Development of a Macroinvertebrate Biological Assessment Index for Alexander Archipelago Streams – Final Report

by

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2005

Acknowledgments

The authors extend their gratitude to the federal, state, and local governments; agencies; tribes; volunteer professional biologists; watershed groups; and private citizens that have supported this project. We thank Kim Hastings of the U.S. Fish and Wildlife Service for coordinating lodging and transportation in Juneau and for use of the research vessels Curlew and Surf Bird. We thank Neil Stichert, Joe McClung, and Deb Rudis, also of the U.S. Fish and Wildlife Service, for field assistance. We thank the U.S. Forest Service for lodging and transportation across the Tongass National Forest; specifically, we thank Julianne Thompson, Emil Tucker, Ann Puffer, Tom Cady, Aaron Prussian, Jim Beard, Steve Paustian, Brandy Prefontaine, and Sue Farzan for coordinating support and for field assistance and Liz Cabrera for support with the Southeast Alaska GIS Library. We thank Jack Gustafson of the Alaska Department of Fish and Game, Cathy Needham of the Central Council of Tlingit and Haida Indian Tribes of Alaska and POWTEC, John Hudson of the USFS Forestry Science Lab, Mike Crotteau of the Alaska Department of Environmental Conservation, and Bruce Johnson of the Alaska Department of Natural Resources for help with field data collection, logistics and local expertise. We thank Skip Call (Kentucky Department of Environmental Quality), Heather Pembrook (Vermont Department of Environmental Conservation), Michael Gangloff (Auburn University), and Lara Panayotoff (Auburn University) for their professional volunteer field efforts. We also thank Ron and Joan Leighton for their time, resources, and hospitality and Paula Peterson of the Organized Village of Kasaan for her generous hospitality. We thank the University of Alaska Anchorage's Environment and Natural Resources Institute for in-kind support. Foremost we thank Kent Patrick-Riley, the Alaska Department of Environmental Conservation and the U.S. Environmental Protection Agency for the funding that made this work possible.

Abstract

We collected benthic macroinvertebrates, physico-chemical data, and habitat data in 123 wadeable, non-glacial streams throughout the Alexander Archipelago in southeastern Alaska for the purpose of developing an ecoregional biological assessment index. We sampled within a twenty-five day window in late April and May for three consecutive years starting in 2002. Fifty-one percent of sites were reference sites, with the remaining sites representing a disturbance gradient including impacts from urbanization, varying levels of timber harvest, and landfill runoff. A multimetric index and a predictive (RIVPACS) model were developed for this data set and both methods performed similarly. Neither method was able to consistently discriminate between reference condition and intermediate levels of stress, including streams impacted by timber harvest. The multimetric index was therefore calibrated using reference and most stressed (urbanized) sites and had an overall discrimination efficiency of 75%. The six metrics selected for the final multimetric index were insect taxa richness, percent non-insect taxa, percent EPT, percent intolerant taxa, clinger taxa richness, and scraper taxa richness. Our data suggest that timber harvest on National Forest land had minimal effect on macroinvertebrate assemblage structure, likely owing to the mitigative effects of riparian standards, but that urbanization was associated with highly altered macroinvertebrate assemblages in southeastern Alaska.

Introduction

The central purpose of biological assessment is to determine how well a water body supports life. Biological assemblages integrate the effects of different pollutant stressors such as nutrient enrichment, toxic chemicals, increased temperature, and sedimentation, thus providing an overall measure of the aggregate impact of the stressors. Biological assemblages respond to stresses of all degrees over time and, therefore, offer information on perturbation not always obtained with "snap shot" water chemical measurements or discrete toxicity tests. Bioassessment allows direct measurement of biological integrity, a primary goal of the Clean Water Act (CWA). Biological data can be used by states to monitor long-term water quality trends, list and de-list waters (303d CWA), establish biological water quality criteria, prioritize sites for total maximum daily loads (TMDLs), test TMDL effectiveness, monitor the effectiveness of restoration projects, and diagnose sources of water quality impairment in addition to an array of other uses (Figure 1).

The aquatic ecology program at the University of Alaska Anchorage's Environment and Natural Resources Institute (ENRI) has been receiving funding from the U.S. Environmental Protection Agency (USEPA) and Alaska Department of Environmental Conservation since 1996 for the incremental development of stream biological assessment techniques for Alaska's ecoregions. Biological index development is partitioned into ecoregions to minimize the amount of climatic, geologic, and biological variability within a large area like Alaska (Hughes et al. 1994, Stoddard 2005). Field data collection began in 1997 on the Kenai Peninsula and then expanded to other areas of the Cook Inlet Basin ecoregion (Nowacki et al. 2001) over the following three years. These data were used to calibrate the Alaska Stream Condition Index, a multimetric macroinvertebrate index for the Cook Inlet Basin ecoregion. Concurrent with data collection on the Kenai Peninsula, we developed and tested standard operating procedures for assessing and monitoring the biological integrity of Alaska streams based on USEPA Rapid Bioassessment Procedures (Barbour et al. 1999; Major and Barbour 2001; Major et al. 1998). The standard operating procedures include macroinvertebrate sampling, physicochemical water quality measurements, and visual assessment of instream and riparian habitat; our approach closely followed the concepts outlined by Barbour (1997). From 2002 to 2004 the focus of our field data collection shifted to southeastern Alaska, where we collected data toward a macroinvertebrate water quality index for non-glacial, wadeable streams in the Alexander Archipelago ecoregion (Nowacki et al. 2001), an area roughly corresponding to the Tongass National Forest. This report presents the results of this work and describes the calibration and application of the resulting biological assessment index.

We tested two different approaches for index development with our Alexander Archipelago macroinvertebrate data: the multimetric approach, commonly used in the United States (see Barbour et al. 1999), and predictive modeling, the approach commonly used in Europe, Australia, and New Zealand (see Wright, Furse, and Armitage 1993, Hawkins et al. 2000). Both approaches rely on data collected at Reference sites–streams that are minimally impacted by human impacts such as logging, mining, and residential or urban development–to represent the expected naturally-occurring conditions across the ecoregion. However, the two methods differ fundamentally in the way biological information is summarized. Multimetric indices are based on a suite of metric scores, quantifiable attributes of the macroinvertebrate assemblage that vary predictably with watershed disturbance.

Predictive modeling estimates the expected taxonomic richness that would occur at a site in the absence of any watershed disturbance; this expected richness is then compared to the observed richness to quantify biological impairment.

