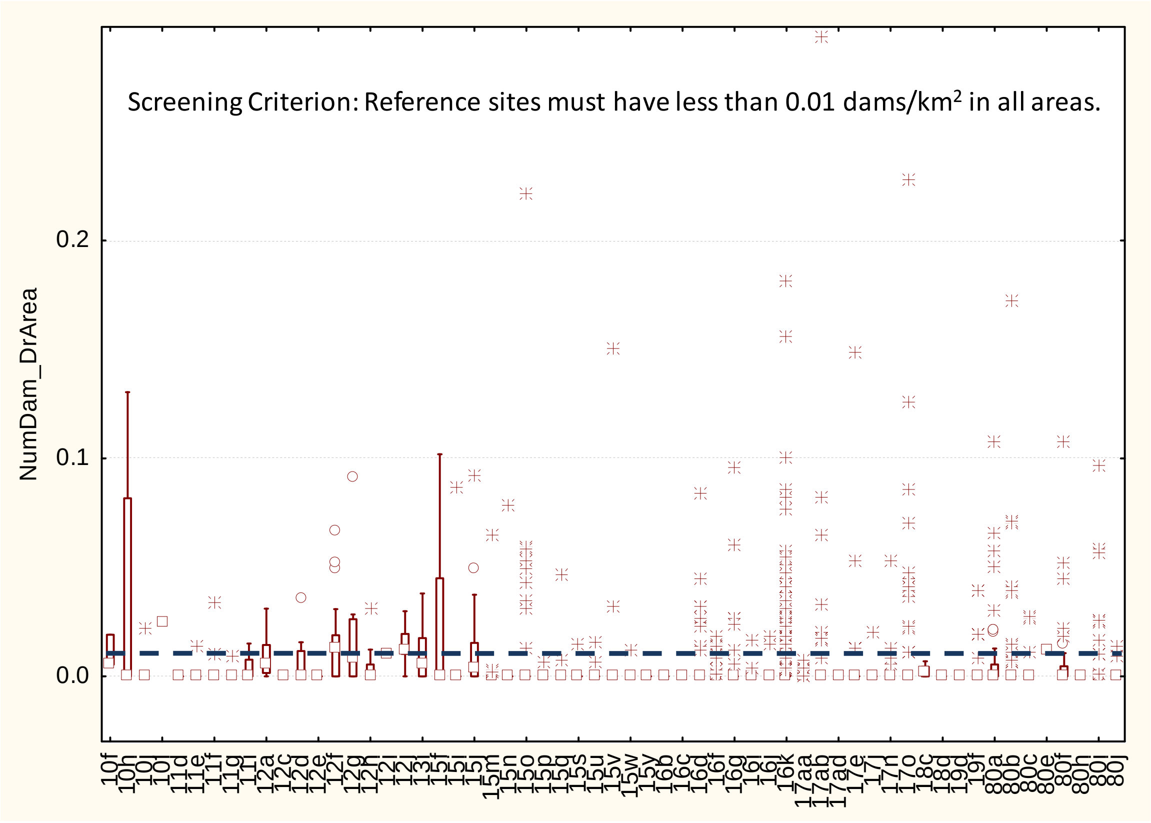


Figure E-9. Dam density at stream sites by level 4 ecoregion.

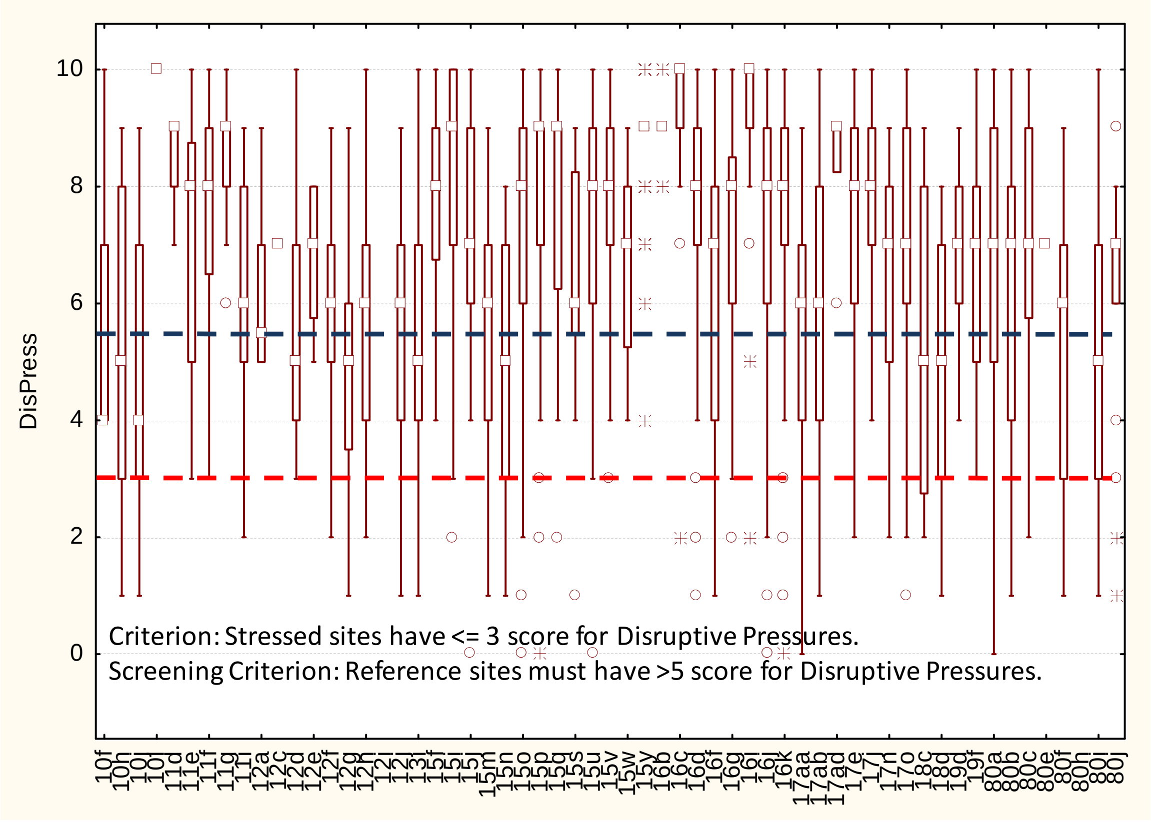


Figure E-10. Disruptive pressure at stream sites, by level 4 ecoregion.

Appendix F

Preliminary River Reference Analysis

Appendix F: Preliminary river reference analysis

In a preliminary analysis to identify reference and stressed river sites, we applied reference criteria to all rivers sampled throughout the State. There was no consideration for distributions of sites among ecoregions – no different criteria to account for different development patterns among ecoregions. As in the final analysis described in the report, there were 108 river sites assessed and GIS variables were derived for contributing areas based on HUC6 delineations. The variables considered to distinguish reference conditions were as follows:

1. Human population density at the point (POP04_SQMI)
2. Road density in the contributing area (Road_Area
3. Steams within 100 meters of roads / total length of streams (RiverNrRd)
4. Canal density in the contributing area (Canal_Total) (Stress indicator only)
5. Mining density, weighted by mine size (WtMines_Area) (Stress indicator only)
6. Landscape Disturbance Index (LDI)
7. Reference and Stressed stream site (Proportion of sampled streams in the contributing area that are reference or stressed)

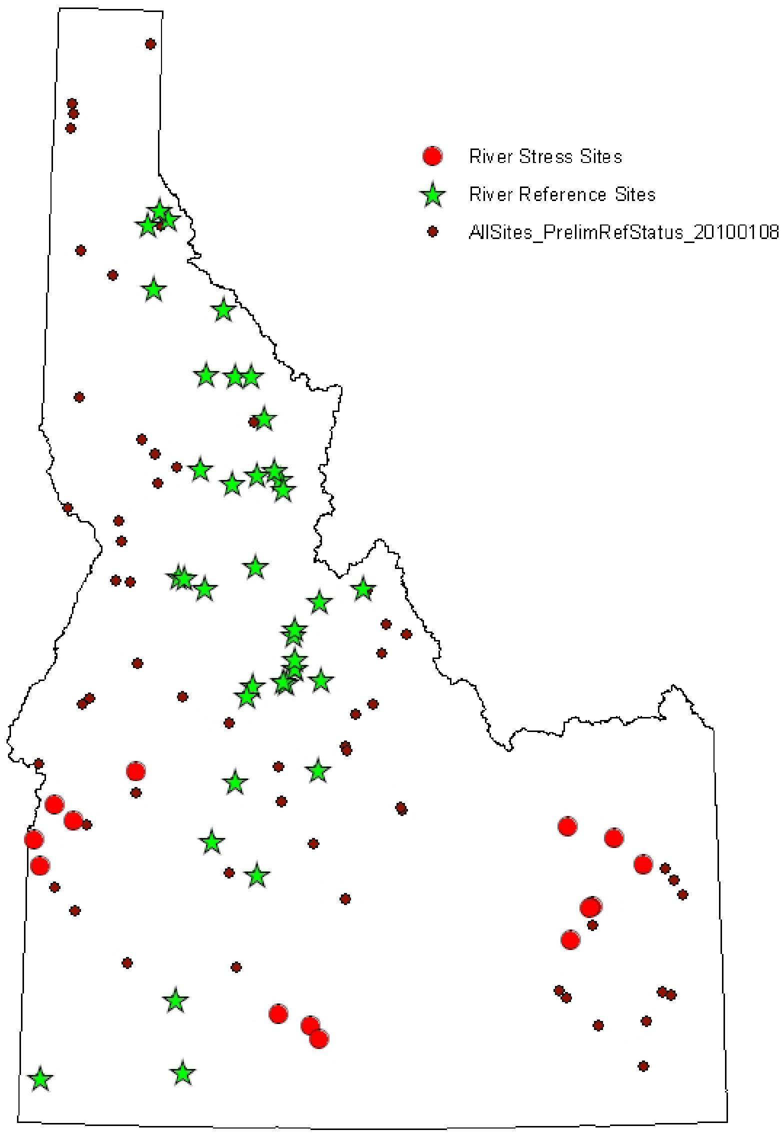
In addition, the following were considered in a subjective manner:

- Site_Type (Wilderness or not)
  - Wilderness sites would not be stressed
- Dam_1km (Proximity to Dam)
  - Sites near dams would not be reference
- Site proximity
  - Sites in close proximity (redundant) will be selectively eliminated

Reference criteria were as follows:

Reference Criterion	Results for individual criteria
POP04_SQMI < 1.0	47 sites (43%)
Road_Area < 0.02	10 sites (9%)
RiverNrRd_ < 0.01	12 sites (11%)
LDI < 0.01	49 sites (45%)
RefSiteProp >= 0.5	3 sites (3%)
Stressed Criterion	Results for individual criteria
POP04_SQMI > 50.0	12 sites (11%)
Road_Area > 2.0	5 sites (5%)
RiverNrRd_ > 0.5	2 sites (2%)
WtMines_Ar > 0.05	4 sites (4%)
Canal_Tota > 0.4	10 sites (9%)
LDI > 0.75	17 sites (16%)
StressedSiteProp >= 0.33	4 sites (4%)

Application of the criteria resulted in uneven spatial distribution of reference and stressed sites, which were reference in mountain ecoregions, stressed in plains ecoregions, as shown below:



Because of the apparent bias or confounding of reference condition and physiographic region using the preliminary methods, revised methods for reference site identification were used, as described in the report.

Appendix G

Benthic Macroinvertebrate Index Trials

Table G-1. Index trials for the Mountain site class in streams. Trial 36 was ultimately selected as the benthic Mountain index. Metric codes are as in Table 4-1.

Type	Metric	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rich.	TotalTax		2	3			6			9				13	14	15	16				
Rich.	EPTTax	1	2		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rich.	Ephemax			3																	
Comp.	EPTpct_NH	1	2	3	4	5	6	7	8	9	10	11	12					17	18	19	20
Comp.	EPpct													13	14	15	16				
Comp.	DipPct							7	8												20
Comp.	ChiroPct																	17		19	
Comp.	D_Marg			3																	
Feed.	pScrapTax_mt												12	13	14	15	16	17	18	19	
Feed.	ScrapTax	1	2	3	4	5	6	7	8	9	10	11									20
Habit	pClngrTax_mt											11		13	14	15	16	17		19	20
Habit	ClngrTax	1	2	3	4				8												
Tol.	pHBI_mt															15					20
Tol.	BeckBI	1	2	3	4	5	6	7	8	9							16	17		19	
Tol.	pIntolPct_mt													13							
Tol.	pIntolTax_mt										10	11	12						18		
Tol.	IntolPct														14						
Volt.	SemVolTax	1	2	3						9	10	11	12	13	14	15	16				
Volt.	MltVolPct																		18		
Ref25th		66.3	66.8	68.5	67.3	65.2	67.0	65.4	65.8	65.9	63.1	59.6	57.1	57.1	57.2	57.0	59.9	58.3	58.8	58.3	60.6
Strs75th		71.1	71.6	72.8	71.9	70.8	72.6	68.1	70.2	71.8	67.2	63.6	63.8	62.5	62.5	64.2	68.3	68.8	65.1	68.8	61.1
DE25		57.6	57.6	60.6	63.6	63.6	57.6	63.6	66.7	57.6	66.7	60.6	57.6	63.6	66.7	57.6	51.5	57.6	63.6	57.6	69.7
StDevRef		12.0	11.5	10.9	11.6	11.8	11.1	11.9	11.4	11.5	12.8	14.1	13.9	12.9	13.0	12.5	13.8	13.8	13.7	13.8	12.1
Z-score		1.24	1.20	1.25	1.30	1.30	1.25	1.33	1.36	1.21	1.27	1.20	1.19	1.15	1.11	1.17	1.05	1.09	1.25	1.09	1.37
Comments		Not adj.	Not adj.	Not adj.	Not adj.	Not adj.	Not adj.	Not adj.	Not adj.	Not adj.	Not adj.	Not adj.									Not adj.

Table G-1 (continued). Index trials for the Mountain site class in streams. Trial 36 was ultimately selected as the benthic Mountain index. Metric codes are as in Table 4-1.

Type	Metric	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Rich.	TotalTax	21	22	23			26						32				36			
Rich.	EPTTax				24	25		27	28	29	30	31		33	34	35	36	37	38	39
Rich.	EphemTax	21	22	23			26						32							
Rich.	TrichTax	21	22	23			26						32							
Comp.	EPTpct_NH	21	22	23	24	25		27	28	29	30	31		33	34			37	38	39
Comp.	EPpct						26						32			35	36			
Comp.	DipPct				24	25														
Comp.	Dom01Pct								28											
Comp.	NonInPct									29	30	31		33	34					
Feed.	pScrapTax_mtn	21	22	23	24	25	26	27	28	29	30	31		33						
Feed.	pCllctTax_mtn														34				38	39
Feed.	FiltrPct												32	33	34	35	36	37	38	39
Habit	pClngrTax_mtn	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Habit	ClngrTax																			
Tol.	pHBI_mtn	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Volt.	SemVolTax	21				25	26	27	28	29			32			35	36	37	38	
Volt.	MltVolPct		22																	
Ref25th		57.1	58.3	57.0	56.7	57.1	57.2	54.3	56.1	53.7	52.3	52.3	62.8	55.9	57.0	61.8	63.6	62.6	59.5	58.6
Strs75th		65.8	64.9	65.3	60.1	62.0	64.5	61.7	61.6	59.6	58.0	58.0	64.2	58.7	60.0	61.6	63.8	61.7	64.5	63.4
DE25		63.6	66.7	63.6	63.6	66.7	66.7	57.6	60.6	66.7	69.7	69.7	72.7	66.7	69.7	75.8	72.7	75.8	66.7	60.6
StDevRef		12.7	12.1	12.6	12.8	12.8	12.5	13.5	13.1	11.0	10.6	10.6	11.0	9.7	9.3	12.0	11.0	12.0	11.3	11.2
Z-score		1.2	1.3	1.2	1.3	1.3	1.2	1.2	1.1	1.3	1.4	1.4	1.5	1.5	1.6	1.5	1.5	1.5	1.5	1.5
IDEQ Rank														Rnk 4	Rnk 2		Rnk 1	Rnk 3		

Table G-2. Index trials for the Foothills site class in streams. Trial 30 was ultimately selected as the benthic Foothills index. Metric codes are as in Table 4-1.

Type	Metric	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Rich.	TotalTax					5											
Rich.	EPTTax	1	2	3			7	8				11	12	13			
Rich.	pEPTtax_FH					5									14	15	16
Rich.	EphemTax				4				8	9							
Rich.	PlecoTax				4				8	9	10						
Rich.	TrichTax				4				8								
Comp.	Shan_base_2										10						
Comp.	D_Marg						6										
Comp.	NonInPct														14		16
Comp.	Eppct													13			
Comp.	EPTpct_NH	1	2	3	4	5	6	7	8	9	10	11	12			15	16
Comp.	AmphPct										10						
Feed.	ScrapTax	1						7				11	12	13	14	15	16
Feed.	PredTax		2	3	4	5	6		8	9							
Habit	SprwlTax	1		3	4	5	6			9			12	13			
Habit	pSprwlTax_FH														14	15	16
Habit	ClmbrPct											11					
Tol.	BeckBI	1	2	3	4	5	6	7	8	9		11	12	13			
Tol.	HBI														14	15	16
Volt.	MltVolPct												12	13			
Volt.	SemVolTax	1			4	5	6		8	9		11					
Ref25th		55.2	50.2	53.8	51.7	54.6	59.1	53.3	49.8	51.6	68.2	59.5	56.7	56.3	49.0	49.5	46.6
Strs75th		59.6	57.9	62.1	59.0	62.7	66.7	58.0	56.9	59.8	71.1	61.5	61.7	61.8	44.6	50.0	44.0
DE25		71.4	57.1	71.4	64.3	57.1	57.1	64.3	64.3	64.3	71.4	71.4	71.4	71.4	78.6	71.4	78.6
stdevRef		12.6	13.7	12.5	12.9	12.6	14.8	12.8	13.7	13.6	8.4	12.1	10.8	11.0	11.0	10.0	9.0
Zscore		1.26	1.18	1.27	1.07	1.02	0.72	1.49	0.99	1.10	1.49	1.37	1.43	1.26	1.27	1.74	1.70
Comment		Not adj.	Not adj.	Not adj.	Not adj.	Not adj.	Not adj.	Not adj.	Not adj.	Not adj.		Not adj.	Not adj.	Not adj.	Hi DE		Hi DE and z

Table G-2 (continued). Index trials for the Foothills site class in streams. Trial 30 was ultimately selected as the benthic Foothills index. Metric codes are as in Table 4-1.

Type	Metric	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rich.	pTotalTax_FH	17														
Rich.	pInsctTax_FH															31
Rich.	pnonInsPT_FH						22						28		30	31
Rich.	pEPTtax_FH		18	19	20	21	22	23	24	25	26		28	29	30	
Rich.	pEphemTax_FH											27				
Rich.	PlecoTax											27				
Rich.	TrichTax											27				
Comp.	NonInPct	17	18	19	20	21	22	23	24	25	26	27	28	29		31
Comp.	Eppct									25						
Comp.	EPTpct_NH	17	18	19	20	21	22	23	24		26	27	28	29	30	31
Feed.	ScrapTax	17	18	19	20		22	23	24	25		27	28	29	30	31
Feed.	FiltrTax					21										
Feed.	FiltrPct										26					
Habit	pSprwlTax_FH	17	18		20	21	22		24	25	26	27	28	29	30	31
Habit	ClmbrPct							23								
Habit	ClngrPct			19												
Tol.	BeckBI									25						
Tol.	HBI	17		19	20	21	22	23			26	27				
Tol.	TolerTax								24				28	29	30	31
Tol.	IntolPct		18													
Volt.	SemVolTax				20											
Ref25th		44.6	42.1	45.4	47.9	43.3	47.7	53.3	49.7	45.9	48.7	46.6	51.5	49.7	53.8	52.0
Strs75th		43.0	41.7	46.1	49.5	46.9	50.8	58.6	48.3	48.3	50.8	48.0	50.7	48.3	54.5	51.1
DE25		78.6	78.6	71.4	71.4	71.4	64.3	71.4	71.4	71.4	64.3	71.4	78.6	71.4	71.4	78.6
stdevRef		10.0	9.9	7.9	9.5	11.3	7.5	8.4	8.7	10.8	9.6	9.2	7.3	8.7	7.9	8.0
Zscore		1.31	1.36	1.90	1.44	1.55	1.95	1.90	2.10	1.40	1.79	1.59	2.36	2.10	2.43	1.99
Comment		Hi DE	Hi DE						Rnk 4				Rnk 2		Rnk 1	Rnk 3

Table G-3. Index trials for the PPBV site class in streams. Trial 34 was ultimately selected as the benthic PPBV index. Metric codes are as in Table 4-1.

Type	Metric	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Rich.	pTotTax_PP								8	9	10	11	12		14
Rich.	pInsctT_PP	1	2	3	4	5		7						13	
Rich.	InsctTax						6								
Rich.	NonInsPT			3											
Comp.	EPTPct			3											
Comp.	NonInPct	1	2		4		6	7	8	9	10	11	12	13	14
Comp.	CrMolPct					5									
Feed.	FltClctTax														14
Feed.	pFiltTax_PP	1	2	3	4	5	6	7	8	9	10				
Feed.	pFiltrPct_PP											11	12	13	
Habit	pClngTax_PP							7			10				
Habit	ClngrPct	1	2	3	4	5	6		8	9		11	12	13	14
Tol.	pBecks_PP		2							9			12		
Tol.	pHBI_PP	1		3	4	5	6	7	8		10	11		13	14
Volt.	SemVolTax	1	2	3		5	6	7	8	9	10	11	12	13	14
Ref25th		59.9	58.4	54.0	61.1	59.8	60.3	56.6	60.4	58.4	57.1	60.6	58.9	60.0	65.4
Strs75th		58.3	56.7	51.9	60.6	57.2	59.5	50.9	57.4	56.6	50.9	56.9	56.7	57.7	61.5
DE25		77.5	75.0	75.0	75.0	77.5	77.5	80.0	77.5	75.0	80.0	77.5	77.5	75.0	80.0
stdevRef		11.5	11.2	12.4	11.6	11.3	11.7	12.1	11.0	10.6	11.5	10.7	10.2	11.3	9.4
Zscore		2.3	2.3	2.0	2.3	2.3	2.1	2.2	2.3	2.4	2.2	2.5	2.6	2.4	2.8
															Rnk 1

Table G-3 (continued). Index trials for the PPBV site class in streams. Trial 34 was ultimately selected as the benthic PPBV index. Metric codes are as in Table 4-1.

Type	Metric	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Rich.	pTotTax_PP	15		17	18	19	20			23					
Rich.	pInsctT_PP		16						22						
Rich.	NonInsPT								22						28
Rich.	EPTTax											25	26		28
Rich.	EphemTax													27	
Rich.	PlecoTax													27	
Rich.	TrichTax													27	
Comp.	NonInPct	15	16	17	18	19		21	22	23	24	25	26	27	28
Feed.	pFltClct_PP	15													
Feed.	pFiltrPct_PP		16	17	18		20	21	22	23	24	25	26	27	28
Habit	ClngrPct	15	16		18	19	20	21	22	23	24	25	26	27	28
Tol.	pBecks_PP		16												
Tol.	pHBI_PP	15		17		19	20	21	22						28
Tol.	pTolerPct_PP									23	24	25	26	27	
Volt.	SemVolTax	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Ref25th		58.2	58.9	56.8	58.0	65.0	54.4	60.5	58.7	58.6	59.1	57.2	57.2	55.1	58.8
Strs75th		56.2	57.3	54.7	55.2	59.3	52.2	56.2	58.4	56.3	56.8	53.5	53.5	51.6	57.8
DE25		77.5	77.5	77.5	77.5	80.0	75.0	80.0	75.0	75.0	80.0	75.0	75.0	75.0	75.0
stdevRef		9.4	10.9	10.6	12.0	10.3	11.3	11.8	11.6	10.8	11.7	12.1	12.1	12.7	12.5
Zscore		2.8	2.5	2.4	2.3	2.7	2.1	2.3	2.4	2.4	2.2	2.1	2.1	2.0	2.2
		Rnk 4				Rnk 3									

Table G-3 (continued). Index trials for the PPBV site class in streams. Trial 34 was ultimately selected as the benthic PPBV index. Metric codes are as in Table 4-1.

Type	Metric	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Rich.	pTotTax_PP	29	30	31	32			35	36				40	41	42
Rich.	pInsctT_PP											39			
Rich.	EPTTax				32	33				37	38				
Comp.	D_Simp						34			37					
Comp.	Dom01Pct					33									
Comp.	EPTPct	29	30	31				35	36		38	39		41	42
Comp.	NonInPct	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Feed.	pFltClct_PP							35	36				40		
Feed.	pFiltTax_PP														
Feed.	pFiltrPct_PP	29	30	31	32	33	34			37	38	39		41	
Habit	pClngTax_PP								36	37	38	39	40	41	42
Habit	ClngrTax			31											
Habit	ClngrPct	29			32	33	34	35							
Tol.	pHBI_PP							35		37			40		
Tol.	pTolerPct_PP	29	30	31	32	33	34		36		38	39		41	42
Volt.	SemVolTax	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Ref25th		54.3	52.6	54.8	57.7	58.4	62.1	54.6	53.7	59.8	55.3	55.7	56.0	54.9	54.8
Strs75th		54.8	50.1	52.1	53.6	53.0	56.1	52.2	50.0	53.4	49.6	51.1	52.6	51.8	51.7
DE25		72.5	80.0	82.5	75.0	80.0	85.0	77.5	77.5	82.5	85.0	82.5	75.0	82.5	75.0
stdevRef		11.0	10.9	11.0	11.4	10.5	9.5	10.1	10.5	10.6	12.8	11.7	10.3	11.2	11.3
Zscore		2.3	2.3	2.3	2.3	2.4	2.6	2.6	2.4	2.4	2.0	2.3	2.6	2.3	2.3
							Rnk 2								

Table G-4. Index trials for the **Mountain** River Benthic Macroinvertebrates. Trial 36 was ultimately selected as the Mountain index. Metric codes are as in Table 4-1.

Metric	1	2	3	4	5	6	7	8	9	10	11
EPTTax									9		
EphemTax	1	2		4	5						
PlecoTax	1	2		4	5						
TrichTax	1	2		4	5						
NonInsPT			3			6	7	8		10	11
EPTPct	1	2		4	5	6	7	8	9	10	11
TrichPct			3								
ColeoPct			3								
TanytPct			3								
ShredPct	1	2		4	5	6	7	8	9	10	11
FiltrTax			3								
SwmmrTax	1	2		4	5	6	7				
ClmbrTax	1	2			5	6	7				
SwmClmTax								8	9	10	11
ClmbrPct			3	4							
IntolTax		2					7	8	9		
TolerTax	1		3	4	5	6				10	11
SemVolTax	1	2		4		6	7	8	9	10	
UniVolPct					5						
ref25th	55.7	55.6	39.7	47.0	53.4	47.7	45.8	44.1	53.7	42.5	43.0
stdev	11.2	11.3	15.6	15.6	11.4	13.5	12.9	15.9	13.8	16.3	17.9
DE	80	70	60	50	60	50	50	60	60	50	50
z	1.50	1.49	0.88	0.97	1.52	1.32	1.40	1.00	1.18	0.96	0.88

Table G-4 (continued). Index trials for the **Mountain** River Benthic Macroinvertebrates. Trial 36 was ultimately selected as the Mountain index. Metric codes are as in Table 4-1.

Metric	12	13	14	15	16	17	18	19	20	21	22
EPTTax						17	18	19	20	21	
EphemTax					16						22
PlecoTax					16						22
TrichTax					16						22
NonInsPT	12										
EPTPct	12	13	14	15	16			19			22
ColeoPct		13									
ChiroPct		13	14	15	16	17	18		20	21	
Tnyt2ChiPct		13	14			17	18	19	20	21	
ShredPct	12								20	21	22
CllctPct		13	14	15	16	17	18	19			
ClngrPct											22
SwmClmTax	12	13	14	15	16	17	18	19	20	21	
BeckBI							18	19			
IntolTax	12	13	14	15	16	17			20	21	
TolerTax											22
SemVolTax											22
MltVolPct		13	14	15	16	17	18	19	20	21	
ref25th	42.3	48.6	48.2	53.9	55.9	50.1	52.4	50.4	47.7	47.7	51.4
stdev	17.1	14.1	14.6	15.0	13.2	12.2	10.9	11.8	12.2	12.2	14.5
DE	60	70	70	70	70	70	70	50	50	50	60
z	0.94	1.11	1.08	1.07	1.05	1.15	1.31	1.29	1.17	1.17	0.82

Table G-4 (continued). Index trials for the **Mountain** River Benthic Macroinvertebrates. Trial 36 was ultimately selected as the Mountain index. Metric codes are as in Table 4-1.

Metric	23	24	25	26	27	28	29	30	31	32	33
TotalTax	23										
EPTTax			25	26		28	29	30	31		33
EphemTax		24			27						
PlecoTax		24			27						
TrichTax					27						
NonInsPT	23	24		26		28		30		32	
EPTPct	23	24		26	27	28	29	30	31	32	33
ChiroPct		24		26		28			31	32	33
ShredPct	23				27		29	30			33
CllctPct		24		26		28			31	32	
SwmmrTax					27						
ClngrPct		24		26							
SwmClmTax	23				27	28	29	30	31	32	33
BeckBI									31	32	33
IntolTax		24		26		28	29	30			
TolerTax	23				27						
SemVolTax	23				27		29	30			
SemVolPct		24		26		28					
MltVolPct									31	32	33
ref25th	47.8	47.2	57.1	46.9	53.3	50.0	53.7	49.5	56.4	53.2	53.3
stdev	13.9	14.1	19.5	13.7	12.6	12.4	13.8	14.8	13.0	13.4	13.1
DE	50	60	40	60	60	50	60	60	70	70	70
z	0.99	0.77	0.24	0.68	1.25	1.01	1.18	0.97	1.13	1.07	1.15

Table G-4 (continued). Index trials for the **Mountain** River Benthic Macroinvertebrates. Trial 36 was ultimately selected as the Mountain index. Metric codes are as in Table 4-1.

Metric	34	35	36	37	38	39	40	41
EPTTax	34		36	37	38		40	41
NonInsPT		35				39		41
EPTPct	34	35	36	37	38	39	40	41
ChiroPct	34	35	36	37	38	39	40	41
PredPct	34	35	36		38			41
CllctPct							40	
SwmClmTax	34	35	36	37	38		40	41
ClmbrPct								
BeckBI	34	35	36	37			40	41
IntolTax					38			
TolerTax						39		
SemVolTax			36	37	38		40	41
MltVolPct	34	35				39		
ref25th	62.4	57.4	63.9	60.1	60.9	44.4	56.9	59.8
stdev	10.8	11.6	10.4	12.2	11.3	18.0	12.9	10.6
DE	70	60	70	60	70	50	70	70
z	1.44	1.31	1.59	1.23	1.43	0.53	1.21	1.39

Table G-5. Index trials for the **Non-mountain** River Benthic Macroinvertebrates. Trial 11 was ultimately selected as the Non-mountain index. Metric codes are as in Table 4-1.

Metric	1	2	3	4	5	6	7	8	9	10
InsectTax	1		3							10
EPTTax		2		4	5	6		8	9	
EphemTax							7			
TrichTax							7			
DipTax		2			5					
NonInsPT	1		3	4		6		8	9	10
EPTPct	1		3	4	5	6	7	8	9	10
EphemPct		2								
CllctTax		2								
ScrapPct			3	4	5	6	7	8	9	10
ScrapTax	1									
ClngrTax	1									
SprwlTax		2							9	10
SwmmrPct			3	4	5	6	7	8		
BeckBI	1		3	4	5					
TolerPct		2				6	7	8	9	10
MltVolPct	1		3	4	5	6	7		9	10
ref25th	58.7	54.2	56.0	57.5	53.9	57.6	53.6	58.5	65.7	66.7
refStdDev	15.1	13.7	11.4	11.5	12.6	9.7	10.7	11.7	8.9	8.8
StrsDE25	75.0	66.7	75.0	75.0	75.0	66.7	50.0	58.3	83.3	83.3
z	1.39	1.43	1.62	1.62	1.40	1.88	1.61	1.48	2.13	2.16

Table G-5 (continued). Index trials for the **Non-mountain** River Benthic Macroinvertebrates. Trial 11 was ultimately selected as the Non-mountain index. Metric codes are as in Table 4-1.

Metric	11	12	13	14	15	16	17	18	19	20
InsectTax	11			14		16			19	20
EPTTax		12	13		15		17	18		
DipTax									19	
NonInsPT	11			14	15	16	17	18		20
EPTPct			13	14	15					
EphemPct	11	12	13			16	17	18	19	20
CllctTax										20
ScrapPct	11	12	13	14	15	16	17	18	19	
ClngrTax				14	15	16	17			
SprwlTax	11	12	13					18	19	20
TolerPct	11	12	13	14	15	16	17	18	19	20
MltVolPct	11	12	13	14	15	16	17	18	19	20
ref25th	68.1	64.8	56.5	63.4	60.7	63.5	60.8	65.8	65.6	61.9
refStdDev	9.2	10.8	12.0	9.0	9.1	9.4	9.7	9.5	10.5	10.8
StrsDE25	91.7	83.3	75.0	75.0	66.7	75.0	66.7	83.3	91.7	75.0
z	2.23	1.83	1.50	2.10	2.08	2.17	2.11	2.17	1.86	1.94

Table G-5 (continued). Index trials for the **Non-mountain** River Benthic Macroinvertebrates. Trial 11 was ultimately selected as the Non-mountain index. Metric codes are as in Table 4-1.

Metric	21	22	23	24	25	26	27	28	29
TotalTax				24					
InsectTax	21	22	23		25	26		28	26
EPTTax							27		
NonInsPT	21	22	23	24	25	26	27	28	26
EphemPct	21	22	23	24	25	26	27	28	26
ScrapPct		22	23	24	25	26	27		26
ScrapTax	21							28	
SprwlTax	21	22	23	24	25	26	27	28	26
BeckBI			23	24					
TolerPct	21	22			25				
HBI						26	27	28	26
SemVolTax					25				26
UniVolPct		22							
MltVolPct	21		23	24		26	27	28	
ref25th	62.3	57.6	59.6	60.5	57.7	69.1	67.2	63.7	59.6
refStdDev	10.8	11.3	12.0	11.9	9.8	9.0	9.6	11.2	9.8
StrsDE25	83.3	75.0	83.3	83.3	66.7	91.7	75.0	83.3	75.0
z	2.06	1.83	1.73	1.66	2.04	2.20	2.08	1.92	1.99

Appendix H

Benthic Macroinvertebrate Taxa Attributes

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Appendix H: Benthic macroinvertebrate taxa attributes

Table H-1. Attribute codes.

Category	Attribute	Description	Category	Attribute	Description
FFG	CG	Collector	TolVal	0-10	0 = sensitive, 10 = tolerant
FFG	PR	Predator	Habit	SW	Swimmer
FFG	CF	Filterer	Habit	CN	Clinger
FFG	PA	Parasite	Habit	SP	Sprawler
FFG	SH	Shredder	Habit	BU	Burrower
FFG	OM	Omnivore	Habit	CM	Climber
FFG	PI	Piercer	Habit	AT	Attached
FFG	SC	Scraper	Habit	FL	Floater
LifeCycle	Uni	Univoltine	Habit	DI	Diver
LifeCycle	Bi	Bivoltine	Habit	PL	Pelagic
LifeCycle	Multi	Multivoltine	Habit	SK	Skater
LifeCycle	Semi	Semivoltine			

Table H-2. Taxa and attributes

ID	FinalID	Order	FAMILY	TOLVAL	FFG	Habit	LifeCycle
<u>Annelida</u>							
419	Annelida			6			
465	Branchiobdellida	Branchiobdellida (class)		6	CG	SW	
467	Erpobdellidae	Arhynchobdellida	Erpobdellidae	8	PR	SW	Semi (fac)
420	Hirudinidae	Arhynchobdellida	Hirudinidae	8	PR		
421	Hirudinea	Hirudinea (class)		8	PR		
470	Glossiphonia complanata	Rhynchobdellida	Glossiphoniidae	8	PR	CN	Semi (fac)

ID	FinalID	Order	FAMILY	TOLVAL	FFG	Habit	LifeCycle
469	Glossiphoniidae	Rhynchobdellida	Glossiphoniidae	8	PR	SW	
984	Helobdella sp.	Rhynchobdellida	Glossiphoniidae	9	PR	SW	Multi (obl)
422	Helobdella stagnalis	Rhynchobdellida	Glossiphoniidae	9	PR	SW	Multi (fac)
768	Placobdella sp.	Rhynchobdellida	Glossiphoniidae	8	PR	SW	
626	Theromyzon sp.	Rhynchobdellida	Glossiphoniidae		PR	SW	Uni
935	Enchytraeidae	Haplotaxida	Enchytraeidae	9	CG	SP	
1193	Haplotaxidae	Haplotaxida	Haplotaxidae		CG	BU	
1291	Haplotaxis cf. gordioides	Haplotaxida	Haplotaxidae	3	PR	BU	
1287	Haplotaxis sp.	Haplotaxida	Haplotaxidae		CG	BU	
1257	Arcteonais lomondi	Haplotaxida	Naididae	6	CG		
1209	Chaetogaster diaphanus	Haplotaxida	Naididae	6	CG	BU	
1102	Chaetogaster diastrophus	Haplotaxida	Naididae	9	PR	SP	
1167	Chaetogaster sp.	Haplotaxida	Naididae	9	CG	BU	
1063	Dero digitata	Haplotaxida	Naididae	10	CG	SP	
1210	Dero furcata	Haplotaxida	Naididae		CG	BU	
1065	Dero sp.	Haplotaxida	Naididae	10	CG	SP	
463	Naididae	Haplotaxida	Naididae	8	CG	SP	
1112	Nais barbata	Haplotaxida	Naididae	8	CG	SP	
1076	Nais behningi	Haplotaxida	Naididae	8	CG	SP	
1178	Nais bicuspidalis	Haplotaxida	Naididae	9	CG	BU	
1071	Nais bretscheri	Haplotaxida	Naididae	8	CG	SP	
1113	Nais communis	Haplotaxida	Naididae	8	CG	SP	
1186	Nais elinguis	Haplotaxida	Naididae	9	CG	BU	
1114	Nais pardalis	Haplotaxida	Naididae	8	CG	SP	
1157	Nais simplex	Haplotaxida	Naididae	8	CG	BU	
1164	Nais sp.	Haplotaxida	Naididae	8	CG	BU	
1115	Nais variabilis	Haplotaxida	Naididae	8	CG	SP	

ID	FinalID	Order	FAMILY	TOLVAL	FFG	Habit	LifeCycle
1072	Ophidonais serpentina	Haplotaxida	Naididae	8	CG	SP	
1131	Pristina jenkinae	Haplotaxida	Naididae	8	CG	SP	
1168	Pristina leidyi	Haplotaxida	Naididae	8	CG	BU	
1199	Pristina sp.	Haplotaxida	Naididae	10	CG	BU	
1077	Rhyacodrilus coccineus	Haplotaxida	Naididae	8	CG	SP	
1136	Slavina appendiculata	Haplotaxida	Naididae	9	CG	BU	
1120	Specaria josinae	Haplotaxida	Naididae	8	CG	SP	
1078	Spirosperma sp.	Haplotaxida	Naididae	8	CG	SP	
1075	Stylaria lacustris	Haplotaxida	Naididae	8	CG	SP	
1239	Vejdovskyella sp.	Haplotaxida	Naididae		CG	BU	
1200	Aulodrilus americanus	Haplotaxida	Tubificidae	10	CG	BU	
1061	Aulodrilus limnobius	Haplotaxida	Tubificidae	8	CG	SP	
1098	Aulodrilus pigueti	Haplotaxida	Tubificidae	8	CG	SP	
1062	Aulodrilus pluriseta	Haplotaxida	Tubificidae	8	CG	SP	
1079	Aulodrilus sp.	Haplotaxida	Tubificidae	8	CG	SP	
1066	Eclipidrilus sp.	Haplotaxida	Tubificidae	8	CG	SP	
1109	Limnodrilus claparedeianus	Haplotaxida	Tubificidae	9	CG	SP	
1067	Limnodrilus hoffmeisteri	Haplotaxida	Tubificidae	9	CG	SP	
1069	Limnodrilus udekemianus	Haplotaxida	Tubificidae	9	CG	SP	
1073	Quistradrilus multisetosus	Haplotaxida	Tubificidae	8	CG	SP	
1165	Rhyacodrilus montana	Haplotaxida	Tubificidae	8	CG	BU	
1135	Rhyacodrilus sp.	Haplotaxida	Tubificidae	8	CG	BU	
1074	Spirosperma ferox	Haplotaxida	Tubificidae	8	CG	SP	
1305	Spirosperma nikolskyi	Haplotaxida	Tubificidae	10	CG	BU	
1281	Telmatodrilus sp.	Haplotaxida	Tubificidae				
1301	Telmatodrilus vejdovskyi	Haplotaxida	Tubificidae		CG		
1081	Tubifex tubifex	Haplotaxida	Tubificidae	10	CG	SP	