During the index development process we also sought to identify the value of genus-level Chironomidae (non-biting midges) identifications. This family of Diptera (true flies) is very common, often comprising >50% of the macroinvertebrate assemblage, and requires slide mounting of specimens and specific expertise that can add considerable time and expense when identifying at the genus level. If data using family-level chironomid identifications yield results similar to data using genus-level identifications, family-level identifications would be preferable in order to reduce laboratory expense. We address this concern by repeating analyses using data from both levels of taxonomic resolution. Default analyses and metric names use family level identification for midges; metrics and analyses calculated with genus-level midge data are noted as such.

This report is organized to first give the reader a brief overview of the multimetric and predictive model approaches to biological assessment. We then review our field data collection methodology and our results as they pertain to calibration and application of a multimetric water quality index using macroinvertebrates. Because the multimetric and predictive model approaches yielded very similar results, we chose to focus on the multimetric index development in this report and refer the reader to Jessup et al. (2005) for details regarding calibration of the predictive model index. We made this decision because the multimetric approach is intuitively more straightforward, is easier to use, and is consistent with our work in the Cook Inlet ecoregion. This report also provides highlights of our statewide education and outreach effort, which is another important aspect of ENRI's biological assessment work.

This project's primary objective was to characterize physical, chemical, and biological reference conditions for Alexander Archipelago ecoregion streams and to develop a benthic macroinvertebrate biological water quality index based on conditions unique to this region. Additional objectives were to compare the results given by the two major contemporary approaches to biological assessment, the multimetric index and predictive model, and to evaluate the relative merits of family- and genus-level taxonomy for Chironomidae.

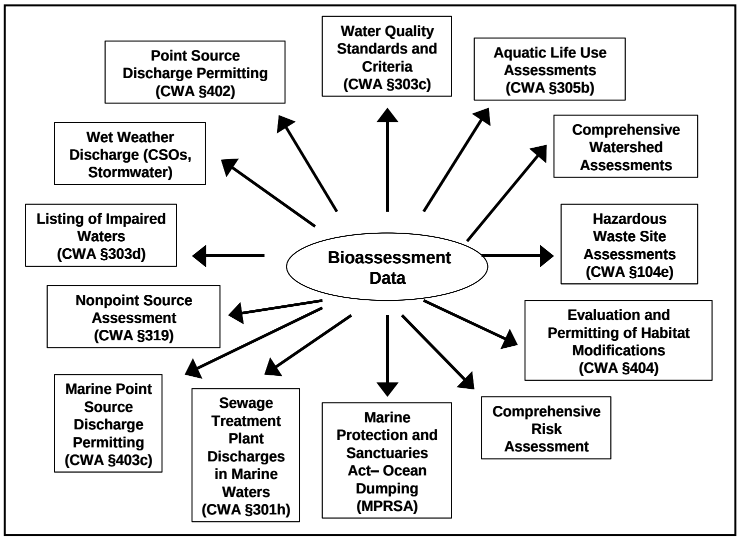

Figure 1. Use of bioassessment in water quality programs (from USEPA 2002).

Methods

Study area

The Alexander Archipelago ecoregion (Nowacki et al. 2001) roughly corresponds to the islands and nearshore mainland of the southeastern Alaska “panhandle”, reaching from the Endicott Range and Glacier Bay in the north to Dixon Entrance in the south. The land masses are mountainous and the climate is maritime and cool, with mean temperatures of -7–4ºC (20–40ºF) in winter and 10–16ºC (50-60ºF) in summer (FAA 1996). Precipitation is abundant (200–500 cm/y; FAA 1996) and greatest at higher elevations; precipitation is highest during fall while spring is the seasonally driest period (Host and Neal 2004). Lush temperate rain forests of Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), and yellow cedar (*Callitropsis nootkatensis*) occur at low elevations on well-drained soils, giving way to stands of red alder (*Alnus rubra*) in disturbed areas. Peatland fens sparsely forested with shore pine (*Pinus contorta*) occur on poorly drained soils. At higher elevations, forests give way to shrublands, alpine tundra, and extensive ice fields.

Streams are common and are generally short and steep, often with low-gradient floodplain reaches just above tidewater. Streams are generally clear and circa-neutral, although some that drain extensive peatlands are tannin stained and acidic. Some mainland rivers drain valley glaciers but, due to the high inorganic sediment loads associated with glacial scouring, we did not include such rivers in this study. Streams host Dolly Varden char (*Salvelinus malma*); steelhead and cutthroat trout (*Oncorhynchus mykiss*, *O. clarkii*); pink, chum, coho, and sockeye salmon (*O gorbuscha*, *O. keta*, *O. kisutch*, and *O. nerka.*); and slimy, prickly, and coastrange sculpin (*Cottus cognatus*, *C. asper*, and *C. aleuticus*).

This region offered a large number of pristine watersheds, allowing us to use true reference sites rather than the “best available” reference sites necessitated in many other areas. However, this region offered very few stressed sites (e.g., watersheds heavily impacted by urbanization and associated rounoff), precluding a rigorous test of index efficacy based on biological responses at an independent set of stressed sites. The dominant forms of human disturbance are urbanization and timber harvest (including associated roads, stream crossings, gravel mines, etc.) and, owing to the region’s steep topography, these tend to be confined to low elevations and comprise a relatively small proportion of the total watershed area. Most of the ecoregion is within the Tongass National Forest where the Tongass Timber Reform Act (TTRA) has mandated 30.5m (100 ft) buffers on anadromous fish streams since 1991 and the Tongass Land Management Plan has mandated variable width buffers based on stream process groups (Paustian 1992) in addition to the TTRA buffers since 1997. The principal towns within the ecoregion are Juneau (pop. = 31,000), Ketchikan (pop. = 9,000), and Sitka (pop. = 8,000; U.S. Census Bureau 2000).

Overview of Multimetric and Predictive Model Approaches

The two approaches – multimetric index and predictive modeling – are similar in that they attempt to discern biological differences between reference sites (i.e., those sites that have little or no disturbance) and sites with increasing degrees of disturbance. The two approaches differ in the way sites are classified into similar natural groupings and in the way the biological information is summarized.

In the multimetric approach, sites are classified into distinct groups based on biological similarities that can be explained by naturally-occurring environmental variables (e.g., channel slope, substrate composition, etc.). Such environmental variables (if any) are detected as clusters of sites with similar environmental characteristics in a multivariate ordination of Reference site assemblages. If natural among-site variation is found to be predictably influencing macroinvertebrate assemblages, sites are partitioned into homogeneous classes according these variable(s) and index development proceeds for each class individually. This process produces biologically homogeneous groups of streams that presumably respond similarly to watershed disturbance.