ID	FinalID	Order	FAMILY	TOLVAL	FFG	Habit	LifeCycle
489	Tubificidae	Haplotaxida	Tubificidae	9	CG	SP	
1082	Tubificidae w/ cap setae	Haplotaxida	Tubificidae	8	CG	SP	
1083	Tubificidae w/o cap setae	Haplotaxida	Tubificidae	8	CG	SP	
786	Lumbricina	Lumbricina		6	CG	BU	
710	Lumbriculidae	Lumbriculida	Lumbriculidae	5	CG	SP	
418	Oligochaeta	Oligochaeta (class)		6	CG	SP	
1177	Aeolosomatidae	Aeolosomatida	Aeolosomatidae		CF	SP	
Arthropoda: Arachnida							
453	Acari	Acari (subclass)		6	PA	SW/CN	Multi (fac)
1274	Oribatei	Sarcoptiformes			PR		
1258	Arrenurus sp.	Trombidiformes			PR		
1259	Atractides sp.	Trombidiformes		7	PR		
1260	Aturus sp.	Trombidiformes			PR		
1264	Estelloxus sp.	Trombidiformes					
1266	Hydrovolzia sp.	Trombidiformes			PR		
1267	Hydryphantidae	Trombidiformes			PR		
1268	Hygrobates sp.	Trombidiformes			PR		
1269	Lebertia sp.	Trombidiformes			PR		
1270	Limnesia sp.	Trombidiformes			PR		
1271	Mideopsis sp.	Trombidiformes			PR		
1275	Pionidae	Trombidiformes			PR		
1276	Protzia sp.	Trombidiformes			PR		
1278	Sperchon sp.	Trombidiformes			PR		
1279	Sperchonopsis sp.	Trombidiformes			PR		
1280	Stygothrombium sp.	Trombidiformes			PR		
1282	Testudacarus sp.	Trombidiformes			PR		
1283	Thyopsis sp.	Trombidiformes					

ID	FinalID	Order	FAMILY	TOLVAL	FFG	Habit	LifeCycle
1284	Torrenticola sp.	Trombidiformes			PR		
1285	Wandesia sp.	Trombidiformes			PR		
1309	Eylais sp.	Trombidiformes	Eylaidae		PR		
1293	Hydrodroma sp.	Trombidiformes	Hydrodromidae	5	PR		
1288	Albertathyas sp.	Trombidiformes	Hydryphantidae		PR		
1998	CORTICACARUS SP.	Trombidiformes	Hygrobatidae				
550	Hygrobatidae	Trombidiformes	Hygrobatidae	8	PR		
1296	Mesobates sp.	Trombidiformes	Hygrobatidae		PR		
1185	Lebertiidae	Trombidiformes	Lebertiidae		PR		
1295	Limnesiidae	Trombidiformes	Limnesiidae	5	PR		
1290	Frontipoda sp.	Trombidiformes	Oxidae		PR		
1298	Piona sp.	Trombidiformes	Pionidae	4	PR		
1322	Panisopsis sp.	Trombidiformes	Thyasidae		PR		
1323	Thyas sp.	Trombidiformes	Thyasidae		PR		
1191	Torrenticolidae	Trombidiformes	Torrenticolidae				
1297	Neumania sp.	Trombidiformes	Unionicolidae	5	PR		
1329	Unionicola sp.	Trombidiformes	Unionicolidae				
Arthropoda: Crustacea							
443	Amphipoda	Amphipoda		7	CG/OM	SP/SW	Multi (fac)
989	Crangonyx sp.	Amphipoda	Crangonyctidae	7	CG/OM	SW/SP	Multi (fac)
1241	Stygobromus sp.	Amphipoda	Crangonyctidae		CG		
1999	Gammaridae	Amphipoda	Gammaridae				
445	Gammarus sp.	Amphipoda	Gammaridae	8	SH	SW/SP	Multi (fac)
446	Hyalella azteca	Amphipoda	Talitridae	9	CG/OM	SW/SP/BU	Multi (fac)
818	Hyalella sp.	Amphipoda	Talitridae	9	CG	SW/SP	
450	Decapoda	Decapoda		6	OM	SW/SP	
451	Pacifastacus connectens	Decapoda	Astacidae	6	OM	SP/BU	Semi

ID	FinalID	Order	FAMILY	TOLVAL	FFG	Habit	LifeCycle
452	Pacifastacus leniusculus	Decapoda	Astacidae	6	OM	SP/BU	Semi
561	Pacifastacus sp.	Decapoda	Astacidae	6	OM	BU/SP	Semi
1175	Orconectes sp.	Decapoda	Cambaridae		CG	SP/BU	
1085	Chydoridae	Diplostraca	Chydoridae				
1197	Cyzicidae	Diplostraca	Cyzicidae		CF	SW	
835	Caecidotea sp.	Isopoda	Asellidae	9	CG/OM	SP/SW	Multi (obl)
442	Ostracoda	Ostracoda		6	CG	SW/SP/BU	Multi (fac)
Arthropoda: Insecta							
533	Coleoptera	Coleoptera			OM		Uni
249	Amphizoa sp.	Coleoptera	Amphizoidae	3	PR	CN/FL	Semi (obl)
280	Carabidae	Coleoptera	Carabidae				
648	Chrysomelidae	Coleoptera	Chrysomelidae		SH	CN/SP	
682	Curculionidae	Coleoptera	Curculionidae				
250	Helichus sp.	Coleoptera	Dryopidae	7	SC/CG	CN/CM	Semi (fac)
588	Agabus sp.	Coleoptera	Dytiscidae	8	PR	CM/DI/SW	Multi (fac)
251	Dytiscidae	Coleoptera	Dytiscidae	7	PR	CM/DI	Semi (fac)
816	Hydaticus sp.	Coleoptera	Dytiscidae	7	PR	CM/DI/SW	Multi (fac)
1232	Hydroporinae	Coleoptera	Dytiscidae		PR	CM/DI/SW	
807	Hydroporus sp.	Coleoptera	Dytiscidae		PR	CM/DI/SW	Multi (fac)
595	Hygrotus sp.	Coleoptera	Dytiscidae	7	PR	CM/DI/SW	Multi (fac)
796	Laccophilus sp.	Coleoptera	Dytiscidae	8	PR	CM/DI/SW	Multi (fac)
1218	Liodessus sp.	Coleoptera	Dytiscidae		PR	CM/DI/SW	
1219	Nebrioporus sp.	Coleoptera	Dytiscidae		PR	CM/DI/SW	
252	Oreodytes sp.	Coleoptera	Dytiscidae	7	PR	CM/DI/SW	Multi (fac)
1220	Rhantus sp.	Coleoptera	Dytiscidae		PR	CM/DI/SW	
1195	Stictotarsus sp.	Coleoptera	Dytiscidae		PR	CM/DI/SW	
1208	Atractelmis wawona	Coleoptera	Elmidae	4	CG		

ID	FinalID	Order	FAMILY	TOLVAL	FFG	Habit	LifeCycle
1144	C. Barr undescribed sp.	Coleoptera	Elmidae				
885	Cleptelmis addenda	Coleoptera	Elmidae	6	SC/CG	CN	Semi (fac)
259	Cleptelmis sp.	Coleoptera	Elmidae	6	CG	CN	
261	Dubiraphia sp.	Coleoptera	Elmidae	9	CG/SC	CN/CM	Uni
253	Elmidae	Coleoptera	Elmidae	5	CG/SC	CN	Semi (fac)
262	Heterlimnius sp.	Coleoptera	Elmidae	3	SC/CG	CN	Semi (fac)
596	Lara sp.	Coleoptera	Elmidae	5	SH	CN/BU	Semiltine
846	Microcylloepus sp.	Coleoptera	Elmidae	8	SC/CG	CN/CM	Uni
265	Narpus sp.	Coleoptera	Elmidae	4	SC/CG	CN	Semi (fac)
267	Optioservus sp.	Coleoptera	Elmidae	7	SC/CG	CN	Semi (fac)
270	Ordobrevia nubifera	Coleoptera	Elmidae	6	SC/CG	CN	Semi (fac)
271	Zaitzevia sp.	Coleoptera	Elmidae	7	SC/CG	CN	Semi (fac)
274	Gyrinus sp.	Coleoptera	Gyrinidae	9	PR	CM/DI/SW	Uni
536	Brychius sp.	Coleoptera	Haliplidae	8	SC/PI	CN/CM/SW/CM	Multi (fac)
275	Haliplidae	Coleoptera	Haliplidae	9	SH	CN/CM	Multi (fac)
641	Haliplus sp.	Coleoptera	Haliplidae	9	PI/SH	CN/CM/SW/CM	Multi (fac)
647	Peltodytes sp.	Coleoptera	Haliplidae	9	PI/SH	CN/CM/SW/CM	Multi (fac)
1221	Helophoridae	Coleoptera	Helophoridae		SH	CM	
774	Hydraena sp.	Coleoptera	Hydraenidae			CN	
1154	Limnebius sp.	Coleoptera	Hydraenidae				
1188	Ochthebius sp.	Coleoptera	Hydraenidae				
961	Ametor sp.	Coleoptera	Hydrophilidae	3	PR	CN/DI/SW	Uni
1148	Anacaena sp.	Coleoptera	Hydrophilidae	5	PR/CG		
785	Berosus sp.	Coleoptera	Hydrophilidae	9	PI/CG	CM/DI/SW	Multi (fac)
1263	Cymbiodyta sp.	Coleoptera	Hydrophilidae				
1158	Enochrus sp.	Coleoptera	Hydrophilidae	7	SH	CN/SP/CM	Uni
654	Helophorus sp.	Coleoptera	Hydrophilidae	5	SH	CM	

ID	FinalID	Order	FAMILY	TOLVAL	FFG	Habit	LifeCycle
705	Hydrobius sp.	Coleoptera	Hydrophilidae	8	PR	CN/SP/ CM/DI/SW	Multi (fac)
276	Hydrophilidae	Coleoptera	Hydrophilidae	8	PR	CN/SP/CM/ BU/DI/SW	Multi (fac)
659	Laccobius sp.	Coleoptera	Hydrophilidae		PI		
798	Paracymus sp.	Coleoptera	Hydrophilidae	7	PR	BU/DI/SW	Multi (fac)
746	Tropisternus sp.	Coleoptera	Hydrophilidae	8	PR/CG/PI	CN/SP/ CM/DI/SW	Multi (fac)
820	Eubrianax edwardsi	Coleoptera	Psephenidae	7	SC	CN	
279	Eubrianax sp.	Coleoptera	Psephenidae	7	SC	CN	Semi (fac)
278	Psephenidae	Coleoptera	Psephenidae	7	SC	CN	Semi (fac)
674	Psephenus sp.	Coleoptera	Psephenidae	8	SC	CN	Semi (fac)
1222	Scirtidae	Coleoptera	SCIRTIDAE	4	SC	CM	
281	Diptera	Diptera					
311	Atherix sp.	Diptera	Athericidae	7	PR	SP	Semi (fac)
643	Agathon sp.	Diptera	Blephariceridae	4	SC	CN	Uni
1304	Bibiocephala grandis	Diptera	Blephariceridae	0	SC	CN	Uni
841	Bibiocephala sp.	Diptera	Blephariceridae	2	SC	CN	Uni
592	Blepharicera sp.	Diptera	Blephariceridae	3	SC	CN	Uni
292	Blephariceridae	Diptera	Blephariceridae	3	SC	CN	Uni
847	Philorus sp.	Diptera	Blephariceridae	2	SC	CN	Uni
804	Atrichopogon sp.	Diptera	Ceratopogonidae		CG/SC	SP	
1183	Bezzia/Palpomyia sp.	Diptera	Ceratopogonidae		PR	BU/SW	
1235	Ceratopogon sp.	Diptera	Ceratopogonidae		PR	BU/SW	
291	Ceratopogonidae	Diptera	Ceratopogonidae	6	PR	SP/BU/SW	Multi (fac)
770	Ceratopogoninae	Diptera	Ceratopogonidae	6	PR	BU	Multi (fac)
1224	Culicoides sp.	Diptera	Ceratopogonidae	10	PR	BU/SW	
1223	Dasyhelea sp.	Diptera	Ceratopogonidae		CG	BU/SW	

ID	FinalID	Order	FAMILY	TOLVAL	FFG	Habit	LifeCycle
886	Forcipomyia sp.	Diptera	Ceratopogonidae	5	SC	SP	
747	Forcipomyiinae	Diptera	Ceratopogonidae	5	PR	SP	
1225	Mallochohelea sp.	Diptera	Ceratopogonidae		PR	BU/SW	
1190	Probezzia sp.	Diptera	Ceratopogonidae		PR	BU/SW	
1205	Stilobezzia sp.	Diptera	Ceratopogonidae		PR	BU/SW	
1163	Chaoboridae	Diptera	Chaoboridae		PR	SW/SP	
994	Chaoborus sp.	Diptera	Chaoboridae	7	PR	SW	Semi (fac)
775	Eucorethra sp.	Diptera	Chaoboridae		PR	SW	
993	Ablabesmyia sp.	Diptera	Chironomidae	8	PR	sp	
1147	Acricotopus sp.	Diptera	Chironomidae	6	CG	SP	
1250	Alotanypus sp.	Diptera	Chironomidae	6	PR	BU/SP	
999	Apedilum sp.	Diptera	Chironomidae		SH	SP	Multi (obl)
1179	Apsectrotanypus sp.	Diptera	Chironomidae	8	PR	BU/SP	
320	Boreochlus sp.	Diptera	Chironomidae	5	CG	SP	Uni
321	Boreoheptagyia sp.	Diptera	Chironomidae		CG/SC	CN	Uni
322	Brillia sp.	Diptera	Chironomidae	6	SH	BU/SP	Multi (Bi)
325	Brundiniella sp.	Diptera	Chironomidae	4	PR	BU/SP	Multi (Bi)
1134	Bryophaenocladius sp.	Diptera	Chironomidae		CG	SP	
1000	Cardiocladius albiplumus	Diptera	Chironomidae	6	PR	BU/CN	Multi (Bi)
326	Cardiocladius sp.	Diptera	Chironomidae	5	PR	BU/CN	Multi (Bi)
319	Chironomidae	Diptera	Chironomidae	6	CG	BU	Uni, Bi, Multi
945	Chironominae	Diptera	Chironomidae	7	CG	BU	Uni, Bi, Multi
543	Chironomini	Diptera	Chironomidae	7	CG	BU	Uni, Bi, Multi
328	Chironomus sp.	Diptera	Chironomidae	10	CF	BU	Multi
995	Cladopelma sp.	Diptera	Chironomidae		CG	BU	Multi (Bi)
329	Cladotanytarsus sp.	Diptera	Chironomidae	7	CG/CF	CN	Uni
1247	Clinotanypus sp.	Diptera	Chironomidae		PR	BU	

ID	FinalID	Order	FAMILY	TOLVAL	FFG	Habit	LifeCycle
330	Conchapelopia sp.	Diptera	Chironomidae	6	PR	SP	Uni
331	Constempellina sp.	Diptera	Chironomidae	4	CG/CF	CN	Multi (fac)
332	Corynoneura sp.	Diptera	Chironomidae	5	SH	SP	Multi (obl)
1172	Cricotopus - Nostoc. Type II	Diptera	Chironomidae	8	CG/SH	CN	
336	Cricotopus (Isocladius) sp.	Diptera	Chironomidae	7	SH	CN	Multi (obl)
1103	Cricotopus (Isocladius) Type I	Diptera	Chironomidae	7	CG/SH	CN	
337	Cricotopus (Nostoc.) nostocicola	Diptera	Chironomidae	3	SH	BU	Multi (obl)
334	Cricotopus bicinctus gr.	Diptera	Chironomidae	7	SH	CN	Multi (obl)
333	Cricotopus sp.	Diptera	Chironomidae	7	SH	CN	Multi (Bi)
339	Cricotopus trifascia gr.	Diptera	Chironomidae	6	SH	CN	Multi
340	Cryptochironomus sp.	Diptera	Chironomidae	8	PR	BU/SP	Multi (Bi)
1002	Cryptotendipes sp.	Diptera	Chironomidae	7	CG	SP	Multi (obl)
1003	Demicryptochironomus sp.	Diptera	Chironomidae	8	CG	BU	Uni
1306	Derotanypus sp.	Diptera	Chironomidae		PR	SP	
341	Diamesa sp.	Diptera	Chironomidae	6	CG/SC	SP	Uni
575	Diamesinae	Diptera	Chironomidae	4	CG	SP	Uni
937	Diamesini	Diptera	Chironomidae	5	CG	SP	Uni
342	Dicrotendipes sp.	Diptera	Chironomidae	8	CG/CF	BU	Multi (obl)
1132	Diplocladius sp.	Diptera	Chironomidae	4	CG	SP	
1248	Doncricotopus sp.	Diptera	Chironomidae		CG	SP	
344	Endochironomus sp.	Diptera	Chironomidae	9	CG/CF/SH	CN	Uni, Bi
346	Eukiefferiella brehmi gr.	Diptera	Chironomidae	4	CG/SC	SP	Multi (Bi)
347	Eukiefferiella brevicalcar gr.	Diptera	Chironomidae	4	CG/SC	SP	Multi (obl)
1105	Eukiefferiella brevicalcar Type I	Diptera	Chironomidae	4	SH	SP	

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1106	Eukiefferiella brevicalcar Type II	Diptera	Chironomidae	4	CG	SP	
348	Eukiefferiella claripennis gr.	Diptera	Chironomidae	8	CG/SC	sp	Multi
1005	Eukiefferiella coerulescens gr.	Diptera	Chironomidae	4	CG/SC	SP	Uni
349	Eukiefferiella devonica gr.	Diptera	Chironomidae	4	CG/SC	SP	Uni, Bi, Multi
350	Eukiefferiella gracei gr.	Diptera	Chironomidae	4	CG/SC	SP	Uni
351	Eukiefferiella pseudomontana gr.	Diptera	Chironomidae	8	CG/SC	SP	Uni
1140	Eukiefferiella rectangularis gr.	Diptera	Chironomidae	4	CG	SP	
1128	Eukiefferiella similis gr.	Diptera	Chironomidae	6	PA	SP	
345	Eukiefferiella sp.	Diptera	Chironomidae	4	CG/SC	SP	Uni, Bi, Multi
1253	Eukiefferiella tirolensis	Diptera	Chironomidae	4	CG	SP	
1006	Euryhapsis sp.	Diptera	Chironomidae		SH	SP	Multi (Bi)
1007	Glyptotendipes sp.	Diptera	Chironomidae	10	SH	BU/CN	Multi (Bi)
352	Heleniella sp.	Diptera	Chironomidae	2	CG	SP	Uni
1010	Helopelopia sp.	Diptera	Chironomidae	6	PR	SP	Uni
1214	Heterotrissocladius marcidus gr.	Diptera	Chironomidae	0	CG/SC	SP/BU	
907	Heterotrissocladius sp.	Diptera	Chironomidae	4	CG/SC	SP	Multi (Bi)
354	Hydrobaenus sp.	Diptera	Chironomidae	8	CG/SC	SP	Uni
1127	Krenopelopia sp.	Diptera	Chironomidae	3	PR	SP	
903	Krenosmittia sp.	Diptera	Chironomidae	1	CG	SP	Uni
1108	Labrundinia sp.	Diptera	Chironomidae	7	PR	SP	
355	Larsia sp.	Diptera	Chironomidae	6	PR	SP	Uni, Bi
1169	Lauterborniella sp.	Diptera	Chironomidae		CG	CM/SP/CN	
356	Limnophyes sp.	Diptera	Chironomidae	8	CG	SP	Uni, Bi, Multi