The metrics comprising a multimetric index are quantifiable attributes of the benthic macroinvertebrate assemblage and are generally classified into 5 groups based on the assemblage attributes quantified (sensu Barbour et al. 1999): taxonomic richness, taxonomic composition, tolerance/intolerance, feeding group, and habit. A suite of candidate metrics is tested and those that are precise (both spatially and temporally), not redundant with other metrics, representative of different metric families, and show predictable responses to watershed disturbance are selected for the final multimetric index, which is a mathematical combination of these metrics.

In the predictive modeling approach, sites are not classified into distinct groups, but are classified along a natural gradient. Membership within a class is defined in terms of probability of membership, based on discriminant function analysis of the biological diversity of reference sites and the environmental characteristics of those sites. The model is built such that the taxa occurring in the reference site classes are used to predict taxa that are expected to occur in sites with similar environmental characteristics. Sites that are environmentally similar to a reference class are expected to have the taxa that occur in that class to the degree of their environmental similarity, defined as the probability of class membership. The prediction of expected taxa and observation of those taxa actually occurring in the sample allows calculation of the degree to which a site is attaining its potential in biological diversity; this calculation is the ratio of observed taxa (O) to expected taxa (E).

Site Selection and Human Disturbance Gradient

We selected many sites based on the recommendations of a bioassessment work group convened to guide the development of this project that included U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), and Alaska Department of Fish and Game personnel. A large number of the sites were chosen due to support offered by cooperating agencies and ease of access. To minimize among-stream biotic variation due to naturally occurring physical and chemical differences, the bioassessment work group eliminated three types of streams from consideration in this project. Since most anthropogenic development in southeastern Alaska occurs at low elevations, sites at greater than 150 m (500 ft) elevation were eliminated from consideration. Because karst geology and glaciers can dramatically influence the physical and chemical character of streams (and accommodating these streams would require a much larger number of sites), streams bearing such influences were also eliminated. Also based on bioassessment work group recommendations, we only included streams with the following USFS stream channel types (i.e., process groups; Paustian 1992) in this study: floodplain, moderate-gradient mixed control, moderate-gradient contained, palustrine, high-gradient contained, and large contained. The estuarine process group was eliminated due to tidal influences; the glacial outwash and alluvial fan process groups were eliminated due to naturally high sediment loads.

We designated all streams *a priori* along a disturbance gradient that indexed the degree of human landscape disturbance within the watershed. We used Reference sites to establish the ecoregional reference condition (i.e., the expected "normal" conditions of unimpaired systems; Barbour et al. 1999) which is the benchmark for making comparisons and for detecting ecological impairment. To measure biological response to environmental degradation, we collected data at a number of streams in watersheds that were highly impacted by urbanization, timber harvest, and landfill runoff. We expect these streams to have an altered macroinvertebrate assemblage due to these impacts and, as such, we refer to them as Stressed sites. We also sampled a number of sites with intermediate degrees of human disturbance (Classes 1 and 2) which we used to test metric and index responsiveness at moderate levels of watershed disturbance.

Our watershed human disturbance gradient incorporated four basin-scale disturbance measures – road density, stream road crossing density, aerial percentage of total timber harvest, and aerial percentage of riparian timber harvest (riparian zones were generally ≥30.5m [100 ft] from both streambanks; Southeast Alaska GIS Library, http://www.fs.fed.us/r10/tongass/gisinfo/pages/about.html) as well as the USEPA's rapid habitat assessment protocol (Barbour et al. 1999) indexed at the time of field data collection. We used non-biological criteria as indices of human disturbance to avoid the circularity inherent in using a biological classification system to predict a biological response. Reference sites, by definition, had zero or negligible human disturbance within the watershed. For non-reference sites, we ranked each disturbance measure and the habitat assessment score according to the range of values observed among non-Reference sites, where a value of zero was assigned to watersheds that lacked the disturbance and values of 1 to 3 were assigned in correspondence to the trisected range of non-reference sites. For each site, we averaged the scores for each disturbance measure to yield a total watershed-scale disturbance score then averaged this number with the habitat assessment score to yield the final disturbance gradient score. As such, all non-reference sites were ranked from 1 to 3, with higher numbers indicating more watershed disturbance (i.e., Class 1, Class 2, and 3 = Stressed). We ranked some sites as Stressed (i.e., streams draining landfills and urbanized areas) that would have otherwise been scored as Class 1 or 2 when we thought the watershed stressor gradient underestimated the true level of disturbance. Figure 2 graphically depicts the disturbance gradient's constituent indices for each of the 4 stream disturbance classes.

We sampled a total of 123 stream sites during April and May of 2002–2004, including 13 sites which were sampled across multiple years and 12 sites at which macroinvertebrate samples were collected in replicate to estimate the temporal variability and precision in biological assessment scores. Of the 123 sites, 64 had no or negligible human influence within the watershed (i.e., Reference sites), 52 sites had some degree of timber harvest and associated road building and/or small amounts of urban development within their watershed (Classes 1 and 2), and 7 sites had watersheds that were heavily impacted by urbanization, municipal landfills, and/or timber harvest (i.e., Stressed sites) (Appendix 2).