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1307	Lopescladius (Cordiella) sp.	Diptera	Chironomidae	2	CG	SP	
357	Lopescladius sp.	Diptera	Chironomidae	4	CG	SP	Uni
358	Macropelopia sp.	Diptera	Chironomidae	6	PR	SP	Uni
948	Macropelopiini	Diptera	Chironomidae		PR	SP	Uni
1129	Meropelopia sp.	Diptera	Chironomidae		PR	SP	
1230	Mesocricotopus sp.	Diptera	Chironomidae		CG	SP	
1146	Metriocnemus hygropetrica gr.	Diptera	Chironomidae		SC	BU/SP	
1012	Metriocnemus sp.	Diptera	Chironomidae		CG/PR	BU/SP	Uni
360	Micropsectra sp.	Diptera	Chironomidae	7	CG	CN/SP	Multi
1203	Micropsectra/Tanytarsus sp.	Diptera	Chironomidae		CG	CN/SP	
1013	Microtendipes pedellus gr.	Diptera	Chironomidae	5	CG	CN	Multi (Bi)
1014	Microtendipes rydalensis gr.	Diptera	Chironomidae	4	CG	CN	Multi (Bi)
361	Microtendipes sp.	Diptera	Chironomidae	5	CG	CN	Multi (Bi)
362	Monodiamesa sp.	Diptera	Chironomidae	7	CG	SP	Uni
363	Nanocladius sp.	Diptera	Chironomidae	7	CG	SP	Uni, Bi, Multi
1015	Natarsia sp.	Diptera	Chironomidae	8	PR	SP	Multi (Bi)
1273	near Heleniella sp.	Diptera	Chironomidae	0			
1016	Nilotanypus fimbriatus	Diptera	Chironomidae	8	PR	SP	Uni
364	Nilotanypus sp.	Diptera	Chironomidae	6	PR	SP	Uni
1215	Nilothauma sp.	Diptera	Chironomidae		CG	CN	
366	Odontomesa sp.	Diptera	Chironomidae	7	CF	SP	Multi
905	Orthocladiinae	Diptera	Chironomidae	5	CG	SP	Uni, Bi, Multi
370	Orthocladius (Eudactylo.) sp.	Diptera	Chironomidae	6	CG	SP	Uni
1240	Orthocladius (Euortho.)	Diptera	Chironomidae	7	CG	SP/BU	

ID	FinalID	Order	FAMILY	TOLVAL	FFG	Habit	LifeCycle
	rivulorum						
371	Orthocladius (Euorthocladius) sp.	Diptera	Chironomidae	6	CG	SP	Uni
1018	Orthocladius (Euorthos.) rivicola gr.	Diptera	Chironomidae	6	CG	SP	Uni
1019	Orthocladius (Euorthos.) rivulorum gr.	Diptera	Chironomidae	6	CG	SP	Uni
1170	Orthocladius (Euorthos.) saxosus	Diptera	Chironomidae	6	CG	SP/BU	
1020	Orthocladius (Symp.) lignicola	Diptera	Chironomidae	5	SH	BU	Uni
1021	Orthocladius annectens	Diptera	Chironomidae	6	CG	SP	Multi (Bi)
1173	Orthocladius coffmani	Diptera	Chironomidae	7	CG	SP/BU	
368	Orthocladius Complex	Diptera	Chironomidae	6	CG	SP	Uni
1122	Orthocladius Genus 5	Diptera	Chironomidae	6	CG	SP	
369	Orthocladius sp.	Diptera	Chironomidae	6	CG	SP	Uni
373	Pagastia sp.	Diptera	Chironomidae	6	CG/SC	SP	Uni
1023	Paraboreochlus sp.	Diptera	Chironomidae	2	CG/SC	SP	Uni
374	Parachaetocladius sp.	Diptera	Chironomidae	2	CG	SP	Multi (Bi)
996	Parachironomus sp.	Diptera	Chironomidae	10	PR/CG/PA	SP	
1025	Paracladius sp.	Diptera	Chironomidae	8	CG	SP	Uni
1117	Paracladopelma sp.	Diptera	Chironomidae	7	PR/CG	SP	
1161	Paracricotopus sp.	Diptera	Chironomidae	6	CG	SP	
375	Parakiefferiella sp.	Diptera	Chironomidae	6	CG	SP	Uni, Bi
1216	Paralauterborniella nigrohalteralis	Diptera	Chironomidae	8	CG	CN/BU	
1026	Paralauterborniella sp.	Diptera	Chironomidae	8	CG	CN	Multi (obl)
376	Paramerina sp.	Diptera	Chironomidae	6	PR	SP	Uni, Bi, Multi
377	Parametriocnemus sp.	Diptera	Chironomidae	5	CG	SP	Multi

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1118	Paraphaenocladius "n. sp."	Diptera	Chironomidae	5	CG	SP	
378	Paraphaenocladius sp.	Diptera	Chironomidae	4	CG	SP	Uni
379	Paratanytarsus sp.	Diptera	Chironomidae	6	CG/CF	SP	Multi (obl)
380	Paratendipes sp.	Diptera	Chironomidae	6	CG	BU	Multi (Bi)
1139	Parochlus sp.	Diptera	Chironomidae	2	CG	SP	
382	Parorthocladius sp.	Diptera	Chironomidae	4	CG	SP	Uni
384	Pentaneura sp.	Diptera	Chironomidae	6	PR	SP	Uni
383	Pentaneurini	Diptera	Chironomidae	6	PR	SP	Uni
385	Phaenopsectra sp.	Diptera	Chironomidae	7	CG/SC	BU	Uni
1255	Platysmittia bilyji	Diptera	Chironomidae		CG	SP	
386	Polypedilum sp.	Diptera	Chironomidae	6	CG/CF/SH	CN	Multi (Bi)
388	Potthastia gaedii gr.	Diptera	Chironomidae	4	CG/SC	SP	Uni
389	Potthastia longimana gr.	Diptera	Chironomidae	6	CG/SC	SP	Uni
390	Procladius sp.	Diptera	Chironomidae	9	PR	SP	Multi (Bi)
391	Prodiamesa sp.	Diptera	Chironomidae	6	CG	BU	Uni, Bi
392	Psectrocladius sp.	Diptera	Chironomidae	8	CG	BU	Uni
396	Psectrotanypus sp.	Diptera	Chironomidae	7	PR	SP	Multi (Bi)
397	Pseudochironomus sp.	Diptera	Chironomidae	6	CG	BU	Uni
398	Pseudodiamesa sp.	Diptera	Chironomidae	3	CG	SP	Uni
399	Pseudorthocladius sp.	Diptera	Chironomidae	4	CG	SP	Uni
1149	Pseudosmittia sp.	Diptera	Chironomidae	6	CG	SP	
1029	Psilometriocnemus sp.	Diptera	Chironomidae	4	CG	SP	Uni
1030	Radotanypus sp.	Diptera	Chironomidae		PR	SP	Multi (Bi)
1031	Reomyia sp.	Diptera	Chironomidae		PR	SP	Multi (Bi)
400	Rheocricotopus sp.	Diptera	Chironomidae	5	CG	SP	Multi
1032	Rheopelopia sp.	Diptera	Chironomidae	4	PR	SP	Uni
1133	Rheosmittia sp.	Diptera	Chironomidae	6	CG/SH/PR	SP	

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401	Rheotanytarsus sp.	Diptera	Chironomidae	6	CG/CF	CN	Multi
986	Robackia demeijerei	Diptera	Chironomidae	8	CG	BU	Multi (Bi)
1302	Robackia sp.	Diptera	Chironomidae	4	CG	BU	Multi (Bi)
1034	Saetheria sp.	Diptera	Chironomidae	6	CG	BU	Multi (Bi)
1237	Saetheria tylus	Diptera	Chironomidae	8	CG	BU	
1119	Sergentia sp.	Diptera	Chironomidae	6	CG	BU	
1035	Smittia sp.	Diptera	Chironomidae		CG	SP	Multi (Bi)
402	Stempellina sp.	Diptera	Chironomidae	3	CG	BU	Uni, Bi
403	Stempellinella sp.	Diptera	Chironomidae	4	CG	BU	Multi (Bi)
1036	Stenochironomus sp.	Diptera	Chironomidae	5	CG	BU	Uni
1037	Stictochironomus sp.	Diptera	Chironomidae	9	CG	BU	Uni
1201	Stictocladius sp.	Diptera	Chironomidae			BU	
1039	Stilocladius sp.	Diptera	Chironomidae	3	CG	SP	Uni
405	Sublettea sp.	Diptera	Chironomidae	6	CG/CF	CN	Multi
404	Symbiocladius sp.	Diptera	Chironomidae	4	CG	CN	Uni
1155	Syndiamesa sp.	Diptera	Chironomidae		CG/SC	SP	
407	Synorthocladius sp.	Diptera	Chironomidae	6	CG	SP	Multi
947	Tanypodinae	Diptera	Chironomidae	6	PR	SP	Uni, Bi
998	Tanypus sp.	Diptera	Chironomidae	10	PR/CG	SP	
545	Tanytarsini	Diptera	Chironomidae	6	CG/CF	CN	Uni, Bi, Multi
408	Tanytarsus sp.	Diptera	Chironomidae	8	CG/CF	CN	Uni, Bi, Multi
908	Thienemanniella sp.	Diptera	Chironomidae	6	CG	SP	Uni, Bi, Multi
1041	Thienemannimyia gr. sp.	Diptera	Chironomidae	6	PR	SP	Uni
1151	Tokunagaia sp.	Diptera	Chironomidae	4			
1042	Tribelos jucundum	Diptera	Chironomidae	7	CG	BU	Uni
1043	Tribelos sp.	Diptera	Chironomidae	7	CG	BU	Uni
531	Trissopelopia sp.	Diptera	Chironomidae	5	PR	SP	Uni

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412	Tvetenia bavarica gr.	Diptera	Chironomidae	4	CG	sp	Uni
1044	Tvetenia discoloripes gr.	Diptera	Chironomidae	6	CG	SP	Multi
411	Tvetenia sp.	Diptera	Chironomidae	5	CG	SP	Multi
1045	Xenochironomus sp.	Diptera	Chironomidae	7	PR	BU	Uni
1217	Xenochironomus xenolabis	Diptera	Chironomidae	4		BU	
1180	Zalutschia sp.	Diptera	Chironomidae				
414	Zavrelia sp.	Diptera	Chironomidae	4	CG	CN	Multi (Bi)
415	Zavrelimyia sp.	Diptera	Chironomidae	8	PR	SP	Uni
1227	Anopheles sp.	Diptera	Culicidae	10	CF	SW	
1228	Culex sp.	Diptera	Culicidae	10	CF	SW	
293	Culicidae	Diptera	Culicidae		CG	SW	Semi (fac)
294	Deuterophlebia sp.	Diptera	Deuterophlebiidae	2	SC	CN	Uni
296	Dixa sp.	Diptera	Dixidae	4	CG	SW	Multi (fac)
675	Dixella sp.	Diptera	Dixidae	9	CG	SW	Multi (fac)
295	Dixidae	Diptera	Dixidae	4	CG	SW	Multi (fac)
800	Meringodixa sp.	Diptera	Dixidae	3	CG	SW	Multi (fac)
698	Dolichopodidae	Diptera	Dolichopodidae	8	PR	SP	Uni
306	Chelifera sp.	Diptera	Empididae	6	PR	SP	Uni
1252	Chelifera/Metachela sp.	Diptera	Empididae				
307	Clinocera sp.	Diptera	Empididae	4	PR	CN	Uni
305	Empididae	Diptera	Empididae	5	PR/CG	SP	Uni
635	Hemerodromia sp.	Diptera	Empididae	8	PR/CG	sp	Uni
1254	Neoplasta sp.	Diptera	Empididae	6		SP	
580	Oreogeton sp.	Diptera	Empididae	2	PR	SP	Uni
1242	Trichoclinocera sp.	Diptera	Empididae		PR		
310	Wiedemannia sp.	Diptera	Empididae	4	PR	CN	Uni
314	Ephydridae	Diptera	Ephydridae	9	OM	BU	Multi (fac)

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646	Limnophora sp.	Diptera	Muscidae	8	PR	BU	Multi (fac)
983	Muscidae	Diptera	Muscidae	8	PR	SP	Multi (fac)
316	Glutops sp.	Diptera	Pelecorhynchidae	3	PR	SP	Uni
298	Maruina sp.	Diptera	Psychodidae	5	SC/CG	CN	Uni
299	Pericoma/Telmatoscopus sp.	Diptera	Psychodidae	5	CG	BU	Multi (fac)
959	Psychoda sp.	Diptera	Psychodidae	10	CG	BU	Multi (fac)
297	Psychodidae	Diptera	Psychodidae	5	CG	BU	Multi (fac)
651	Ptychoptera sp.	Diptera	Ptychopteridae	8	CG	BU	Uni
300	Ptychopteridae	Diptera	Ptychopteridae	8	CG	BU	Uni
833	Sciomyzidae	Diptera	Sciomyzidae	8	PR	BU	
766	Metacnephia sp.	Diptera	Simuliidae		CF	CN	Multi (fac)
302	Prosimulium sp.	Diptera	Simuliidae	3	CF	CN	Uni
301	Simuliidae	Diptera	Simuliidae	6	CF	CN	Multi (fac)
303	Simulium sp.	Diptera	Simuliidae	7	CF	CN	Multi (fac)
1229	Stegopterna sp.	Diptera	Simuliidae			CM	
304	Twinnia sp.	Diptera	Simuliidae	6	SC	CN	Uni
617	Caloparyphus sp.	Diptera	Stratiomyidae	8	CG	SP	Uni
618	Euparyphus sp.	Diptera	Stratiomyidae	8	CG/SC	SP	Uni
1141	Hedriodiscus/Odontomyia sp.	Diptera	Stratiomyidae	8	CG	SP	
1272	Myxosargus sp.	Diptera	Stratiomyidae				
1046	Nemotelus sp.	Diptera	Stratiomyidae	7	CG	SW	Uni
1156	Stratiomys sp.	Diptera	Stratiomyidae	8	CG		
317	Stratiomyidae	Diptera	Stratiomyiidae	7	CG	SP	Uni
916	Syrphidae	Diptera	Syrphidae	9	CG	BU	Multi (fac)
1321	Atylotus/Tabanus sp.	Diptera	Tabanidae	5	PR	SP	Uni
1292	Hybomitra sp.	Diptera	Tabanidae	5	PR	SP	

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318	Tabanidae	Diptera	Tabanidae	8	PR	SP	
988	Protanyderus sp.	Diptera	Tanyderidae	5		BU	Semi (fac)
732	Thaumalea sp.	Diptera	Thaumaleidae	3	SC	CN	
733	Thaumaleidae	Diptera	Thaumaleidae	3	SC	CN	
284	Antocha sp.	Diptera	Tipulidae	7	CG	CN	Multi (fac)
870	Cryptolabis sp.	Diptera	Tipulidae	7		BU	
285	Dicranota sp.	Diptera	Tipulidae	5	PR	SP	Uni
767	Erioptera sp.	Diptera	Tipulidae	4	CG	BU	
751	Gonomyia sp.	Diptera	Tipulidae			BU	Uni
287	Hesperoconopa sp.	Diptera	Tipulidae	3		BU	Uni
286	Hexatoma sp.	Diptera	Tipulidae	4	PR	BU	Uni
283	Limnophila sp.	Diptera	Tipulidae	3	PR	BU	Multi (fac)
288	Limonia sp.	Diptera	Tipulidae	8	SH	BU	Multi (fac)
1226	Limoniinae	Diptera	Tipulidae				
1145	Megistocera sp.	Diptera	Tipulidae				
867	Molophilus sp.	Diptera	Tipulidae			BU	Uni
1324	Ormosia (Sceleroprocta) sp.	Diptera	Tipulidae	6	CG	BU	
708	Ormosia sp.	Diptera	Tipulidae	4	CG	BU	Multi (fac)
289	Pedicia sp.	Diptera	Tipulidae	3	PR	BU	
831	Pilaria sp.	Diptera	Tipulidae	4	PR	BU	Uni
877	Rhabdomastix fascigera gr.	Diptera	Tipulidae	3		BU	Uni
892	Rhabdomastix setigera gr.	Diptera	Tipulidae	3		BU	Uni
1277	Rhabdomastix tricophora gr.	Diptera	Tipulidae	1			
290	Tipula sp.	Diptera	Tipulidae	6	SH	BU	Semi (fac)
282	Tipulidae	Diptera	Tipulidae	5	SH	BU	
13	Ameletus sp.	Ephemeroptera	Ameletidae	4	SC/CG	CN/SW	Uni

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601	Acentrella insignificans	Ephemeroptera	Baetidae	7	CG	SW/CN	Multi (fac)
640	Acentrella sp.	Ephemeroptera	Baetidae	6	CG	CN/SW	Multi (fac)
781	Acentrella turbida	Ephemeroptera	Baetidae	6	CG	SW/CN	Multi (fac)
1211	Acerpenna pygmaea	Ephemeroptera	Baetidae		SC	CN/SW	
1249	Acerpenna sp.	Ephemeroptera	Baetidae		SC	CN/SW	
16	Baetidae	Ephemeroptera	Baetidae	6	CG/SC	CN/SW	Multi (fac)
978	Baetis alius	Ephemeroptera	Baetidae	4	CG/SC	SW/CN	Multi (fac)
18	Baetis bicaudatus	Ephemeroptera	Baetidae	2	SC/CG	SW/CN	Uni
1176	Baetis brunneicolor	Ephemeroptera	Baetidae	5	CG	CN/SW	
790	Baetis flavistriga	Ephemeroptera	Baetidae	6	CG/SC	SW/CN	Multi (fac)
869	Baetis notos	Ephemeroptera	Baetidae	8	CG/SC	SW/CN	Multi (fac)
17	Baetis sp.	Ephemeroptera	Baetidae	7	CG/SC	CN/SW	Multi (fac)
20	Baetis tricaudatus	Ephemeroptera	Baetidae	7	SC/CG	CN/SW	Semi (obl)
21	Callibaetis sp.	Ephemeroptera	Baetidae	9	CG	CN/SW	Multi (fac)
1245	Camelobaetidius variabilis	Ephemeroptera	Baetidae	4	CG	CN/SW	
22	Centroptilum sp.	Ephemeroptera	Baetidae	8	CG/SC	CN/SW	Multi (fac)
679	Diphetor hageni	Ephemeroptera	Baetidae	5	CG/SC	CN/SW	Multi (fac)
929	Fallceon quilleri	Ephemeroptera	Baetidae	8	CG/SC	CN/SW	Multi (obl)
1049	Fallceon sp.	Ephemeroptera	Baetidae	8	CG	SW	
1328	Heterocloeon sp.	Ephemeroptera	Baetidae				
1050	Plauditus armillatus	Ephemeroptera	Baetidae	6	CG/SC	CN/SW	Multi (fac)
1160	Plauditus cestus	Ephemeroptera	Baetidae	6	SC	CN/SW	
1051	Plauditus punctiventris	Ephemeroptera	Baetidae	6	SC	CN/SW	
1125	Plauditus sp.	Ephemeroptera	Baetidae	6	CG/SC	CN/SW	Multi (fac)
928	Procloeon sp.	Ephemeroptera	Baetidae	4	CG/SC	CN/SW	Multi (fac)
1299	Pseudocloeon apache	Ephemeroptera	Baetidae	4.4	SC	SW	
925	Pseudocloeon sp.	Ephemeroptera	Baetidae	4	CG	CN/SW	Multi (fac)

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59	Caenidae	Ephemeroptera	Caenidae	9	CG	SP/CM	Multi (fac)
878	Caenis latipennis	Ephemeroptera	Caenidae	9	CG/SC	SP/CM	Multi (fac)
60	Caenis sp.	Ephemeroptera	Caenidae	9	CG/SC	SP/CM	Multi (fac)
1262	Caenis tardata	Ephemeroptera	Caenidae	8			
1053	Caenis youngi	Ephemeroptera	Caenidae	9	CG/SC	SP/CM	Multi (fac)
600	Attenella margarita	Ephemeroptera	Ephemerellidae	7	CG/SC	CN	Uni
37	Attenella sp.	Ephemeroptera	Ephemerellidae	6	CG/SC	CN	Uni
40	Caudatella edmundsi	Ephemeroptera	Ephemerellidae	3	CG/SC/SH	CN	Uni
41	Caudatella heterocaudata	Ephemeroptera	Ephemerellidae	4	CG/SC/OM	CN	Uni
42	Caudatella hystrix	Ephemeroptera	Ephemerellidae	3	CG/SC/SH	CN	Uni
39	Caudatella sp.	Ephemeroptera	Ephemerellidae	4	CG/SC/SH	CN	Uni
946	Caurinella idahoensis	Ephemeroptera	Ephemerellidae	0	CG	CN	Uni
622	Drunella coloradensis/flavilinea	Ephemeroptera	Ephemerellidae	4	SC/PR	CN/SP	Uni
43	Drunella doddsi	Ephemeroptera	Ephemerellidae	3	SC/CG	CN	Uni
51	Drunella grandis	Ephemeroptera	Ephemerellidae	6	CG/SC/PR	CN/SP	Uni
45	Drunella sp.	Ephemeroptera	Ephemerellidae	4	SC/PR/CG	CN/SP	Uni
48	Drunella spinifera	Ephemeroptera	Ephemerellidae	3	PR/SC/CG	CN/SP	Uni
50	Ephemerella aurivillii	Ephemeroptera	Ephemerellidae	7	CG	CN/SW	Uni
616	Ephemerella inermis/infrequens	Ephemeroptera	Ephemerellidae	7	CG	CN/SW	Uni
49	Ephemerella sp.	Ephemeroptera	Ephemerellidae	6	CG/SC	SW	
36	Ephemerellidae	Ephemeroptera	Ephemerellidae	4	CG/SC	CN	Uni
1202	Eurylophella sp.	EPHEMEROPTERA	EPHEMERELLIDAE	3	CG/SC	CN	
53	Serratella sp.	Ephemeroptera	Ephemerellidae	5	CG	CN	Multi (fac)
645	Serratella teresa	Ephemeroptera	Ephemerellidae	6	CG	CN	Multi (fac)
54	Serratella tibialis	Ephemeroptera	Ephemerellidae	5	CG	CN	
55	Timpanoga hecuba	Ephemeroptera	Ephemerellidae	7	CG	CN/SP	