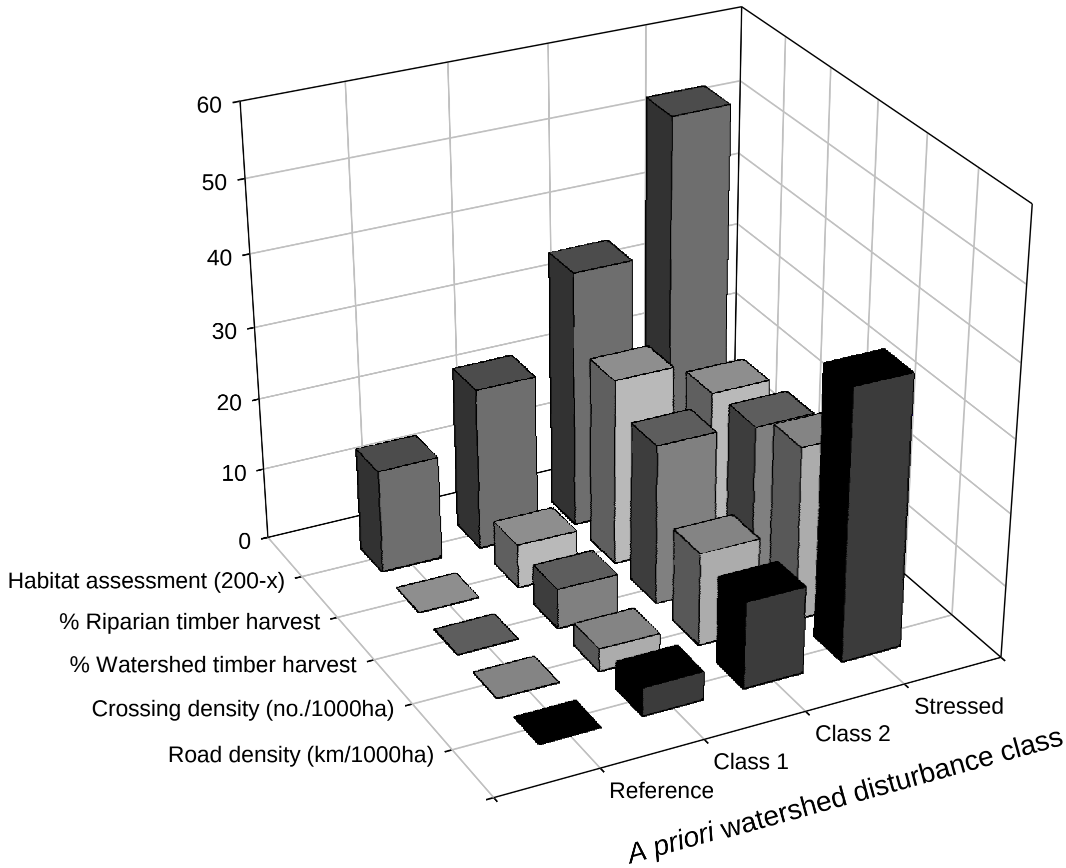

Figure 2. Mean values for the habitat assessment index and the 4 watershed human disturbance measures constituting the watershed disturbance gradient displayed for each of the 4 *a priori* watershed disturbance classes. The habitat assessment is from Barbour et al.(1999) and is expressed as 200 minus habitat assessment score for consistency with graph axis.

Field Sampling and Macroinvertebrate Processing

We collected biological and associated environmental data from wadeable streams throughout southeastern Alaska during late April and May of 2002, 2003, and 2004. This sampling period corresponded to seasonally low rainfall and stable weather and also allowed us to avoid the confounding influence of substrate disturbance and nutrient enrichment associated with spawning salmon, which are abundant during summer in most southeastern Alaska streams. Our field methods followed the sampling methods of Major and Barbour (2001), a modification of the USEPA Rapid Bioassessment Protocols for use in Alaska.

Classifying an ecoregion's streams into smaller units is often necessary to reduce natural variation among sites (Barbour et al. 1995). For example, stream gradient and substrate particle size strongly influenced stream biota in southcentral Alaska (Major et al. 2001); as such, three different biotic indices were calibrated to accommodate different combinations of gradient and substrate. Anticipating the need to reduce natural variation among southeastern Alaska streams during index calibration, we compiled a suite of physical attributes for each stream. We measured discharge by the incremental cross-sectional area method using an electronic flow meter (Marsh-McBirney model 2000). We measured channel slope over the sample reach using a clinometer and classified stream channel morphology using USFS (Paustian 1992) and Rosgen (Rosgen and Silvey 1998) methodology. We estimated percent coverage of streambed substrates at each sample reach in five size classes: bedrock, boulder (> 256 mm), cobble (64–256 mm), gravel (2–64 mm), sand (0.06–2.00 mm), and silt (< 0.06 mm). We noted the color of each stream's water (i.e., clear vs. tannin-stained). In the lab, we characterized each site's basin area, latitude, and geographical region from remote sensing data.

We measured water physicochemical parameters (pH, conductivity, temperature, total dissolved solids, and dissolved oxygen) in situ at each site using a Hydrolab Surveyor 4 and Minisonde that was calibrated daily. We expected some of these parameters to be influenced by watershed disturbance and, if so, to indicate potential mechanisms by which landscape processes influence stream macroinvertebrates. As such, we used one-way ANOVA ($\alpha = 0.05$) and LSD post-hoc tests to test for significant differences in water physicochemical parameters among Reference, Class 1, Class 2, and Stressed sites.

Our field methods followed the sampling methods of Major and Barbour (2001), a modification of the USEPA Rapid Bioassessment Protocols for use in Alaska. We collected macroinvertebrate samples throughout a 100-m reach at each site with a 350-µm-mesh D-frame net. Each sample was a composite of 20 subsamples collected from various instream habitats in proportion to each habitat's abundance. Riffles were the predominant substrate sampled, with large woody debris, submerged streambanks, and emergent vegetation, in turn, comprising increasingly smaller portions. For riffle samples we disturbed an area of streambed approximately 1.5 ft^2 (1350 cm^2) to a depth of 4 in (10 cm) and rubbed each cobble and boulder by hand to ensure all macroinvertebrates were dislodged and swept into the net by the stream's current. We sampled woody debris by manually scouring a 1.5 ft^2 (1350 cm^2) area of wood immediately upstream of the net. We sampled streambanks and emergent vegetation by making three successive sweeps of the net across a 1.5 ft^2 (1350 cm^2) area while rapidly jabbing the net into the substrate. We preserved all samples in the field with ethanol and returned them to ENRI's lab for processing. In the lab, we subsampled each macroinvertebrate sample to a fixed count of 300±20% organisms to standardize the taxonomic effort across all sites. In addition, we conducted a 5-minute search through the remaining sample to select any large and/or rare taxa that may have been missed during subsampling. We identified all insects to genus (or lowest taxon practical) and non-insects to higher taxa (usually family or order) using standard taxonomic keys (Weiderholm 1983, Pennak 1989, Merritt and Cummins 1996, Wiggins 1996, Thorpe and Covich 2001, Stewart and Stark 2002).

Multimetric Index Development

The multimetric index development process occurs as a series of steps:

1. Data organization and metric calculation	The data were delivered for analysis in the Ecological Data Application System. EDAS can answer data queries and calculate metrics. These data were generally transferred to other programs for analysis (Excel, PC-Ord, and Statistica). QC issues were addressed before finalizing analyses.
2. Site Classification	Biological samples from Reference sites were examined for evidence of natural variability that could be explained by the environmental variables recorded in the database.
3. Correlation Analysis	Correlation analysis was performed to identify metrics that may be redundant, and therefore should not be included simultaneously in an index.
4. Precision Analysis	Metric precision was investigated using analysis of variance techniques with replicate samples.
5. Discrimination Efficiency	The degree to which metric values indicate a difference among Reference and Stressed samples was calculated so that discriminating metrics could be considered for the index.
6. Metric Combination	Combinations of metrics were tested to find a reliable, discriminating index for southeastern Alaska streams.