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729	Ephemera sp.	Ephemeroptera	Ephemeridae	8	CG/PR/CF	BU	Semi (fac)
25	Cinygma sp.	Ephemeroptera	Heptageniidae	4	SC/CG	CN	Uni
26	Cinygmula sp.	Ephemeroptera	Heptageniidae	5	SC/CG	CN	
1325	Ecdyonurus sp.	Ephemeroptera	Heptageniidae				
28	Epeorus albertae	Ephemeroptera	Heptageniidae	6	CG	CN	Uni
29	Epeorus deceptivus	Ephemeroptera	Heptageniidae	2	CG	CN	Uni
32	Epeorus grandis	Ephemeroptera	Heptageniidae	3	CG	CN	
31	Epeorus longimanus	Ephemeroptera	Heptageniidae	4	CG	CN	Uni
27	Epeorus sp.	Ephemeroptera	Heptageniidae	5	CG/SC	CN	
34	Heptagenia sp.	Ephemeroptera	Heptageniidae	7	SC/CG	CN	Multi (obl)
24	Heptageniidae	Ephemeroptera	Heptageniidae	5	SC/CG	CN	
33	Ironodes sp.	Ephemeroptera	Heptageniidae	5	SC/CG	CN	
872	Leucrocuta sp.	Ephemeroptera	Heptageniidae	8	SC/CG	CN	
483	Nixe criddlei	Ephemeroptera	Heptageniidae	7	SC	CN	
783	Nixe sp.	Ephemeroptera	Heptageniidae	7	SC/CG	CN	
35	Rhithrogena sp.	Ephemeroptera	Heptageniidae	6	CG/SC	CN	Uni
700	Stenonema sp.	Ephemeroptera	Heptageniidae	8	SC/CG	CN	
1055	Stenonema terminatum	Ephemeroptera	Heptageniidae	8	SC	CN	
1236	Asioplax sp.	Ephemeroptera	Leptohyphidae		CG	CN/SP	
638	Choroterpes sp.	Ephemeroptera	Leptophlebiidae	8	CG/SC	CN	
61	Leptophlebiidae	Ephemeroptera	Leptophlebiidae	8	CG/SC	SW	
64	Paraleptophlebia bicornuta	Ephemeroptera	Leptophlebiidae	8	CG	SW/CN/SP	
63	Paraleptophlebia sp.	Ephemeroptera	Leptophlebiidae	6	SH	CN	Uni
471	Piscicola salmositica	Ephemeroptera	Piscicolidae	4	PR		
623	Piscicola sp.	Ephemeroptera	Piscicolidae		PR		
488	Ephoron sp.	Ephemeroptera	Polymitarcyidae	8	CG/CF	BU	Uni
12	Siphlonuridae	Ephemeroptera	Siphloneuridae	9	CG	SW	

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979	Siphlonurus sp.	Ephemeroptera	Siphloneuridae	9	CG/PR	SW	Uni
57	Tricorythodes sp.	Ephemeroptera	Tricorythidae	8	CF	BU	
136	Corixidae	Hemiptera	Corixidae	9	PR/PI/CG	SW	Semi (fac)
141	Hesperocorixa sp.	Hemiptera	Corixidae	9	PI/CG	SW	Multi (fac)
142	Sigara sp.	Hemiptera	Corixidae	9	PI/CG	SW	Semi (fac)
597	Ambrysus sp.	Hemiptera	Naucoridae	7	PR	CN	Multi (fac)
862	Notonectidae	Hemiptera	Notonectidae		PR	SW	Multi (fac)
532	Lepidoptera	Lepidoptera	Coleophoridae sp.		SH	CN/AT/MI	
248	Petrophila sp.	Lepidoptera	Pyralidae	7	SC	CN/AT	
247	Pyralidae	Lepidoptera	Pyralidae	7	SH	CN/CM/AT/MI	
149	Sialis sp.	Megaloptera	Sialidae	8	PR	CN/CM/BU	Semi (fac)
973	Anisoptera	Odonata		8	PR		
490	Odonata	Odonata		7	PR		
3021	Zygoptera	Odonata					
932	Aeshna sp.	Odonata	Aeschnidae	8	PR	CM	Semi (fac)
4	Aeshnidae	Odonata	Aeschnidae	8	PR	SP	
8	Argia sp.	Odonata	Coenagrionidae	8	PR	CN	Uni
969	Coenagrion/Enallagma sp.	Odonata	Coenagrionidae	9	PR		
6	Coenagrionidae	Odonata	Coenagrionidae	9	PR	CM	Semi (fac)
9	Enallagma sp.	Odonata	Coenagrionidae	9	PR	CM	Semi (fac)
670	Cordulegaster sp.	Odonata	Cordulegasteridae	6	PR	BU	Semi (obl)
1196	Cordulegaster dorsalis	Odonata	Cordulegastridae		PR	BU	
832	Corduliidae	Odonata	Cordulidae	5	PR	SP	
1238	Erpetogomphus compositus	Odonata	Gomphidae	3	PR		
894	Erpetogomphus sp.	Odonata	Gomphidae	8	PR	BU	
1	Gomphidae	Odonata	Gomphidae	7	PR	BU	
1189	Ophiogomphus severus	Odonata	Gomphidae	5	PR	BU	

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3	Ophiogomphus sp.	Odonata	Gomphidae	7	PR	BU	
840	Lestes sp.	Odonata	Lestidae	9	PR	SW	Uni
1294	Leucorrhinia sp.	Odonata	Libellulidae	9	PR	CM	
811	Libellulidae	Odonata	Libellulidae	9	PR	CM	
1303	Plathemis subornata	Odonata	Libellulidae		PR		
7	Amphiagrion sp.	Odonata	Protoneuridae	7	PR	CM	
492	Plecoptera	Plecoptera					
1261	Bolshecapnia sp.	Plecoptera	Capniidae			CN	Uni
100	Capniidae	Plecoptera	Capniidae	4	SH	CN	Uni
1265	Eucapnopsis brevicauda	Plecoptera	Capniidae			CN	Uni
131	Alloperla sp.	Plecoptera	Chloroperlidae		PR		
1130	Bisancora sp.	Plecoptera	Chloroperlidae				
130	Chloroperlidae	Plecoptera	Chloroperlidae	5	PR/SC/CG	CN	
1204	Haploperla sp.	Plecoptera	Chloroperlidae		PR		
944	Kathroperla sp.	Plecoptera	Chloroperlidae	3	CG/SC		
853	Neaviperla forcipata	Plecoptera	Chloroperlidae	5			
133	Paraperla sp.	Plecoptera	Chloroperlidae	3			
584	Plumiperla sp.	Plecoptera	Chloroperlidae				
577	Suwallia sp.	Plecoptera	Chloroperlidae	4	PR		
134	Sweltsa sp.	Plecoptera	Chloroperlidae	5	PR	CN	
865	Triznaka sp.	Plecoptera	Chloroperlidae		PR		
1152	Utaperla sp.	Plecoptera	Chloroperlidae				
94	Despaxia augusta	Plecoptera	Leuctridae	3	SH	CN	Semi (fac)
93	Leuctridae	Plecoptera	Leuctridae	3	SH	CN	Semi (fac)
97	Paraleuctra sp.	Plecoptera	Leuctridae	3	SH	CN	Semi (fac)
99	Perlomyia sp.	Plecoptera	Leuctridae	3	SH	CN	Semi (fac)
1246	Pomoleuctra sp.	Plecoptera	Leuctridae		SH		

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82	Amphinemura sp.	Plecoptera	Nemouridae	6	SH	CN	Uni
83	Malenka sp.	Plecoptera	Nemouridae	6	SH	CN	Uni
81	Nemouridae	Plecoptera	Nemouridae	5	SH	CN	Uni
84	Podmosta sp.	Plecoptera	Nemouridae	3	SH	CN	Uni
87	Visoka cataractae	Plecoptera	Nemouridae	2	SH	CN	Semi (fac)
89	Zapada cinctipes	Plecoptera	Nemouridae	5	SH	CN	Multi (fac)
90	Zapada columbiana	Plecoptera	Nemouridae	2	SH	CN	Semi (fac)
91	Zapada frigida	Plecoptera	Nemouridae	3	SH	CN	Uni
92	Zapada oregonensis gr.	Plecoptera	Nemouridae	3	SH	CN	Uni
88	Zapada sp.	Plecoptera	Nemouridae	4	SH	CN	Uni
72	Peltoperlidae	Plecoptera	Peltoperlidae	3	SH	CN	Semi (obl)
75	Yoraperla brevis	Plecoptera	Peltoperlidae	3	SH	CN	
1192	Yoraperla brevis/mariana	Plecoptera	Peltoperlidae	0	SH	CN	
74	Yoraperla sp.	Plecoptera	Peltoperlidae	3	SH	CN	Semi (obl)
109	Calineuria californica	Plecoptera	Perlidae	5	PR	CN	Semi (obl)
108	Claassenia sabulosa	Plecoptera	Perlidae	6	PR	CN	Semi (obl)
110	Doroneuria sp.	Plecoptera	Perlidae	3	PR	CN	Semi (obl)
113	Hesperoperla pacifica	Plecoptera	Perlidae	6	PR	CN	Semi (obl)
104	Perlidae	Plecoptera	Perlidae	4	PR	CN	Semi (obl)
116	Cultus sp.	Plecoptera	Perlodidae	3	PR	CN	Uni
127	Isoperla sp.	Plecoptera	Perlodidae	4	PR/CG	CN	
119	Kogotus sp.	Plecoptera	Perlodidae	3	PR/SC	CN	Uni
121	Megarcys sp.	Plecoptera	Perlodidae	2	PR	CN	Semi (fac)
123	Perlinodes aurea	Plecoptera	Perlodidae	6	PR	CN	
114	Perlodidae	Plecoptera	Perlodidae	4	PR/SC/CG	CN	Uni
665	Rickera sorpta	Plecoptera	Perlodidae	3	PR	CN	
787	Setvena sp.	Plecoptera	Perlodidae	2	PR	CN	Semi (fac)

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126	Skwala sp.	Plecoptera	Perlodidae	6	PR	CN	Uni
66	Pteronarcella sp.	Plecoptera	Pteronarcyidae	6	SH	CN	Semi (fac)
65	Pteronarcyidae	Plecoptera	Pteronarcyidae	5	SH	CN	Semi (fac)
70	Pteronarcys californica	Plecoptera	Pteronarcyidae	6	SH	CN	Semi (obl)
71	Pteronarcys princeps	Plecoptera	Pteronarcyidae	3	SH	CN	Semi (obl)
69	Pteronarcys sp.	Plecoptera	Pteronarcyidae	5	SH	CN	Semi (obl)
77	Taeniopterygidae	Plecoptera	Taeniopterygidae	3	SH	CN	Uni
1126	Taeniopteryx sp.	Plecoptera	Taeniopterygidae	7	SH	CN	Uni
744	Trichoptera	Trichoptera					
875	Allomyia sp.	Trichoptera	Apataniidae	1	SH	CN	
212	Apatania sp.	Trichoptera	Apataniidae	3	SC/CG	CN	Uni
1251	Apataniidae	Trichoptera	Apataniidae		SC		
501	Amiocentrus aspilus	Trichoptera	Brachycentridae	6	SC/CG	CN	Multi (fac)
232	Amiocentrus sp.	Trichoptera	Brachycentridae	6	CG	CN	
500	Brachycentridae	Trichoptera	Brachycentridae	5	CF/CG/SH	CN	
234	Brachycentrus americanus	Trichoptera	Brachycentridae	5	CF/SC	CN	Uni
235	Brachycentrus occidentalis	Trichoptera	Brachycentridae	6	CF/SC	CN	Uni
233	Brachycentrus sp.	Trichoptera	Brachycentridae	5	CF/SC	CN	Uni
236	Micrasema sp.	Trichoptera	Brachycentridae	4	SH	CN	Semi (fac)
171	Agapetus sp.	Trichoptera	Glossosomatidae	5	SC/CG	CN	Uni
172	Anagapetus sp.	Trichoptera	Glossosomatidae	3	SC	CN	Uni
1091	Culoptila sp.	Trichoptera	Glossosomatidae	7	SC	CN	Multi (fac)
173	Glossosoma sp.	Trichoptera	Glossosomatidae	5	SC	CN	Multi (fac)
170	Glossosomatidae	Trichoptera	Glossosomatidae		SC	CN	
179	Protoptila sp.	Trichoptera	Glossosomatidae	7	SC	CN	Multi (fac)
238	Helicopsyche sp.	Trichoptera	Helicopsychidae	8	SC/CG	CN	Multi (fac)
192	Arctopsyche grandis	Trichoptera	Hydropsychidae	4	CF/PR	CN	Semi (fac)

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190	Arctopsychinae	Trichoptera	Hydropsychidae	4			
327	Chaetocladius sp.	Trichoptera	Hydropsychidae	6	CG	SP	
197	Cheumatopsyche sp.	Trichoptera	Hydropsychidae	8	CF	CN	Multi (fac)
1184	Hydropsyche morosa gr.	Trichoptera	Hydropsychidae	5	CF	CN	
198	Hydropsyche sp.	Trichoptera	Hydropsychidae	6	CF	CN	
196	Hydropsychidae	Trichoptera	Hydropsychidae		CF/PR	CN	
955	Hydropsychinae	Trichoptera	Hydropsychidae	6	CF		
194	Parapsyche almota	Trichoptera	Hydropsychidae	5	CF/PR	CN	Semi (fac)
195	Parapsyche elsis	Trichoptera	Hydropsychidae	2	CF/PR	CN	Semi (obl)
193	Parapsyche sp.	Trichoptera	Hydropsychidae	4	CF/PR	CN	Semi (fac)
181	Agraylea sp.	Trichoptera	Hydroptilidae	3	PI/CG	CM	Multi (fac)
182	Hydroptila sp.	Trichoptera	Hydroptilidae	8	PI/SC	CN	Multi (fac)
180	Hydroptilidae	Trichoptera	Hydroptilidae	8	PI/SC/CG	CN	
517	Leucotrichia sp.	Trichoptera	Hydroptilidae	9	SC/CG	CN	Multi (fac)
854	Mayatrichia sp.	Trichoptera	Hydroptilidae	8	SC/CG	CN	
1150	Metrichia sp.	Trichoptera	Hydroptilidae	7	SH		
594	Neotrichia sp.	Trichoptera	Hydroptilidae	8	SC	CN	
518	Ochrotrichia sp.	Trichoptera	Hydroptilidae	6	CG/PI	CN	Multi (fac)
765	Oxyethira sp.	Trichoptera	Hydroptilidae	9	PI	CM	Multi (fac)
184	Stactobiella sp.	Trichoptera	Hydroptilidae	6	SH	CN	Multi (fac)
237	Lepidostoma sp.	Trichoptera	Lepidostomatidae	5	SH	CM	Uni
521	Lepidostomatidae	Trichoptera	Lepidostomatidae	5	SH	CM	
611	Ceraclea sp.	Trichoptera	Leptoceridae	6	OM	CN	
242	Leptoceridae	Trichoptera	Leptoceridae	7	CG/SH/PR	CM	
243	Mystacides sp.	Trichoptera	Leptoceridae	6	CG/SH	SP	Multi (fac)
639	Nectopsyche sp.	Trichoptera	Leptoceridae	9	SH	CM/SP/CN	Multi (fac)
1092	Oecetis avara	Trichoptera	Leptoceridae	8	PR	CN	Multi (fac)

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1198	Oecetis disjuncta	Trichoptera	Leptoceridae	8	PR	CN/SP	
244	Oecetis sp.	Trichoptera	Leptoceridae	8	PR	CN	Multi (fac)
1138	Ylodes sp.	Trichoptera	Leptoceridae	8	SH	CM	Multi (fac)
201	Allocosmoecus partitus	Trichoptera	Limnephilidae	3	SC/SH	SP/CN	Uni
1143	Amphicosmoecus canax	Trichoptera	Limnephilidae	2	SH	CN	Uni
922	Anabolia sp.	Trichoptera	Limnephilidae	6	SH	CM	Uni
1162	Asynarchus sp.	Trichoptera	Limnephilidae	2		CM/SP	
215	Chyranda centralis	Trichoptera	Limnephilidae	2	SH	SP	Semi (fac)
202	Cryptochia sp.	Trichoptera	Limnephilidae	3	SH	SP	Semi (obl)
850	Desmona sp.	Trichoptera	Limnephilidae	2	SH	SP	Uni
204	Dicosmoecus atripes	Trichoptera	Limnephilidae	2	PR/SC/SH	CN	Semi (fac)
205	Dicosmoecus gilvipes	Trichoptera	Limnephilidae	5	SC/SH	CN	Semi (fac)
203	Dicosmoecus sp.	Trichoptera	Limnephilidae	4	OM	SP	Semi (fac)
206	Ecclisocosmoecus scylla	Trichoptera	Limnephilidae	2	SC		
207	Ecclisomyia sp.	Trichoptera	Limnephilidae	3	PR/SC/CG	CN/SP/CM	Uni
686	Eocosmoecus schmidi	Trichoptera	Limnephilidae	1	SH	CN	Semi (fac)
666	Eocosmoecus sp.	Trichoptera	Limnephilidae	1	SH	CN	Semi (fac)
761	Glyphopsyche sp.	Trichoptera	Limnephilidae	6		SP	
848	Goeracea sp.	Trichoptera	Limnephilidae	2	SC	CN	Semi (fac)
1123	Halesochila sp.	Trichoptera	Limnephilidae	1	CG/SH		
216	Hesperophylax sp.	Trichoptera	Limnephilidae	8	SH	SP	Uni
217	Homophylax sp.	Trichoptera	Limnephilidae	2	SH	CN	Uni
1124	Lenarchus sp.	Trichoptera	Limnephilidae	2	CG/SH	SP	Uni
199	Limnephilidae	Trichoptera	Limnephilidae		SH	CM	
219	Limnephilus sp.	Trichoptera	Limnephilidae	8	SH	CM	Uni
209	Onocosmoecus sp.	Trichoptera	Limnephilidae	5	SH	SP/CN	Uni
527	Onocosmoecus unicolor	Trichoptera	Limnephilidae	5	SH	SP	Uni

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210	Pedomoecus sierra	Trichoptera	Limnephilidae	3	SC	CN	
954	Philocasca sp.	Trichoptera	Limnephilidae	1	SH	SP	Semi (fac)
220	Psychoglypha sp.	Trichoptera	Limnephilidae	3	CG/SH/OM	SP	Uni
1244	Marilia sp.	Trichoptera	ODONTOCERIDAE	1	SH/OM		
593	Chimarra sp.	Trichoptera	Philopotamidae	7	CF	CN	Uni
188	Dolophilodes sp.	Trichoptera	Philopotamidae	2	CF	CN	Multi (fac)
187	Philopotamidae	Trichoptera	Philopotamidae		CF	CN	
189	Wormaldia sp.	Trichoptera	Philopotamidae	4	CF	AT	Multi (fac)
1212	Phryganeidae	Trichoptera	Phryganeidae	4	SH	CM	
1213	Ptilostomis sp.	Trichoptera	Phryganeidae		SH	CM/SP	
529	Polycentropodidae	Trichoptera	Polycentropidae	6	CF/PR	CN	
185	Polycentropus sp.	Trichoptera	Polycentropidae	6	PR/FI	CN/AT	Multi (fac)
1300	Psychomyia flavida	Trichoptera	Psychomyiidae	3.3	SC	AT/CN	Uni
186	Psychomyia lumina	Trichoptera	Psychomyiidae	6	SC/CG	AT	Uni
606	Psychomyia sp.	Trichoptera	Psychomyiidae	6	CG/SC	AT	Multi (fac)
825	Tinodes sp.	Trichoptera	Psychomyiidae	5	SC/CG	AT	Multi (fac)
155	Rhyacophila alberta gr.	Trichoptera	Rhyacophilidae	2	PR	CN	Semi (fac)
156	Rhyacophila angelita gr.	Trichoptera	Rhyacophilidae	5	PR	CN	Uni
162	Rhyacophila arnaudi	Trichoptera	Rhyacophilidae	6	PR	CN	Uni
157	Rhyacophila betteni gr.	Trichoptera	Rhyacophilidae	4	PR	CN	Uni
158	Rhyacophila brunnea gr.	Trichoptera	Rhyacophilidae	6	PR	CN	Uni
1174	Rhyacophila coloradensis	Trichoptera	Rhyacophilidae	1	PR	CN	
159	Rhyacophila coloradensis gr.	Trichoptera	Rhyacophilidae	7	PR	CN	Uni
160	Rhyacophila hyalinata gr.	Trichoptera	Rhyacophilidae	3	PR	CN	Semi (fac)
166	Rhyacophila narvae	Trichoptera	Rhyacophilidae	4	PR	CN	Uni
801	Rhyacophila pellisa/valuma	Trichoptera	Rhyacophilidae	4	PR	CN	
164	Rhyacophila sibirica gr.	Trichoptera	Rhyacophilidae	3	PR	CN	Uni