Data organization and metric calculation

All macroinvertebrate and field data were entered into ENRI's Ecological Data Application System, a relational database designed for aquatic biological assessment data. EDAS was used to query data and to calculate biological metrics; these data were generally transferred to other programs for analysis (Excel, PC-Ord, and Statistica). We subjected all data to quality assurance checks prior to data analysis.

We calculated a suite of standard bioassessment metrics that quantify different attributes of the macroinvertebrate assemblage and that were expected to respond to habitat degradation (Resh and

Jackson 1993, Lenat and Barbour 1994, Barbour et al. 1999). We used a number of metrics from each of 5 metric categories (richness, composition, tolerance/intolerance, feeding group, and habit). Since metrics generally express multiple assemblage attributes (e.g., Ephemeroptera richness simultaneously expresses diversity, composition, and tolerance), these groupings are somewhat arbitrary and used mainly for convenience. See Jessup et al. (2005) for a complete list of metrics calculated.

Site Classification – Non-metric Multidimensional Scaling ordination

The ability to detect changes in assemblage composition due to human-induced disturbances would be confounded if naturally-occurring environmental variation among our sample sites (e.g., channel slope, latitude, etc.) was strongly influencing macroinvertebrate assemblage composition. This situation would require the partitioning of our study sites into two or more classes (within each of which the confounding variable is held relatively constant) and the calibration of a separate index for each class. To test for any naturally-occurring environmental variables influencing macroinvertebrate taxonomic composition, we used non-metric multidimensional scaling (NMS) ordination. The NMS ordination first calculated Bray-Curtis similarity measures for each sample pair then arranged the samples in an ordination diagram that placed taxonomically similar samples close together and dissimilar samples further apart. Examination of the diagram can reveal the environmental and taxonomic characteristics of sample groupings in relation to the ordination axes and to each other. Potential site classes would be evident if an environmental variable is found to explain the arrangement of the ordination diagram. This analysis included only Reference site data and tested for the influence of region (Juneau vs. Ketchikan vs. Wrangell, etc.), stream color (i.e., clear vs. stained), channel slope, watershed area, substrate composition, channel morphology (Rosgen classification, Rosgen and Silvey 1998), latitude, longitude, and riparian vegetation type.

We examined four different NMS ordination schemes: relative abundance of macroinvertebrate taxa with Chironomidae identified to genus, relative abundance of macroinvertebrate taxa with Chironomidae identified to family, presence/absence of macroinvertebrate taxa with Chironomidae identified to genus, and presence/absence of macroinvertebrate data with Chironomidae identified to family. Prior to ordination, we developed operational taxonomic units to ensure that macroinvertebrate taxonomic distinctions were consistent across all samples and eliminated rare taxa (those with <5 occurrences among reference sites) due to the potentially confounding influence sampling rare taxa merely by chance. See Jessup et al. (2005) for additional details regarding the NMS ordination and supplementary analyses.

Correlation and Precision Analyses

We constructed a Pearson correlation matrix to check for correlations between each possible pair of metrics. If any two metrics were correlated at ≥ 0.85, one of the metrics would be eliminated from the final multimetric index.

Precision analysis gives an indication of the agreement among multiple measures, such as replicates from the same sites (i.e., sampling error) or from different years (i.e., interannual variation). Likewise, the coefficient of variation (CV) can be calculated, which standardizes variability on the mean of measures (CV = root mean square error/mean), allowing comparison of relative precision among metrics and among treatment groups. Metrics were precise enough for inclusion in the multimetric index if the CV was less than 50%

Discrimination Efficiency

At this point in the index development we randomly separated Reference site data into calibration and verification sets, allowing us to test the repeatability of the final multimetric index on an independent data set. Calibration samples included 57 of the 81 samples. Due to the small number of Stressed sites (n=8), all Stressed site data were used for index calibration.

We calculated discrimination efficiencies for all metrics by comparing metric values from Stressed sites with the calibration set Reference metric values. Discrimination efficiency (DE) was calculated as the total number of Stressed sites that fell below the lower quartile of the Reference sites (or above the upper quartile for metrics that increase with stress) and dividing by the total number of Stressed sites. Only metrics with discrimination efficiencies of >50% were considered for inclusion in the final multimetric index.

Metric Combination

A multimetric index is composed of a suite of non-redundant metrics that show high precision, high discrimination efficiency, and that quantify different attributes of the macroinvertebrate assemblage. Although quantitative standards for precision and discrimination efficiency were used to screen potential metrics, we used professional judgment to ensure that metrics included in the index have understandable response mechanisms and have sufficient ranges of values to make scoring meaningful.

Seventy-two (72) indices were compiled by selecting different suites of metrics from as many categories as possible and averaging the scores to obtain a final index score. The scores obtained from the Stressed sites were then compared to the 25^{th} percentile of Reference site scores and the DE was calculated the same way as for the individual metrics. The best performing indices were screened for correlation among the selected metrics. If any two metrics had a correlation coefficient of greater than 0.85, one metric was omitted from potential selection.

Metrics were scored on a 100-point scale using either the 5^{th} or 95^{th} percentiles of all samples, depending on how each metric responds to stress. For metrics that decrease with stress, the 95^{th} percentile of all the samples was considered an optimal metric value and metric values greater than or equal to optimal were given a score of 100. For the metrics that increase with stress, the 5^{th} percentile of the distribution was used and all metric values less than the standard were given a score of 100. The remaining metrics were scored using the following formula:

$$score = \left(\frac{x_{max} - x}{x_{max} - x_5} \right) \times 100$$

where x is the observed value, x_5 is the 5^{th} percentile, and x_{max} is the maximum possible value (e.g., 100% for percentage metrics; 10 for Hilsenhoff's Biotic Index; Hilsenhoff 1987). For richness metrics, the maximum observed value was used.

Results and Discussion

Physical Characterization

Appendix 4 provides site-by-site physical characterization data. Stream physiology ranged from a steep, boulder-dominated stream (20% slope and 60% boulder; unnamed stream near Benjamin Island, Juneau area) to a low-gradient, silt-dominated stream (0.5% slope, 55% silt; Duck Creek, Juneau). The extensive siltation observed in Duck Creek was likely related to watershed erosion, as other streams with similarly low channel slope generally had coarser substrates. Discharge ranged more than three orders of magnitude, from four headwater streams of <0.1 cfs to 151 cfs at Ward Creek near Ketchikan. A range of Rosgen stream types was represented, with B and C channels being the most common: A (19 sites), B (66 sites), C (32 sites), F (3 sites), and G (2 sites). Duck Creek has been extensively channelized, which precluded classification by this method. USFS stream types were well represented by floodplain (44 sites) and moderate-gradient mixed control (24 sites) and, to a lesser degree, by moderate-gradient contained (20 sites), low-gradient contained (19 sites), high-gradient contained (13 sites), and palustrine (3 sites).

Water Physicochemical Variables

Appendix 5 provides the complete water physicochemical results. Conductivity, a measure of dissolved electrolytes that often increase in association with landscape disturbance and urban runoff (Ometo et al. 2000), averaged 37.8 (±38.9) µs/cm at Reference sites, 23.8 (±16.9) µs/cm at Class 1 sites, 40.0 (±28.5) µs/cm at Class 2 sites, and 97.1 (±66.8) µs/cm at Stressed sites (Figure 3). Duck Creek, a highly urbanized stream in Juneau, showed the highest conductivity (241 µs/cm) while four Reference sites showed the lowest conductivity (approaching zero). Conductivity was significantly higher at Stressed sites than at Reference and Class 1 sites (ANOVA and LSD post-hoc test natural log transformed to homogenize variance, $p = 0.038$; Figure 3).

Dissolved oxygen was near saturation at all Reference and Class 1 sites (mean ≈ 94%), where oxygen concentrations averaged ~12 mg/L (Figure 3). Stressed sites showed lower dissolved oxygen saturation (mean = 88.6%) and concentration (10.7 mg/L) than did Reference and Class 1 sites. Dissolved oxygen levels at Class 2 sites were intermediate relative to the other stream classes. Low oxygen levels are often associated with high water temperatures and/or organic enrichment (Wetzel 2001; Wilcock et al. 1995). The lowest dissolved oxygen was measured at Duck Creek in Juneau (8.3 mg/L).

Temperature and pH showed no significant difference among the four *a priori* watershed disturbance classes. Most streams were circa-neutral, but several streams that drained peatland fens had tannin stained and acidic water (pH values <6).

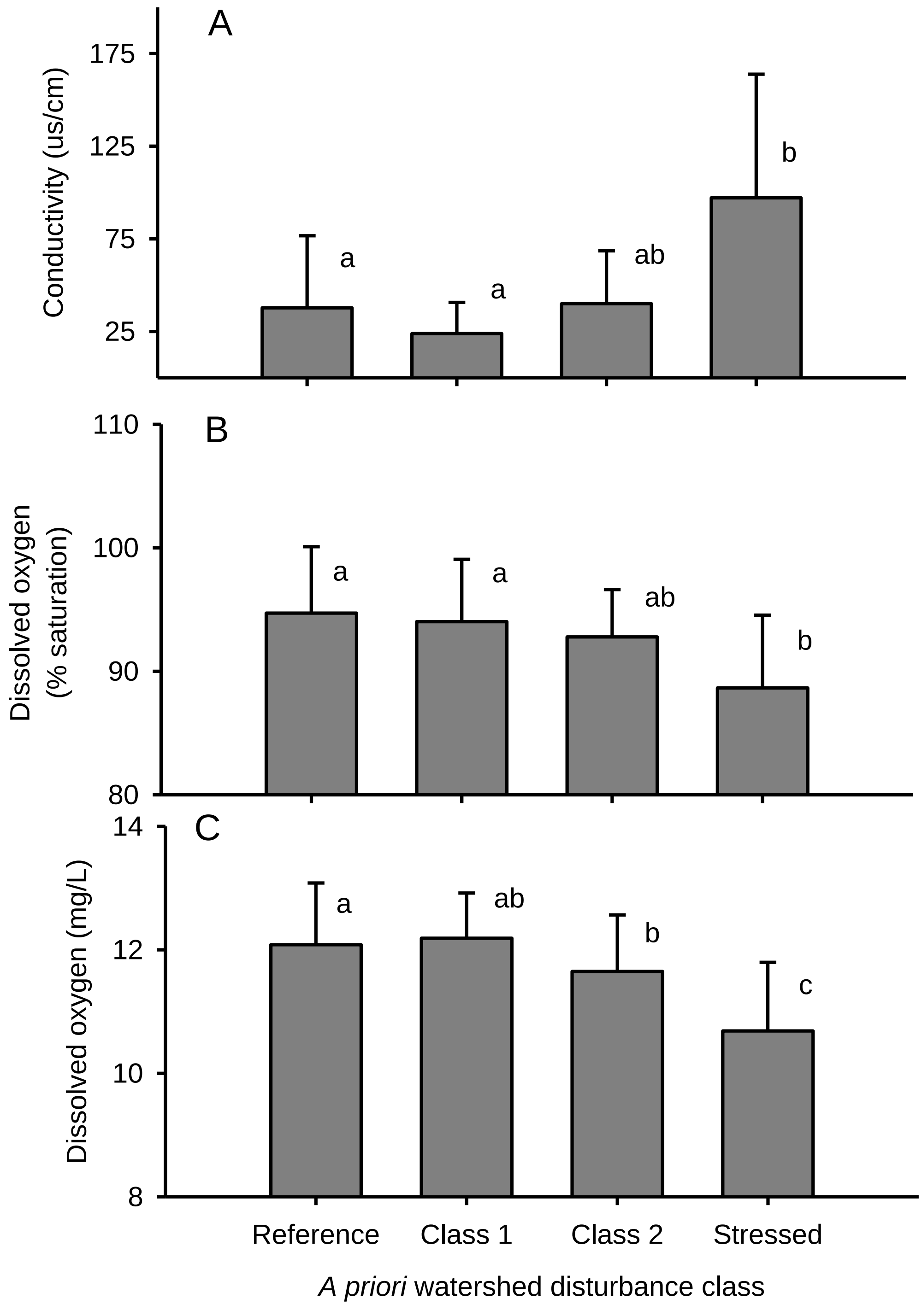

Figure 3. Mean (+ standard error) conductivity (A), dissolved oxygen saturation (B), and dissolved oxygen concentration (C) for the four *a priori* watershed disturbance classes. Within each panel, bars that do not share a lower case letter are significantly different (ANOVA, LSD post-hoc test, $\alpha = 0.05$). Conductivity data were natural log transformed to satisfy homogeneity of variance assumptions.