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153	Rhyacophila sp.	Trichoptera	Rhyacophilidae	4	PR	CN	Uni
168	Rhyacophila vagrita gr.	Trichoptera	Rhyacophilidae	3	PR	CN	Uni
169	Rhyacophila verrula	Trichoptera	Rhyacophilidae	2	SH	CN	Semi (fac)
1194	Rhyacophila verrula gr.	Trichoptera	Rhyacophilidae	1	PR	CN	
812	Rhyacophila vofixa gr.	Trichoptera	Rhyacophilidae	5	PR	CN	Semi (fac)
226	Neophylax occidentis	Trichoptera	Uenoidae	3	SC	CN	Uni
227	Neophylax rickeri	Trichoptera	Uenoidae	6	SC	CN	Uni
225	Neophylax sp.	Trichoptera	Uenoidae	4	SC	CN	Uni
228	Neophylax splendens	Trichoptera	Uenoidae	4	SC	CN	Uni
1187	Neothremma alicia	Trichoptera	Uenoidae	1	SC	CN	
229	Neothremma sp.	Trichoptera	Uenoidae	2	SC/CG	CN	Semi (obl)
231	Oligophlebodes sp.	Trichoptera	Uenoidae	3	SC/CG	CN	Uni
902	Sericostriata surdickae	Trichoptera	Uenoidae	1	SC/CG	CN	Semi (obl)
683	Uenoidae	Trichoptera	Uenoidae	2	SC/CG	CN	
Coelenterata: Hydrozoa							
689	Hydra sp.	Hydroida	Hydridae	9	PR	PL/AT	Multi (fac)
Mollusca: Bivalvia							
1137	Bivalvia	Bivalvia (class)			CF		
1206	Margaritifera falcata	Unionida	Margaritiferidae		CF		
1159	Gonidea angulata	Unionida	Unionidae	6	SC/CG	AT	Multi (fac)
990	Corbicula fluminea	Veneroida	Corbiculidae	9	CF/CG	SP	Multi (fac)
1289	Corbicula sp.	Veneroida	Corbiculidae	6.3	CF	BU	Multi
991	Musculium sp.	Veneroida	Sphaeriidae		CF	BU	Multi (fac)
435	Pisidium sp.	Veneroida	Sphaeriidae	5	CF	BU	Multi (fac)
567	Sphaeriidae	Veneroida	Sphaeriidae	6	CF		
826	Sphaerium sp.	Veneroida	Sphaeriidae	6	CF	BU	
Mollusca: Gastropoda							

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428	Ancylidae	Basommatophora	Ancylidae	8	SC	CN	
429	Ferrissia sp.	Basommatophora	Ancylidae	8	SC	CN	
563	Fossaria sp.	Basommatophora	Lymnaeidae	5	SC	CN	
430	Lymnaeidae	Basommatophora	Lymnaeidae	8	CG	CN	
1231	Radix auricularia	Basommatophora	Lymnaeidae		CG	CN	
605	Stagnicola sp.	Basommatophora	Lymnaeidae	8	CG	CN	
434	Physa (Physella) sp.	Basommatophora	Physidae	9	SC/CG	CN	
433	Physa sp.	Basommatophora	Physidae	9	CG	CN	
432	Physidae	Basommatophora	Physidae	9	CG	CN	
431	Gyraulus sp.	Basommatophora	Planorbidae	8	CG	CN	
1107	Helisoma sp.	Basommatophora	Planorbidae	8	SC	CN	
900	Planorbella sp.	Basommatophora	Planorbidae	8	SC	CN	
436	Planorbidae	Basommatophora	Planorbidae	7	CG	CN	
1308	Promenetus umbilicatellus	Basommatophora	Planorbidae		CG	CN	
834	Vorticifex effusa	Basommatophora	Planorbidae	7	SC	CN	
427	Gastropoda	Gastropoda (class)					
1234	Valvata humeralis	Heterostropha	Valvatidae	3	SC	CM	
738	Valvata sp.	Heterostropha	Valvatidae	3	CG	CM	
437	Fluminicola sp.	Neotaenioglossa	Hydrobiidae	7	SC		
560	Hydrobiidae	Neotaenioglossa	Hydrobiidae	5	SC	CN	
810	Potamopyrgus antipodarum	Neotaenioglossa	Hydrobiidae	9	SC/CG		Multi (obl)
808	Prionoxystus	Neotaenioglossa	Hydrobiidae				
1320	Pristinicola hemphilli	Neotaenioglossa	Hydrobiidae				
1207	Pristinicola sp.	Neotaenioglossa	Hydrobiidae				
1057	Pleuroceridae	Neotaenioglossa	Pleuroceridae		SC/CG		
1256	Thiaridae	Neotaenioglossa	Thiaridae				

Platyhelminthes: Turbellaria

ID	FinalID	Order	FAMILY	TOLVAL	FFG	Habit	LifeCycle
416	Turbellaria			4	PR	SP	Multi (fac)
608	Dugesia tigrina	Tricladida	Planariidae	8	PR	SP	Multi (fac)
619	Polycelis coronata	Tricladida	Planariidae	4	PR		
757	Polycelis sp.	Tricladida	Planariidae	4	PR		
Other							
417	Nematoda	Nematoda (phylum)		6	OM	BU	Multi (fac)
727	Nematomorpha	Nematomorpha (phylum)		8	PA	SP	Multi (fac)
1233	Prostoma sp.	Hoplonemertea	Tetrastemmatidae				
685	Porifera	Porifera (phylum)		6	CF	AT/CN	

Appendix I

Fish Index Trials

Table I-1. **Fish** index trials for the **streams** in the **mountain** site class. Trial 34 was ultimately selected as the fish Mountain index. Metric codes are as in report Table 5-1. Metrics preceded with "a" are adjusted by catchment size.

Type	Metric	MT1	MT2	MT3	MT4	MT5	MT6	MT7	MT8	MT9	MT10	MT11	MT12
Rich	aNatTax_fish	1	2	3		5	6	7	8	9	10	11	12
Rich	NatTax												
Rich	ExotPT	1	2	3		5	6	7	8	9	10	11	
Rich	aMinnTax_fish												12
Rich	aTotTax_fish												
Toler	ExoticPct	1	2			5	6			9	10		
Toler	NatIntPct	1	2	3		5	6	7	8	9	10	11	12
Toler	aLngLivPct_fish			3				7	8	9	10	11	12
Comp	IndPUEtime	1										11	
Comp	afDom01Pct_fish								8				
Comp	fIndpNatTax		2	3		5	6	7		9	10		12
Repro	aCypNumSiz_fish	1	2	3		5					10		
Repro	aLithPct_fish				4			7	8	9		11	12
Trophic	aInvrtPct_fish	1	2	3			6	7	8	9	10	11	12
Trophic	aPiscPct_fish												
Ref25th		81.6	84.2	81.7	74.6	82.7	85.9	80.0	77.6	82.3	83.4	79.7	69.0
Strs75th		85.1	86.6	84.9	98.8	89.1	85.4	83.8	83.9	85.9	86.7	81.1	70.7
DE25		66.7	66.7	66.7	50.0	61.1	72.2	72.2	72.2	72.2	66.7	72.2	72.2
Z-score		1.85	1.85	2.08	1.36	1.68	1.79	2.08	1.85	1.97	1.97	2.09	2.10
Comments								Rnk 3		Rnk 5			Rnk 2

Table I-1 (continued). **Fish** index trials for the **streams** in the **mountain** site class. Trial 34 was ultimately selected as the fish Mountain index. Metric codes are as in Table 5-1. Metrics preceded with "a" are adjusted by catchment size.

Type	Metric	MT13	MT14	MT15	MT16	MT17	MT18	MT19	MT20	MT21	MT22	MT23
Rich	aNatTax_fish	13		15	16	17	18	19	20		22	
Rich	NatTax		14									
Rich	ExotPT	13	14	15	16	17	18	19	20	21	22	23
Rich	aMinnTax_fish											
Rich	aTotTax_fish									21		23
Toler	ExoticPct				16	17	18	19	20	21	22	
Toler	NatIntPct	13	14	15	16	17	18	19	20	21	22	23
Toler	aLngLivPct_fish	13	14	15	16							
Comp	IndPUEtime						18	19				
Comp	afDom01Pct_fish			15	16	17		19	20	21	22	23
Comp	fIndpNatTax	13	14									
Repro	aCypNumSiz_fish				16		18		20	21		
Repro	aLithPct_fish					17						
Trophic	aInvrtPct_fish	13	14	15	16	17	18	19	20	21	22	23
Trophic	aPiscPct_fish											
Ref25th		82.0	81.2	78.8	79.1	81.1	81.6	79.9	78.5	78.3	81.6	76.7
Strs75th		82.7	77.8	82.8	87.0	84.5	85.1	76.8	85.8	83.7	83.7	77.3
DE25		72.2	77.8	72.2	66.7	72.2	66.7	83.3	72.2	72.2	72.2	72.2
Z-score		2.05	1.85	1.80	1.80	1.72	1.85	1.83	1.69	1.67	1.62	1.64
Comments												

Table I-1 (continued). **Fish** index trials for the **streams** in the **mountain** site class. Trial 34 was ultimately selected as the fish Mountain index. Metric codes are as in Table 5-1. Metrics preceded with "a" are adjusted by catchment size.

Type	Metric	MT24	MT25	MT26	MT27	MT28	MT29	MT30	MT31	MT32	MT33	MT34
Rich	aNatTax_fish	24				28			31	32	33	34
Rich	NatTax											
Rich	ExotPT	24	25	26	27	28		30				
Rich	aMinnTax_fish									32		
Rich	aTotTax_fish		25	26	27		29					
Toler	ExoticPct		25				29	30	31			
Toler	NatIntPct	24	25	26	27	28	29	30	31	32	33	34
Toler	aLngLivPct_fish										33	
Comp	IndPUEtime											
Comp	afDom01Pct_fish	24	25	26	27	28	29	30	31			
Comp	fIndpNatTax			26						32	33	34
Repro	aCypNumSiz_fish	24										
Repro	aLithPct_fish									32	33	34
Trophic	aInvrtPct_fish	24	25	26	27	28	29	30	31	32	33	34
Trophic	aPiscPct_fish				27							
Ref25th		78.6	79.8	79.7	76.0	77.9	80.0	80.0	80.8	69.0	80.5	82.8
Strs75th		83.5	81.0	71.6	78.9	80.4	79.7	83.7	82.6	65.8	82.4	79.0
DE25		72.2	72.2	77.8	72.2	72.2	72.2	72.2	72.2	77.8	72.2	77.8
Z-score		1.74	1.61	1.91	1.73	1.68	1.53	1.56	1.61	2.12	2.10	2.12
Comments				Rnk 4								Rnk 1

Table I-2. **Fish** index trials for the **streams** in the **foothills** site class. Trial 24 was ultimately selected as the fish Foothills index. Metric codes are as in Table 5-1. Metrics preceded with “a” are adjusted by catchment size.

Type	Metric	Fh1	Fh2	Fh3	Fh4	Fh5	Fh6	Fh7	Fh8	Fh9	Fh10	Fh11	Fh12
Rich	aMinnTax_fish	1	2	3	4	5	6	7	8	9	10	11	12
Rich	SlmSclpPT	1	2	3	4	5	6	7	8	9	10	11	12
Rich	aTotTax_fish												
Toler	aCldWtrPct_fish	1	2	3	4	5	6						
Toler	ModTolerPct								8				
Toler	aLngLivPct_fish							7		9			
Comp	aMinnPct_fish				4	5		7			10	11	12
Comp	IndPUEtime	1	2	3			6		8	9			
Repro	aCypNumSiz_fish	1	2		4	5		7	8	9	10	11	12
Repro	HiderTaxa			3									
Repro	SalNumSiz						6						
Trophic	aBenTax_fish		2		4			7			10		
Trophic	FOHPct											11	
Trophic	PiscPct	1		3		5	6		8	9			
Ref25th		85.4	84.1	83.3	81.7	85.9	78.4	68.3	85.4	68.7	82.0	88.2	85.3
Strs75th		54.5	65.1	49.6	58.1	48.6	55.2	49.4	59.2	43.9	59.3	61.3	56.9
DE25		92.3	84.6	92.3	84.6	92.3	84.6	84.6	92.3	84.6	84.6	84.6	84.6
Z-score		3.13	3.71	2.98	2.95	2.62	2.89	3.25	3.12	3.36	3.25	3.76	3.28
Comments			Rnk 2					Rnk 5				Rnk 3	

Table I-2 (continued). **Fish** index trials for the **streams** in the **foothills** site class. Trial 24 was ultimately selected as the fish Foothills index. Metric codes are as in Table 5-1. Metrics preceded with "a" are adjusted by catchment size.

Type	Metric	Fh13	Fh14	Fh15	Fh16	Fh17	Fh18	Fh19	Fh20	Fh21	Fh22	Fh23	Fh24
Rich	aMinnTax_fish	13	14	15	16				20	21		23	24
Rich	SlmSclpPT	13	14	15	16		18	19	20	21	22	23	24
Rich	aTotTax_fish					17							
Toler	aCldWtrPct_fish	13	14	15	16	17	18	19	20	21	22		
Toler	ModTolerPct									21	22	23	24
Toler	aLngLivPct_fish							19	20				
Comp	aMinnPct_fish	13	14	15	16	17	18	19	20	21	22	23	24
Comp	IndPUEtime												
Repro	aCypNumSiz_fish	13		15	16	17	18	19	20		22	23	
Repro	HiderTaxa												
Repro	SalNumSiz												
Trophic	aBenTax_fish		14	15									24
Trophic	FOHPct		14	15	16	17	18	19	20	21	22	23	24
Trophic	PiscPct												
Ref25th		84.3	86.0	84.3	86.9	69.3	87.8	73.2	74.5	91.2	89.8	90.2	89.2
Strs75th		54.0	69.3	64.1	59.7	45.9	55.9	46.5	51.2	66.8	58.6	63.1	73.1
DE25		84.6	76.9	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6
Z-score		2.90	3.43	3.27	3.24	2.35	2.91	2.91	3.24	3.00	2.69	3.29	3.51
Comments			Rnk 4										Rnk 1

Table I-3. **Fish** index trials for the **streams** in the **PPBV** site class. Trial 23 was ultimately selected as the fish PPBV index. Metric codes are as in Table 5-1. Metrics preceded with "a" are adjusted by catchment size.

Type	Metric	PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10	PP11	PP12
Rich	aNatTax_fish	1		3						9			
Rich	aTotTax_fish					5		7					
Rich	fTotalTax						6		8				
Toler	aLngLivPct_fish	1	2	3	4	5	6					11	
Toler	ExotPT												
Toler	CldWtrPct							7	8	9	10		12
Toler	aCldWtrPct_fish												
Comp	fIndpNatTax	1			4	5	6	7	8	9	10		12
Comp	afDom01Pct_fish											11	
Comp	aMinnPct_fish												
Repro	aLithPct_fish	1		3	4	5	6	7	8	9	10	11	12
Trophic	aInvrtPct_fish	1		3	4	5	6	7	8	9	10	11	12
Trophic	aPiscPct_fish	1		3	4	5	6	7	8	9	10	11	12
Ref25th		78.6	40.7	82.0	86.8	85.4	82.1	68.8	65.4	61.9	66.8	82.6	66.8
Strs75th		84.5	100.0	84.9	89.5	85.9	84.6	69.2	68.4	67.8	69.5	89.9	69.5
DE25		66.7	26.7	73.3	66.7	73.3	66.7	73.3	66.7	60.0	66.7	66.7	66.7
Z-score		1.63	0.39	1.55	1.44	1.68	1.60	1.69	1.60	1.58	1.45	1.55	1.45
Comments		Rnk 4		Rnk 2			Rnk 5						

Table I-3 (continued). **Fish** index trials for the **streams** in the **PPBV** site class. Trial 23 was ultimately selected as the fish PPBV index. Metric codes are as in Table 5-1. Metrics preceded with "a" are adjusted by catchment size.

Type	Metric	PP13	PP14	PP15	PP16	PP17	PP18	PP19	PP20	PP21	PP22	PP23
Rich	aNatTax_fish				16	17	18				22	23
Rich	aTotTax_fish	13		15				19	20	21		
Rich	fTotalTax		14									
Toler	aLngLivPct_fish	13		15	16	17	18	19	20	21		
Toler	ExotPT				16	17			20		22	23
Toler	CldWtrPct											
Toler	aCldWtrPct_fish		14									
Comp	fIndpNatTax		14					19				
Comp	afDom01Pct_fish	13		15	16	17	18		20			
Comp	aMinnPct_fish											23
Repro	aLithPct_fish	13	14	15	16	17	18	19	20	21	22	23
Trophic	aInvrtPct_fish	13	14			17				21	22	23
Trophic	aPiscPct_fish	13	14	15	16	17	18	19	20	21	22	23
Ref25th		78.0	78.2	73.6	77.7	77.8	73.2	82.5	77.8	84.2	86.3	77.7
Strs75th		86.9	82.3	84.3	78.8	81.4	79.2	83.0	79.0	89.9	79.2	76.4
DE25		60.0	66.7	60.0	73.3	66.7	60.0	73.3	73.3	66.7	86.7	86.7
Z-score		1.59	1.85	1.48	1.28	1.44	1.35	1.69	1.48	1.65	1.34	1.62
Comments			Rnk 3									Rnk 1

Table I-4. **Fish** index trials for the **rivers** in the **mountain** site class. Trial 17 was ultimately selected as the fish PPBV index. Metric codes are as in Table 5-1.

Metric	1	2	3	4	5	6	7	8	9	10
fTotalTax		2							9	
ExoticPT	1		3	4	5	6	7	8		10
MinnTax			3							
SucTax	1	2			5					
SuckerPct						6	7	8	9	
Dom01Pct	1	2	3	4	5	6	7	8	9	10
InvrtPct							7			
FOHPct	1	2	3	4	5	6		8	9	10
BenTax										10
CldWtrPct				4						
LithPct								8	9	10
CypNumSiz	1	2	3	4	5	6	7			
NatIntTax					5	6	7	8	9	10
TolerPct	1	2	3	4						
ref25th	86.2	83.4	87.0	88.4	86.2	88.5	83.6	86.1	83.7	75.4
DE	100	100	100	100	100	100	100	100	100	100
z-score	2.04	1.94	1.81	1.78	2.51	2.69	2.41	3.21	2.99	2.65

Table I-4 (continued). **Fish** index trials for the **rivers** in the **mountain** site class. Trial 17 was ultimately selected as the fish PPBV index. Metric codes are as in Table 5-1.

Metric	11	12	13	14	15	16	17	18	19
fTotalTax									
ExoticPT	11		13	14	15	16	17	18	19
MinnTax									
SucTax									
SuckerPct	11	12	13		15	16	17	18	19
Dom01Pct	11	12	13	14					
InvrtPct						16			
FOHPct	11	12	13	14	15	16	17	18	19
BenTax									
CldWtrPct								18	
LithPct	11	12		14	15	16	17		19
LngLivPct									19
CypNumSiz							17	18	
NatIntTax		12	13	14	15	16	17	18	19
NatIntPct	11								
TolerPct									
ref25th	78.4	83.4	86.3	83.4	87.0	83.6	84.6	89.9	79.7
DE	100	88.9	100	100	88.9	88.9	100	100	88.9
z	2.53	3.23	2.83	2.78	3.79	3.91	3.59	2.86	4.29

Table I-5. **Fish** index trials for the **rivers** in the **non-mountain** site class. Trial 22 was ultimately selected as the fish PPBV index. Metric codes are as in Table 5-1.