Multimetric Index Development

Site classification

Non-metric multidimensional scaling ordination revealed only minor differences in macroinvertebrate assemblage composition among Reference sites from the 9 regions sampled (i.e., Juneau, Admiralty Island, Couverden, Kake, Petersburg, Wrangell, Ketchikan, Prince of Wales Island, and Sitka). Although 4 ordination schemes were conducted (i.e., relative abundance with Chironomidae at genus and family as well as absolute abundance with Chironomidae at genus and family), the results from relative abundance with Chironomidae at genus offer a good example of the other three analyses and, therefore, are the only data presented here (Figure 4). The horizontal axis of the ordination was driven by the relative abundance of *Baetis bicaudatus* and *Baetis tricaudatus*, two species of generalist mayflies. There was relatively little overlap between Prince of Wales and Juneau samples due to a greater relative abundance of *B. tricaudatus* at Prince of Wales sites and a greater relative abundance of *B. bicaudatus* at Juneau sites, a pattern that may be related to the higher stream water conductivity observed at the Juneau sites. Couverden and Wrangell sites grouped relatively closely, but near the center of the plot and with considerable overlap with other regions. In addition to the ordinations coded by region, ordinations coded by stream color (i.e., clear vs. stained), channel slope, watershed area, substrate composition, channel morphology (Rosgen classification, Rosgen and Silvey 1998), latitude, longitude, and riparian vegetation type showed no distinct groupings. Based on these ordinations we concluded that variation in macroinvertebrate assemblage composition was not driven by location within the study area or by any natural variation in stream or riparian habitats. As such, there was no basis to partition our streams into distinct classes to minimize among-site biological differences and one index was calibrated to represent all sites. See Jessup et al. (2005) for more details and data regarding site classification.

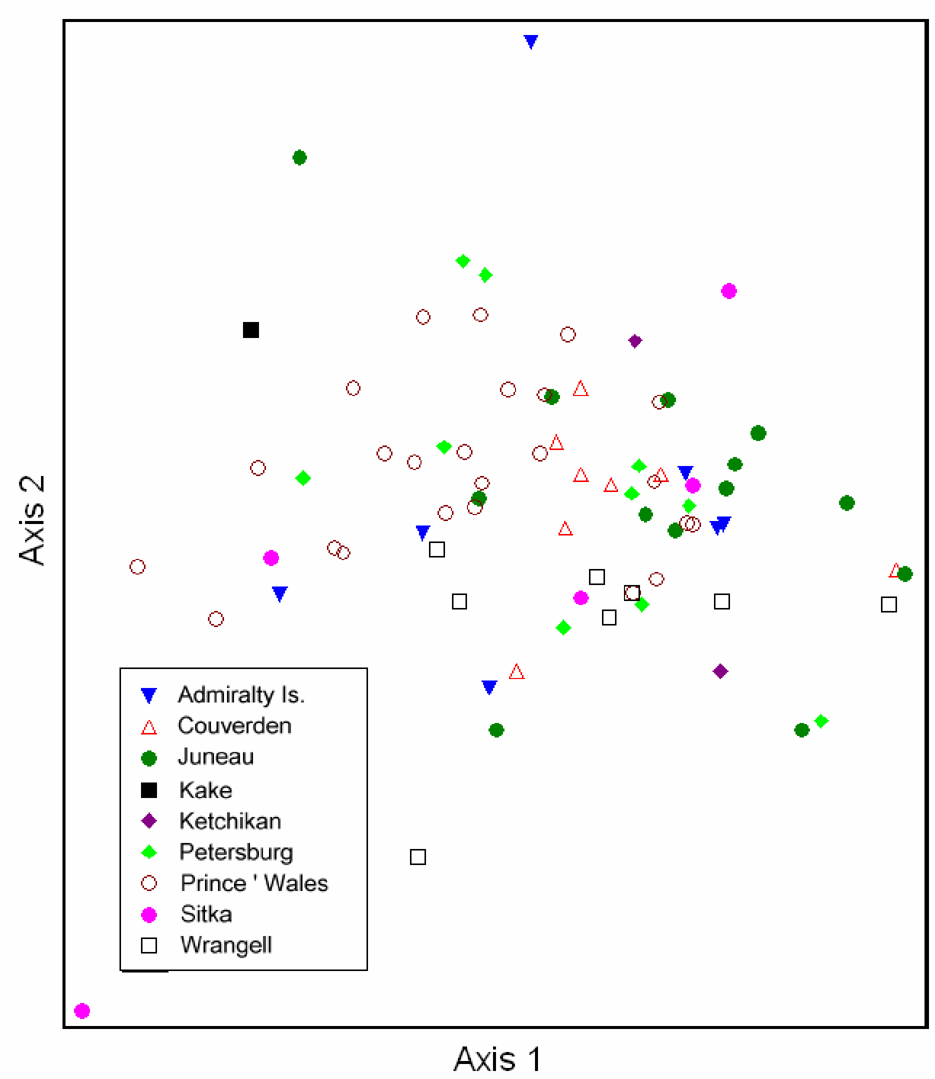

Figure 4. NMS ordination diagram showing biological similarity of reference site samples by region of southeastern Alaska. This diagram is based on relative abundance of taxa with Chironomidae identified to genus level.

Correlation and precision analyses

Correlations between metrics were found where expected (e.g., between total taxa and insect taxa; insect taxa and EPT taxa; and chironomid percent and burrower percent). Coefficients for all correlated metrics are given in Jessup et al. (2005); no correlated metrics were included in the multimetric index. Precision analysis showed a large degree of variation in precision among the various metrics. For the 104 metrics calculated in this study, replicate CV (i.e., CV of duplicate samples collected at the same site on the same date) ranged from 6 to 490 while annual CV (i.e., CV of samples collected at the same site but on different years) ranged from 10 to 270. Replicate CV was positively correlated with annual CV ($r^2 = 0.36$, $P < 0.0001$), suggesting that some metrics were inherently imprecise while others were relatively precise. Only metrics whose annual CV and replicate CV were both less than 50% (71 of the 104 metrics calculated) were considered for inclusion in the multimetric index. Replicate CVs were similar or slightly lower in metrics calculated with genus-level midges compared to their counterparts at family-level. Precision data for all metrics are given in Jessup et al. (2005).

Discrimination efficiency

Metrics that distinguished between Reference and Stressed sites were found in all 5 metric categories (sensu Barbour et al. 1999; richness, composition, tolerance/intolerance, feeding group, and habit). Those metrics showing the greatest discrimination efficiency (75%) were total taxa richness, non-insect percent of taxa, EPT (Ephemeroptera, Plecoptera, and Trichoptera) taxa richness, EP taxa richness, % Oligochaeta, Clinger taxa richness, % clingers (and % clinger genera), intolerant taxa richness (and intolerant genera), Beck's Biotic Index, and Baetidae / Ephemeroptera. Although a number of metrics distinguished between Reference and Stressed sites, discrimination efficiencies between Reference and intermediately stressed sites (i.e., Classes 1 and 2) were low (generally less than 40%). Because individual metrics did not effectively discriminate between Reference sites and Class 1 and 2 sites, we decided to calibrate the index based solely on the discrimination between Reference and Stressed sites. Discrimination efficiencies for all metrics tested are given in Jessup et al. (2005).