Metric	1	2	3	4	5	6	7	8	9	10
NatTax	1	2	3	4	5	6	7			10
ExoticPT	1	2	3	4	5	6	7	8	9	10
SunTaxa	1	2	3	4	5					
SuckerPct									9	10
InvrtPct	1		3	4	5	6	7		9	10
PisciTaxa		2								
FOHPct							7			
LithPct	1	2	3		5	6	7			
LithTaxa									9	
SalNumSiz				4						
ModTolerPct	1	2		4						
IntolTax					5	6	7	8	9	10
NatIntTax			3							
Ref25th	59.27	61.98	61.33	61.05	61.33	62.71	55.14	58.04	66.60	72.86
DE25	61.54	61.54	61.54	53.85	61.54	69.23	53.85	69.23	61.54	69.23
z	1.52	1.81	1.51	1.70	1.51	1.76	1.34	1.69	1.34	1.71

Table I-5 (continued). **Fish** index trials for the **rivers** in the **non-mountain** site class. Trial 22 was ultimately selected as the fish PPBV index. Metric codes are as in Table 5-1.

Metric	11	12	13	14	15	16	17	18	19	20
NatTax	11	12	13	14	15	16	17	18	19	20
ExoticPT	11	12	13	14	15	16	17	18	19	20
SunTaxa		12	13	14	15	16	17	18	19	20
SuckerPct	11		13	14			17		19	20
CldWtrPct	11									
InvrtPct	11			14						
PisciTaxa		12	13			16		18	19	20
FOHPct					15		17			
LithPct		12	13	14	15		17		19	
LithTaxa						16		18		20
IntolTax	11	12	13	14	15	16	17			
NatIntPct								18	19	20
Ref25th	62.99	66.97	67.85	66.86	58.91	65.92	64.78	65.79	67.24	67.35
DE25	69.23	76.92	76.92	61.54	69.23	76.92	69.23	76.92	84.62	84.62
z	1.55	1.58	1.52	1.45	1.53	1.71	1.55	1.74	1.58	1.75

Table I-5 (continued). **Fish** index trials for the **rivers** in the **non-mountain** site class. Trial 22 was ultimately selected as the fish PPBV index. Metric codes are as in Table 5-1.

Metric	21	22	23	24	25	26	27	28	29	30
NatTax	21	22	23	24	25	26	27	28	29	30
ExoticPT	21	22	23	24	25	26	27	28	29	30
NatMinTax		22	23	24	25	26	27		29	30
SuckerPct	21							28		
InvrtPct					25		27	28	29	
PisciTaxa	21	22	23	24		26				30
LithPct		22	23	24	25					
LithTaxa	21					26				
IntolTax		22			25	26	27	28	29	30
NatIntTax			23							
NatIntPct	21			24						
Ref25th	63.52	67.44	67.44	65.41	62.71	67.15	66.43	72.86	66.43	68.04
DE25	69.23	76.92	76.92	69.23	69.23	69.23	69.23	69.23	69.23	69.23
z	1.56	1.61	1.61	1.71	1.76	1.71	2.36	1.71	2.36	1.86

Appendix J

Fish Taxa Attributes

Appendix J
Fish Taxa Attributes

Table J-1. Abbreviations

Abbreviation	Meaning
Habits	
B	Benthic
WC	Water column
-H	Hider
Tolerance	
II	Intolerant
MI	Moderately intolerant
MT	Moderately tolerant
TT	Tolerant
Trophic guilds	
H	Herbivore
O	Omnivore
I	Invertivore
IP	Invertivore/Piscivore
P	Piscivore

Table J-2. Fish taxa and their attributes.

AFSCNAME	AFSSNAME	FFAMILY	Habitat	Native	Toler.	Cld/Wrm	Longlive	Litho.	Trophic	Anad.
fish	Unidentified			0						
CRAYFISH		<vertebrate>								
SPOTTED FROG	Rana pretiosa	<vertebrate>								
GREAT BASIN SPADEFOOT	Spea intermontana	<vertebrate>								

AFSCNAME	AFSSNAME	FFAMILY	Habitat	Native	Toler.	Cld/Wrm	Longlive	Litho.	Trophic	Anad.
bluehead sucker	Catostomus discobolus	Catastomidae	B	1	MT	COL	X		H	
bridgelip sucker	Catostomus columbianus	Catastomidae	B	1	MT	COL	X		H	
largescale sucker	Catostomus macrocheilus	Catastomidae	B	1	MT	COL	X		O	
longnose sucker	Catostomus catostomus	Catastomidae	B	1	MI	CLD	X	X	I	
mountain sucker	Catostomus platyrhychus	Catastomidae	B	1	MI	COL	X		H	
sucker	Catostomus sp.	Catastomidae	B	1			X			
Utah sucker	Catostomus ardens	Catastomidae	B	1	MT	COL	X		O	
sunfish	Centrarchidae	Centrarchidae	WC	0	MT					
bluegill	Lepomis macrochirus	Centrarchidae	WCH	0	MT	WRM			IP	
pumpkinseed	Lepomis gibbosus	Centrarchidae	WCH	0	MT	COL			IP	
sunfish	Lepomis sp.	Centrarchidae	WC	0	MT				IP	
bass	Micropterus sp.	Centrarchidae	WC	0	MT		X		P	
largemouth bass	Micropterus salmoides	Centrarchidae	WCH	0	MT	WRM	X		P	
smallmouth bass	Micropterus dolomieu	Centrarchidae	WCH	0	MI	COL	X		P	
black crappie	Pomoxis nigromaculatus	Centrarchidae	WCH	0	MT	WRM			IP	
Mozambique tilapia	Tilapia mossambica	CICHLIDAE	WC	0	TT	WRM			IP	
mottled sculpin	Cottus bairdi	COTTIDAE	BH	1	MI	COL			I	
Paiute sculpin	Cottus beldingi	COTTIDAE	BH	1	MI	CLD			I	
sculpin	Cottus sp.	COTTIDAE	B	1	MI	CLD			I	
shorthead sculpin	Cottus confusus	COTTIDAE	BH	1	II	CLD			I	
slimy sculpin	Cottus cognatus	COTTIDAE	BH	1	MI	CLD			I	
torrent sculpin	Cottus rhotheus	COTTIDAE	BH	1	MI	CLD			IP	
Wood river sculpin	Cottus leiopomus	COTTIDAE	BH	1	II	CLD			I	
chiselmouth	Acrocheilus alutaceus	Cyprinidae	B	1	MT	COL			H	
minnows	Cyprinidae	Cyprinidae		0		COL				
common carp	Cyprinus carpio	Cyprinidae	B	0	TT	WRM	X		O	

AFSCNAME	AFSSNAME	FFAMILY	Habitat	Native	Toler.	Cld/Wrm	Longlive	Litho.	Trophic	Anad.
Utah chub	Gila atraria	Cyprinidae	WCH	1	MT	COL	X		O	
northern squawfish	Ptychocheilus oregonensis	Cyprinidae	WC	1	TT	COL			IP	
squawfish	Ptychocheilus sp.	Cyprinidae	WC	1	TT	COL			IP	
dace	Rhinichthys sp.	Cyprinidae	B	0	MT	COL		X	I	
leopard dace	Rhinichthys falcatus	Cyprinidae	BH	1	MI	COL		X	I	
longnose dace	Rhinichthys cataractae	Cyprinidae	BH	1	MI	COL		X	I	
speckled dace	Rhinichthys osculus	Cyprinidae	BH	1	MT	COL		X	I	
redside shiner	Richardsonius balteatus	Cyprinidae	WC	1	MT	COL		X	I	
shiner	Richardsonius sp.	Cyprinidae	WC	1	MT	COL			I	
tench	Tinca tinca	Cyprinidae	WC	0	MT	WRM			I	
black bullhead	Ameiurus melas	ICTALURIDAE	BH	0	TT	WRM			IP	
catfish	Ictalurus sp.	ICTALURIDAE		0	TT	WRM				
yellow perch	Perca flavescens	PERCIDAE	WC	0	MI	COL			IP	
Pacific lamprey	Lampetra tridentata	Petromyzontidae		1			X	X	O	A
western mosquitofish	Gambusia affinis	POECILIIDAE	WC	0	TT	WRM			I	
guppy	Poecilia reticulata	POECILIIDAE	WC	0	TT	WRM			O	
green swordtail	Xiphophorus helleri	POECILIIDAE	WC	0	TT	WRM			O	
lake whitefish	Coregonus clupeaformis	Salmonidae	WC	0	MI	CLD			I	
whitefish	Coregonus sp.	Salmonidae	WC	0	MI	CLD			I	
chinook salmon	Oncorhynchus tshawytscha	Salmonidae	WC	1	II	CLD	X	X	I	A
coho salmon	Oncorhynchus kisutch	Salmonidae	WC	1	II	CLD	X	X	I	A
cutthroat trout	Oncorhynchus clarki	Salmonidae	WCH	1	II	CLD	X	X	IP	
cutthroat trout (all stocks) x rainbow trout	Oncorhynchus clarki X O. mykiss	Salmonidae	WC	1	II	CLD	X	X	IP	
kokanee	Oncorhynchus nerka	Salmonidae	WC	1	II	CLD	X	X	I	

AFSCNAME	AFSSNAME	FFAMILY	Habitat	Native	Toler.	Cld/Wrm	Longlive	Litho.	Trophic	Anad.
Pacific salmon/trout	Oncorhynchus sp.	Salmonidae	WC	1	II	CLD	X	X		
rainbow trout	Oncorhynchus mykiss	Salmonidae	WCH	1	II	CLD	X	X	IP	
steelhead	Oncorhynchus mykiss	Salmonidae	WC	1	II	CLD	X	X	IP	
Bear Lake whitefish	Prosopium abyssicola	Salmonidae	WC	1	MI	CLD			I	
Bonneville cisco	Prosopium gemmiferum	Salmonidae	WC	1	II	CLD			I	
mountain whitefish	Prosopium williamsoni	Salmonidae	B	1	MI	CLD			I	
pygmy whitefish	Prosopium coulteri	Salmonidae	WC	1	MI	CLD			I	
whitefish	Prosopium sp.	Salmonidae		1		CLD				
Atlantic salmon	Salmo salar	Salmonidae	WC	0	II	CLD	X	X	IP	
Atlantic salmon/trout	Salmo sp.	Salmonidae	WC	0		CLD	X	X	IP	
brown trout	Salmo trutta	Salmonidae	WCH	0	MI	CLD	X	X	IP	
trout	Salmonidae	Salmonidae		0		CLD	X	X		
brook trout	Salvelinus fontinalis	Salmonidae	WCH	0	MI	CLD	X	X	IP	
brook trout x bull trout	Salvelinus fontinalis X S. confluentus	Salmonidae	WCH	0	II	CLD	X	X	IP	
bull trout	Salvelinus confluentus	Salmonidae	WCH	1	II	CLD	X	X	IP	
char	Salvelinus sp.	Salmonidae	WCH	0		CLD	X	X		
mudminnows	Umbridae	UMBRIDAE	B		MT					

Appendix K

Habitat Index Trials

Table K-1. **Habitat** index trials for the **streams** in all **Riffle-Run** sites. Trial 3 contains the metrics of the SHI. Trial 22 was ultimately selected as the Habitat Riffle-Run index. Metric codes are as in Table 6-2.

	RR1	RR2	RR3	RR4	RR5	RR6	RR7	RR8	RR9	RR10	RR11	RR12
AvPoMAXDEPTH				4								12
AvPoSUBSIZE		2									11	12
BankCoverPercent			3									
BankStabPercent							7	8		10		
CanopyRaw	1	2	3	4	5	6	7	8	9	10	11	12
CSHAPERaw			3									
EMBEDRaw	1	2	3	4	5	6	7	8	9	10	11	12
LODRaw	1	2	3	4	5	6	7	8	9	10	11	12
PctFinesBF	1	2						8				
PctFinesWW			3	4	5	6	7		9	10	11	12
PoolRiffleRatio							7	8	9			
STREAMCORaw	1	2	3	4	5	6	7	8	9	10	11	12
WDRatio				4		6			9	10		
WolmanRaw	1	2	3	4	5	6	7	8	9	10	11	12
DISPRES	1	2	3	4	5	6	7	8	9	10	11	12
ZONEINFL		2	3	4	5	6	7	8	9	10	11	12
RefSD	10.64	10.57	8.83	10.12	10.22	10.10	8.45	8.47	9.14	9.27	10.75	10.18
DE25	81.3	84.6	83.5	82.4	83.5	81.3	80.2	81.3	80.2	81.3	83.5	83.3
z-score	1.92	2.06	2.16	1.89	2.12	1.95	2.15	2.14	1.90	2.05	2.16	1.96
Remarks			SHI									

Table K-1 (continued). **Habitat** index trials for the **streams** in all **Riffle-Run** sites. Trial 3 contains the metrics of the SHI. Trial 22 was ultimately selected as the Habitat Riffle-Run index. Metric codes are as in Table 6-2.

	RR13	RR14	RR15	RR16	RR17	RR18	RR19	RR20	RR21	RR22	RR23	RR24
AvPoMAXDEPTH	13					18						
AvPoSUBSIZE				16	17		19		21			
BankCoverPercent								20		22		
BankStabPercent	13	14			17	18	19		21		23	
CanopyRaw	13	14	15	16	17	18	19	20	21		23	
CSHAPERaw		14	15						21			24
EMBEDRaw	13	14	15	16	17	18	19	20			23	
LODRaw	13	14	15	16	17	18	19	20			23	
PctFinesBF				16		18						
PctFinesWW	13	14	15		17		19	20	21	22	23	
PoolRiffleRatio												
STREAMCORaw	13	14	15	16	17	18	19	20	21	22	23	24
WDRatio												
WolmanRaw	13	14	15	16	17	18	19	20			23	
DISPRES	13	14	15	16	17	18	19	20	21	22	23	24
ZONEINFL	13	14	15	16	17	18	19	20		22	23	24
RefSD	9.13	8.88	9.67	10.44	9.57	9.22	9.67	9.24	9.19	8.56	9.31	10.80
DE25	82.1	83.5	84.6	83.3	80.8	83.3	83.5	82.4	85.7	86.8	81.3	76.9
z-score	2.10	2.20	2.10	2.03	2.13	2.08	2.16	2.18	2.15	2.74	2.22	2.19
Remarks									BestOfCat	PPBVbest	MtnBest	FHbest

Table K-2. **Habitat** index trials for the **streams** in **Mountain** Riffle-Run sites. Trial 5 contains the metrics of the SHI. Trial 20 was ultimately selected as the Habitat Mountain index. Metric codes are as in Table 6-2.

	Mtn1	Mtn2	Mtn3	Mtn4	Mtn5	Mtn6	Mtn7	Mtn8	Mtn9	Mtn10	Mtn11
AvPoMAXDEPTH	Mtn1	Mtn2	Mtn3			Mtn6					
AvPoSUBSIZE			Mtn3								
AvPoLENGTH											
BankCoverPercent					Mtn5						
BankStabPercent									Mtn9	Mtn10	
CanopyRaw				Mtn4	Mtn5	Mtn6	Mtn7	Mtn8	Mtn9	Mtn10	Mtn11
CSHAPERaw		Mtn2	Mtn3		Mtn5						
EMBEDRaw		Mtn2	Mtn3	Mtn4	Mtn5	Mtn6	Mtn7	Mtn8	Mtn9	Mtn10	Mtn11
LODRaw	Mtn1	Mtn2	Mtn3	Mtn4	Mtn5	Mtn6	Mtn7	Mtn8	Mtn9	Mtn10	Mtn11
PctFinesBF	Mtn1	Mtn2	Mtn3	Mtn4						Mtn10	
PctFinesWW					Mtn5	Mtn6	Mtn7	Mtn8	Mtn9		Mtn11
PoolRiffleRatio									Mtn9	Mtn10	Mtn11
STREAMCORaw	Mtn1	Mtn2	Mtn3	Mtn4	Mtn5	Mtn6	Mtn7	Mtn8	Mtn9	Mtn10	Mtn11
WDRatio						Mtn6		Mtn8			Mtn11
WolmanRaw	Mtn1	Mtn2	Mtn3	Mtn4	Mtn5	Mtn6	Mtn7	Mtn8	Mtn9	Mtn10	Mtn11
DISPRES	Mtn1	Mtn2	Mtn3	Mtn4	Mtn5	Mtn6	Mtn7	Mtn8	Mtn9	Mtn10	Mtn11
ZONEINFL	Mtn1	Mtn2	Mtn3		Mtn5	Mtn6	Mtn7	Mtn8	Mtn9	Mtn10	Mtn11
RefSD	9.02	8.37	8.88	8.78	7.40	7.81	8.21	8.12	7.07	7.25	7.56
DE25	80.6	83.9	90.3	81.6	81.6	87.1	84.2	86.8	81.6	78.9	78.9
z-score	1.85	1.80	1.72	1.85	2.19	1.82	2.22	2.03	2.23	2.13	2.00
Remarks					SHI						

Table K-2 (continued). **Habitat** index trials for the **streams** in **Mountain** Riffle-Run sites. Trial 3 contains the metrics of the SHI. Trial 20 was ultimately selected as the Habitat Mountain index. Metric codes are as in Table 6-2.

	Mtn12	Mtn13	Mtn14	Mtn15	Mtn16	Mtn17	Mtn18	Mtn19	Mtn20	Mtn21	Mtn22
AvPoMAXDEPTH			Mtn14	Mtn15	Mtn16						
AvPoSUBSIZE		Mtn13	Mtn14								
AvPoLENGTH											
BankCoverPercent											
BankStabPercent	Mtn12			Mtn15	Mtn16	Mtn17			Mtn20	Mtn21	
CanopyRaw	Mtn12	Mtn13	Mtn14	Mtn15	Mtn16	Mtn17	Mtn18		Mtn20	Mtn21	
CSHAPERaw						Mtn17	Mtn18	Mtn19			Mtn22
EMBEDRaw	Mtn12	Mtn13	Mtn14	Mtn15	Mtn16	Mtn17	Mtn18		Mtn20	Mtn21	Mtn22
LODRaw	Mtn12	Mtn13	Mtn14	Mtn15	Mtn16	Mtn17	Mtn18		Mtn20	Mtn21	Mtn22
PctFinesBF					Mtn16					Mtn21	Mtn22
PctFinesWW	Mtn12	Mtn13	Mtn14	Mtn15		Mtn17	Mtn18		Mtn20		
PoolRiffleRatio											
STREAMCORaw	Mtn12	Mtn13	Mtn14	Mtn15	Mtn16	Mtn17	Mtn18	Mtn19	Mtn20	Mtn21	Mtn22
WDRatio	Mtn12										
WolmanRaw	Mtn12	Mtn13	Mtn14	Mtn15	Mtn16	Mtn17	Mtn18		Mtn20	Mtn21	Mtn22
DISPRES	Mtn12	Mtn13	Mtn14	Mtn15	Mtn16	Mtn17	Mtn18	Mtn19	Mtn20	Mtn21	Mtn22
ZONEINFL	Mtn12	Mtn13	Mtn14	Mtn15	Mtn16	Mtn17	Mtn18	Mtn19	Mtn20	Mtn21	Mtn22
RefSD	7.50	8.48	8.33	7.19	7.44	7.36	7.98	9.95	7.54	7.69	8.46
DE25	86.8	80.6	87.1	83.9	87.1	81.6	84.2	73.7	86.8	84.2	86.8
z-score	2.10	1.94	1.87	2.04	1.93	2.22	2.15	2.26	2.28	2.19	2.08
Remarks									MtnBest		

Table K-2 (continued). **Habitat** index trials for the **streams** in **Mountain** Riffle-Run sites. Trial 3 contains the metrics of the SHI. Trial 30 was ultimately selected as the Habitat Mountain index. Metric codes are as in Table 6-2.

	Mtn23	Mtn24	Mtn25	Mtn26	Mtn27	Mtn28	Mtn29	Mtn30	Mtn31
AvPoMAXDEPTH		Mtn24	Mtn25						
AvPoSUBSIZE	Mtn23			Mtn26			Mtn29		
AvPoLENGTH						Mtn28			
BankCoverPercent					Mtn27			Mtn30	
BankStabPercent		Mtn24	Mtn25	Mtn26			Mtn29		
CanopyRaw	Mtn23	Mtn24	Mtn25	Mtn26	Mtn27		Mtn29		
CSHAPERaw						Mtn28	Mtn29		Mtn31
EMBEDRaw	Mtn23	Mtn24	Mtn25	Mtn26	Mtn27				
LODRaw	Mtn23	Mtn24	Mtn25	Mtn26	Mtn27				
PctFinesBF	Mtn23	Mtn24	Mtn25						
PctFinesWW				Mtn26	Mtn27		Mtn29	Mtn30	
PoolRiffleRatio									
STREAMCORaw	Mtn23	Mtn24	Mtn25	Mtn26	Mtn27	Mtn28	Mtn29	Mtn30	Mtn31
WDRatio									
WolmanRaw	Mtn23	Mtn24	Mtn25	Mtn26	Mtn27				
DISPRES	Mtn23	Mtn24	Mtn25	Mtn26	Mtn27	Mtn28	Mtn29	Mtn30	Mtn31
ZONEINFL	Mtn23	Mtn24	Mtn25	Mtn26	Mtn27	Mtn28		Mtn30	Mtn31
RefSD	8.74	7.44	7.44	7.87	7.56	8.71	8.36	7.82	9.95
DE25	87.1	87.1	87.1	80.6	86.8	74.2	77.4	84.2	73.7
z-score	1.85	1.93	1.93	1.98	2.27	1.89	1.73	2.59	2.26
Remarks							BestOfCat	PPBVbest	FHbest

Table K-3. **Habitat** index trials for the **streams** in **Foothills** Riffle-Run sites. Trial 3 contains the metrics of the SHI. Trial 38 was ultimately selected as the Habitat Foothills index. Metric codes are as in Table 6-2.

	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH9	FH10	FH11	FH12
AvPoMAXDEPTH				FH4								FH12
AvPoMAXWIDTH												
AvPoSUBSIZE		FH2									FH11	FH12
AvPoCOVER												
AvPoUCBANK												
AvPoLENGTH												
BankCoverPercent			FH3									
BankStabPercent							FH7	FH8		FH10		
CanopyRaw	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH9	FH10	FH11	FH12
CSHAPERaw			FH3									
EMBEDRaw	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH9	FH10	FH11	FH12
LODRaw	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH9	FH10	FH11	FH12
PctFinesBF	FH1	FH2						FH8				
PctFinesWW			FH3	FH4	FH5	FH6	FH7		FH9	FH10	FH11	FH12
PoolRiffleRatio							FH7	FH8	FH9			
STREAMCORaw	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH9	FH10	FH11	FH12
WDRatio				FH4		FH6			FH9	FH10		
WolmanRaw	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH9	FH10	FH11	FH12
DISPRES	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH9	FH10	FH11	FH12
ZONEINFL		FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH9	FH10	FH11	FH12
RefSD	13.31	13.15	9.89	11.76	12.67	11.95	10.96	10.64	11.39	10.82	13.34	13.24
DE25	50.0	50.0	72.2	44.4	55.6	44.4	44.4	44.4	44.4	50.0	61.1	55.6
z-score	0.74	0.92	1.25	0.66	0.93	0.72	0.84	0.84	0.61	0.78	0.94	0.85
Remarks			SHI									

Table K-3 (continued). **Habitat** index trials for the **streams** in **Foothills** Riffle-Run sites. Trial 3 contains the metrics of the SHI. Trial 38 was ultimately selected as the Habitat Foothills index. Metric codes are as in Table 6-2.

	FH13	FH14	FH15	FH16	FH17	FH18	FH19	FH20	FH21	FH22	FH23	FH24
AvPoMAXDEPTH					FH17							
AvPoMAXWIDTH												
AvPoSUBSIZE												FH24
AvPoCOVER		FH14	FH15						FH21			FH24
AvPoUCBANK		FH14		FH16	FH17	FH18			FH21			
AvPoLENGTH												
BankCoverPercent											FH23	
BankStabPercent			FH15				FH19					
CanopyRaw	FH13	FH14	FH15	FH16	FH17	FH18	FH19		FH21	FH22	FH23	
CSHAPERaw	FH13	FH14	FH15			FH18	FH19	FH20	FH21	FH22	FH23	FH24
EMBEDRaw	FH13	FH14	FH15	FH16	FH17	FH18	FH19		FH21	FH22	FH23	
LODRaw	FH13			FH16	FH17	FH18	FH19				FH23	
PctFinesBF												
PctFinesWW	FH13	FH14	FH15	FH16	FH17	FH18	FH19				FH23	
PoolRiffleRatio												
STREAMCORaw	FH13	FH14	FH15	FH16	FH17	FH18	FH19	FH20	FH21	FH22	FH23	FH24
WDRatio												FH24
WolmanRaw	FH13			FH16	FH17	FH18	FH19				FH23	
DISPRES	FH13	FH14	FH15	FH16	FH17	FH18	FH19		FH21	FH22	FH23	FH24
ZONEINFL	FH13	FH14	FH15	FH16	FH17	FH18	FH19	FH20	FH21	FH22	FH23	FH24
RefSD	11.14	10.52	9.55	11.69	11.48	10.61	10.10	11.45	10.81	10.33	10.08	10.34
DE25	77.8	61.1	66.7	55.6	55.6	72.2	66.7	72.2	55.6	72.2	72.2	83.3
z-score	1.19	1.16	1.34	0.91	0.83	1.13	1.24	1.90	1.29	1.55	1.22	1.42
Remarks												

Table K-3 (continued). **Habitat** index trials for the **streams** in **Foothills** Riffle-Run sites. Trial 3 contains the metrics of the SHI. Trial 38 was ultimately selected as the Habitat Foothills index. Metric codes are as in Table 6-2.

	FH25	FH26	FH27	FH28	FH29	FH30	FH31	FH32	FH33	FH34	FH35	FH36
AvPoMAXDEPTH												
AvPoMAXWIDTH					FH29				FH33			
AvPoSUBSIZE												
AvPoCOVER	FH25	FH26	FH27	FH28	FH29		FH31	FH32	FH33	FH34		FH36
AvPoUCBANK			FH27		FH29				FH33			
AvPoLENGTH					FH29	FH30	FH31	FH32	FH33		FH35	FH36
BankCoverPercent												
BankStabPercent												
CanopyRaw				FH28								FH36
CSHAPERaw	FH25	FH26	FH27	FH28	FH29	FH30	FH31	FH32	FH33	FH34	FH35	FH36
EMBEDRaw				FH28								FH36
LODRaw												
PctFinesBF					FH29							FH36
PctFinesWW												
PoolRiffleRatio												
STREAMCORaw	FH25	FH26	FH27	FH28	FH29	FH30	FH31	FH32	FH33	FH34	FH35	FH36
WDRatio	FH25				FH29			FH32				FH36
WolmanRaw												
DISPRES	FH25			FH28						FH34	FH35	FH36
ZONEINFL	FH25	FH26	FH27	FH28	FH29	FH30	FH31	FH32	FH33	FH34	FH35	FH36
RefSD	9.38	12.21	13.27	10.42	9.93	10.26	10.32	8.87	10.92	11.17	9.63	9.07
DE25	72.2	77.8	61.1	61.1	44.4	61.1	77.8	61.1	50.0	77.8	88.9	50.0
z-score	1.49	1.64	1.22	1.52	0.35	1.23	1.27	0.92	0.70	1.80	1.48	0.82
Remarks												

Table K-3 (continued). **Habitat** index trials for the **streams** in **Foothills** Riffle-Run sites. Trial 3 contains the metrics of the SHI. Trial 38 was ultimately selected as the Habitat Foothills index. Metric codes are as in Table 6-2.

	FH37	FH38	FH39	FH40	FH41	FH42	FH43	FH44	FH45	FH46	FH47
AvPoMAXDEPTH						FH42	FH43				
AvPoMAXWIDTH											
AvPoSUBSIZE			FH39	FH40				FH44			
AvPoCOVER	FH37				FH41						
AvPoUCBANK											
AvPoLENGTH											
BankCoverPercent									FH45		
BankStabPercent			FH39	FH40	FH41	FH42	FH43	FH44		FH46	FH47
CanopyRaw			FH39	FH40	FH41	FH42	FH43	FH44		FH46	FH47
CSHAPERaw	FH37	FH38						FH44			
EMBEDRaw			FH39	FH40	FH41	FH42	FH43			FH46	FH47
LODRaw			FH39	FH40	FH41	FH42	FH43			FH46	FH47
PctFinesBF				FH40	FH41	FH42					
PctFinesWW			FH39				FH43	FH44	FH45	FH46	FH47
PoolRiffleRatio											
STREAMCORaw	FH37	FH38	FH39	FH40	FH41	FH42	FH43	FH44	FH45		FH47
WDRatio											
WolmanRaw			FH39	FH40	FH41	FH42	FH43			FH46	FH47
DISPRES	FH37	FH38	FH39	FH40	FH41	FH42	FH43	FH44	FH45	FH46	FH47
ZONEINFL	FH37	FH38	FH39	FH40	FH41	FH42	FH43		FH45	FH46	FH47
RefSD	9.77	10.66	12.22	12.06	10.82	11.02	11.20	11.45	9.94	11.72	11.39
DE25	77.8	88.9	50.0	50.0	55.6	50.0	50.0	66.7	61.1	50.0	55.6
z-score	1.64	2.01	0.97	0.96	1.04	0.88	0.90	1.09	1.27	0.88	0.98
Remarks		FHbest						BestOfCat	PPBVbest	MtnBest	MtnBest

Table K-4. **Habitat** index trials for the **streams** in **PPBV** Riffle-Run sites. Trial 3 contains the metrics of the SHI. Trial 22 was ultimately selected as the Habitat PPBV index. Metric codes are as in Table 6-2.

	PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10	PP11
TOTPOOLS											
AvPoMAXDEPTH				PP4							
AvPoRESDEPTH											
AvPoSUBSIZE		PP2								PP10	PP11
BankCoverPercent			PP3								
BankStabPercent							PP7		PP9	PP10	
CanopyRaw	PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10	PP11
CSHAPERaw			PP3								
EMBEDRaw	PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10	PP11
LODRaw	PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10	PP11
PctFinesBF	PP1	PP2					PP7				
PctFinesWW			PP3	PP4	PP5	PP6		PP8	PP9	PP10	PP11
PoolRiffleRatio							PP7	PP8			
STREAMCORaw	PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10	PP11
WDRatio				PP4		PP6		PP8	PP9		
WolmanRaw	PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10	PP11
DISPRES	PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10	PP11
ZONEINFL		PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10	PP11
RefSD	12.49	12.48	10.15	11.61	11.80	11.84	9.74	10.58	10.81	11.26	12.51
DE25	74.3	96.4	80.0	75.0	80.0	77.1	91.4	85.7	82.9	89.3	89.3
z-score	2.43	1.91	1.88	1.72	1.96	1.79	2.17	1.84	1.93	2.03	2.03
Remarks			SHI								

Table K-4 (continued). **Habitat** index trials for the **streams** in **PPBV** Riffle-Run sites. Trial 3 contains the metrics of the SHI. Trial 22 was ultimately selected as the Habitat PPBV index. Metric codes are as in Table 6-2.

	PP12	PP13	PP14	PP15	PP16	PP17	PP18	PP19	PP20	PP21	PP22
TOTPOOLS				PP15			PP18				
AvPoMAXDEPTH	PP12										
AvPoRESDEPTH				PP15							
AvPoSUBSIZE	PP12										
BankCoverPercent				PP15	PP16	PP17	PP18	PP19	PP20	PP21	PP22
BankStabPercent		PP13									
CanopyRaw	PP12	PP13	PP14	PP15	PP16	PP17			PP20		
CSHAPERaw		PP13	PP14								
EMBEDRaw	PP12	PP13	PP14	PP15	PP16	PP17			PP20	PP21	
LODRaw	PP12	PP13	PP14		PP16	PP17					
PctFinesBF							PP18	PP19	PP20	PP21	
PctFinesWW	PP12	PP13	PP14			PP17	PP18	PP19	PP20	PP21	PP22
PoolRiffleRatio						PP17					
STREAMCORaw	PP12	PP13	PP14		PP16	PP17	PP18	PP19	PP20	PP21	PP22
WDRatio											
WolmanRaw	PP12	PP13	PP14		PP16	PP17					
DISPRES	PP12	PP13	PP14	PP15	PP16	PP17	PP18	PP19	PP20	PP21	PP22
ZONEINFL	PP12	PP13	PP14	PP15	PP16	PP17	PP18	PP19	PP20	PP21	PP22
RefSD	11.99	9.93	10.88	12.26	12.15	9.67	9.86	9.57	11.67	11.34	9.20
DE25	85.7	80.0	80.0	75.0	71.4	91.4	85.7	85.7	82.9	82.9	85.7
z-score	1.79	1.99	1.84	1.88	1.73	2.06	2.73	2.79	2.25	2.33	2.77
Remarks											PPBVbest

Table K-4 (continued). **Habitat** index trials for the **streams** in **PPBV** Riffle-Run sites. Trial 3 contains the metrics of the SHI. Trial 22 was ultimately selected as the Habitat PPBV index. Metric codes are as in Table 6-2.

	PP23	PP24	PP25	PP26	PP27	PP28	PP29	PP30	PP31	PP32
TOTPOOLS	PP23									
AvPoMAXDEPTH				PP26		PP28				
AvPoRESDEPTH										
AvPoSUBSIZE			PP25		PP27			PP30		
BankCoverPercent	PP23						PP29			
BankStabPercent		PP24		PP26	PP27	PP28		PP30	PP31	
CanopyRaw		PP24	PP25	PP26	PP27	PP28		PP30	PP31	
CSHAPERaw								PP30		PP32
EMBEDRaw		PP24	PP25	PP26	PP27	PP28	PP29		PP31	
LODRaw		PP24	PP25	PP26	PP27	PP28			PP31	
PctFinesBF			PP25	PP26						
PctFinesWW	PP23	PP24			PP27	PP28	PP29	PP30	PP31	
PoolRiffleRatio		PP24								
STREAMCORaw	PP23	PP24	PP25	PP26	PP27	PP28	PP29	PP30	PP31	PP32
WDRatio										
WolmanRaw		PP24	PP25	PP26	PP27	PP28			PP31	
DISPRES	PP23	PP24	PP25	PP26	PP27	PP28	PP29	PP30	PP31	PP32
ZONEINFL	PP23	PP24	PP25	PP26	PP27	PP28	PP29		PP31	PP32
RefSD	8.57	9.47	12.70	10.85	11.26	10.46	11.38	11.30	10.68	11.31
DE25	68.6	91.4	89.3	78.6	89.3	78.6	80.0	92.9	82.9	80.0
z-score	1.37	2.18	1.88	1.97	2.03	2.01	2.23	2.02	2.11	1.85
Remarks										

Table K-5. **Habitat** index trials for the **streams** in **Pool-Glide** sites. Trial 1 contains the metrics of the SHI. Trial 6 was ultimately selected as the Habitat Pool-Glide index. Metric codes are as in Table 6-2.

	PG1	PG2	PG3	PG4	PG5	PG6	PG7	PG8	PG9	PG10	PG11	PG12
AvPoMAXDEPTH											PG11	PG12
AvPoMAXWIDTH												
AvPoSUBSIZE		PG2		PG4	PG5				PG9	PG10	PG11	
AvPoCOVER			PG3									
AvPoUCBANK												
AvPoLENGTH												
BankCoverPercent	PG1					PG6						
BankStabPercent		PG2	PG3		PG5		PG7		PG9			PG12
CanopyRaw	PG1	PG2	PG3		PG5		PG7		PG9	PG10	PG11	PG12
CSHAPERaw	PG1				PG5			PG8				
EMBEDRaw	PG1	PG2	PG3				PG7		PG9	PG10	PG11	PG12
LODRaw	PG1	PG2	PG3				PG7		PG9	PG10	PG11	PG12
PctFinesBF		PG2	PG3									
PctFinesWW	PG1				PG5	PG6	PG7		PG9	PG10	PG11	PG12
STREAMCORaw	PG1	PG2	PG3	PG4	PG5	PG6	PG7	PG8	PG9	PG10	PG11	PG12
WDRatio												
WolmanRaw	PG1	PG2	PG3				PG7		PG9	PG10	PG11	PG12
DISPRES	PG1	PG2	PG3		PG5	PG6	PG7	PG8	PG9	PG10	PG11	PG12
ZONEINFL	PG1	PG2	PG3			PG6	PG7	PG8	PG9	PG10	PG11	PG12
RefSD	9.87	9.72	10.21	13.22	8.39	8.08	10.72	13.14	9.92	11.14	10.93	10.55
DE25	95.8	95.8	91.7	79.2	91.7	100.0	95.8	95.8	95.8	95.8	95.8	95.8
z-score	3.00	3.01	2.96	1.82	3.24	4.72	2.96	3.14	2.96	2.77	3.03	3.21
Remarks	SHI				BestOfCat	PPBVbest	MtnBest	FHbest				

Table K-5 (continued). **Habitat** index trials for the **streams** in **Pool-Glide** sites. Trial 1 contains the metrics of the SHI. Trial 6 was ultimately selected as the Habitat Pool-Glide index. Metric codes are as in Table 6-2.

	PG13	PG14	PG15	PG16	PG17	PG18	PG19	PG20	PG21	PG22	PG23	PG24
AvPoMAXDEPTH	PG13					PG18						
AvPoMAXWIDTH												
AvPoSUBSIZE												PG24
AvPoCOVER			PG15	PG16						PG22		PG24
AvPoUCBANK			PG15		PG17	PG18	PG19			PG22		
AvPoLENGTH												
BankCoverPercent												
BankStabPercent	PG13			PG16				PG20				
CanopyRaw	PG13	PG14	PG15	PG16	PG17	PG18	PG19	PG20		PG22	PG23	
CSHAPERaw		PG14	PG15	PG16			PG19	PG20	PG21	PG22	PG23	PG24
EMBEDRaw	PG13	PG14	PG15	PG16	PG17	PG18	PG19	PG20		PG22	PG23	
LODRaw	PG13	PG14			PG17	PG18	PG19	PG20				
PctFinesBF	PG13											
PctFinesWW		PG14	PG15	PG16	PG17	PG18	PG19	PG20				
STREAMCORaw	PG13	PG14	PG15	PG16	PG17	PG18	PG19	PG20	PG21	PG22	PG23	PG24
WDRatio												PG24
WolmanRaw	PG13	PG14			PG17	PG18	PG19	PG20				
DISPRES	PG13	PG14	PG15	PG16	PG17	PG18	PG19	PG20		PG22	PG23	PG24
ZONEINFL	PG13	PG14	PG15	PG16	PG17	PG18	PG19	PG20	PG21	PG22	PG23	PG24
RefSD	10.51	11.41	12.72	10.64	11.82	11.50	11.62	10.14	15.65	14.47	13.50	8.19
DE25	100.0	95.8	91.7	91.7	91.7	100.0	91.7	95.8	95.8	91.7	91.7	95.8
z-score	3.21	2.86	2.54	2.77	2.93	3.17	2.88	3.05	2.54	2.11	2.29	3.68
Remarks												

Table K-5 (continued). **Habitat** index trials for the **streams** in **Pool-Glide** sites. Trial 1 contains the metrics of the SHI. Trial 6 was ultimately selected as the Habitat Pool-Glide index. Metric codes are as in Table 6-2.

	PG25	PG26	PG27	PG28	PG29	PG30	PG31	PG32	PG33	PG34	PG35	PG36
AvPoMAXDEPTH												
AvPoMAXWIDTH					PG29				PG33			
AvPoSUBSIZE												
AvPoCOVER	PG25	PG26	PG27	PG28	PG29		PG31	PG32	PG33		PG35	PG36
AvPoUCBANK			PG27		PG29				PG33			
AvPoLENGTH					PG29	PG30	PG31	PG32	PG33	PG34	PG35	
BankCoverPercent												
BankStabPercent												
CanopyRaw				PG28							PG35	
CSHAPERaw	PG25	PG26	PG27	PG28	PG29	PG30	PG31	PG32	PG33	PG34	PG35	PG36
EMBEDRaw				PG28							PG35	
LODRaw												
PctFinesBF					PG29						PG35	
PctFinesWW												
STREAMCORaw	PG25	PG26	PG27	PG28	PG29	PG30	PG31	PG32	PG33	PG34	PG35	PG36
WDRatio	PG25				PG29			PG32			PG35	
WolmanRaw												
DISPRES	PG25			PG28						PG34	PG35	PG36
ZONEINFL	PG25	PG26	PG27	PG28	PG29	PG30	PG31	PG32	PG33	PG34	PG35	PG36
RefSD	8.90	14.82	16.84	13.66	10.90	14.80	13.27	10.14	14.09	13.07	9.78	12.89
DE25	95.8	91.7	95.8	91.7	91.7	87.5	91.7	91.7	91.7	95.8	91.7	95.8
z-score	3.80	2.31	2.12	2.12	3.16	2.42	2.43	2.98	2.46	2.89	3.00	2.83
Remarks												