Metric combination

Six metrics representing all 5 metric categories (sensu Barbour et al. 1999) were selected for inclusion in the final multimetric index (Figure 5). Insect taxa richness, which is generally held to decrease with environmental degradation (Resh and Jackson 1993, Kerans and Karr 1994), was lower at Stressed sites relative to Reference sites. The non-insect proportion of the assemblage, considered to be relatively pollution tolerant (Deshon 1995), was greater at Stressed sites. Two metrics indicative of macroinvertebrate tolerance to environmental degradation, the proportion of the macroinvertebrate assemblage as EPT (i.e., the orders Ephemeroptera, Plecoptera, and Trichoptera; Barbour et al. 1999) and the proportion of the assemblage as intolerant taxa (Hilsenhoff 1987, Barbour et al. 1999), were lower at Stressed sites relative to Reference sites. The number of clinger and scraper taxa was lower at Stressed sites than at Reference sites. These taxa require well-oxygenated, sediment-free substrates and, as such, can be indicative of organic pollution and/or excessive sedimentation (Fore et al. 1996, Barbour et al. 1999). Functional feeding group (i.e., scraper) and habit (i.e., clinger) classifications can be found in Merritt and Cummins (1996). Tolerance values can be found in Barbour et al. (1999). Appendix 6 presents the complete macroinvertebrate metric results.

To apply the index, the six individual metric scores are calculated using the formulas in Table 1, any scores greater than 100 are reset to 100, and the scores are averaged. As a preliminary screening criteria, the index score is compared to the 25th percentile of Reference scores (67.8); higher scores indicate samples similar to reference conditions and lower scores indicate possible impairment.

For each promising multimetric index tested during the development process, we tested two complimentary indices: one where insects within the family Chironomidae were identified to genus and one where they were simply grouped at the family level. We conducted these analyses to test the influence of varying taxonomic resolution for chironomids, a speciose family for which generic identifications are difficult and time consuming, on the discrimination efficiency of the various metrics. Indices using generic midge data generally performed slightly worse than their family-level counterparts, indicating that the added expense of generic identification for Chironomidae may not be necessary for biological assessment in this ecoregion.

Multimetric index performance

Discrimination efficiency for the final multimetric index was 86% (i.e., 6 of 7 Stressed sample scores were lower than the 25th percentile of Reference). The 2 high-scoring Stressed samples were from the only sites classified as Stressed based solely on the extent of timber harvest (i.e., no urbanization within the watershed), suggesting that urbanization had a stronger influence on index scores than did intense levels of timber harvest. Of the subset of Reference sites that were withheld from index calibration for use as a validation data set, all samples (100%) were greater than the 25th percentile of calibration Reference samples (Figure 6). No data were available for verification of responses in Stressed samples because the entire set of Stressed sites was required for calibration. However, Medvejie Creek offers an insightful test of index efficacy. This stream, which has a salmon hatchery upstream of the sampling site, was withheld from the data set used for index calibration and, due to hatchery effluent, we expected this stream to have an altered macroinvertebrate assemblage. The multimetric index score (Figure 6) and each of the constituent metric scores for Medvejie Creek were below the median score observed at Stressed sites, suggesting that the multimetric index was reflecting an altered macroinvertebrate assemblage at this site.

Precision of the index was high; the coefficient of variation (CV) for metrics calculated from simultaneously-collected replicate samples was 6.7% and the detectable difference with 90% confidence was ±8.2 index units around an observation. Variability over years was somewhat higher than among replicates in the same year. The CV from annually-replicated samples was 15.3% and the detectable difference at 90% confidence was ±17.1 index units around an observation

Since the dominant form of landscape disturbance at Class 1 and 2 sites was timber harvest and associated road building activity, these sites offer a test of the extent to which macroinvertebrate biological assessment can detect habitat changes associated with logging. Some potential mechanisms for altered macroinvertebrate taxonomic composition at logged sites are (1) increased abundance of algae scraping taxa due to decreases in stream shading, (2) increased detritivore abundance due to a shift from coniferous forest to red alder (*Alnus rubra*) in disturbed riparian areas, and (3) a decrease in taxa intolerant to fine sediment loading. The macroinvertebrate metrics tested generally failed to detect differences between Reference sites and sites with intermediate levels of watershed disturbance (Class 1 and 2 sites). Additionally, the 2 highest scoring Stressed sites were designated as such solely due to timber harvest, whereas other Stressed sites had watershed urbanization. Most study sites were on anadromous fish streams on USFS land and, as such, were either subject to riparian buffers or were logged greater than 12 years prior to sampling. The Tongass Timber Reform Act (TTRA) has mandated 100 ft buffers on anadromous fish streams since 1991, and the Tongass Land Management Plan has mandated variable width buffers based on stream process groups (Paustian 1992) in addition to the TTRA buffers since 1997. Additionally, physicochemical data suggest that impairment was relatively subtle at Class 1 and 2 sites, as only dissolved oxygen differed significantly from Reference sites (Figure 3). Therefore, it is possible that changes in macroinvertebrate assemblages at logged sites were either nonexistent or so subtle that bioassessment metrics could not detect them. Although our data precluded a direct comparison of streams logged with and without riparian buffers, the relative lack of biological and physicochemical impact at logged sites suggests that riparian buffers are mitigating stream habitat damage associated with logging (see Murphy and Milner 1997). Other studies have found similar macroinvertebrate assemblage composition streams with and without timber harvest (Duncan and Brusven 1985, Herlihy et al. 2005). However, a number of studies have shown that timber harvest can impact salmonid populations in southeastern Alaska streams, primarily through increased sedimentation, increased temperature, and reduced winter carrying capacity (see Murphy and Milner 1997 for review). This study was not designed to assess changes in fish habitat associated with timber harvest and should not be interpreted as such.

Macroinvertebrate metrics consistently detected altered macroinvertebrate taxonomic composition at sights with highly altered watersheds (i.e., Stressed sites). As such, biological assessment holds immediate promise for the detection and management of impaired urban water bodies. Potential mechanisms for the observed macroinvertebrate patterns include increases in nutrient and toxin loads associated with urban and landfill runoff (as evidenced by the observed increased conductivity; Figure 3), decreased dissolved oxygen levels associated with increased biological oxygen demand (Figure 3), and increased sedimentation (observed at numerous sites but not measured). Biological benchmarks based on Reference site biota could be used to screen stream sites for listing (303d CWA) and to prioritize sites for TMDL development. Biological data could then be used as a criterion for de-listing, testing TMDL effectiveness, and long-term monitoring.

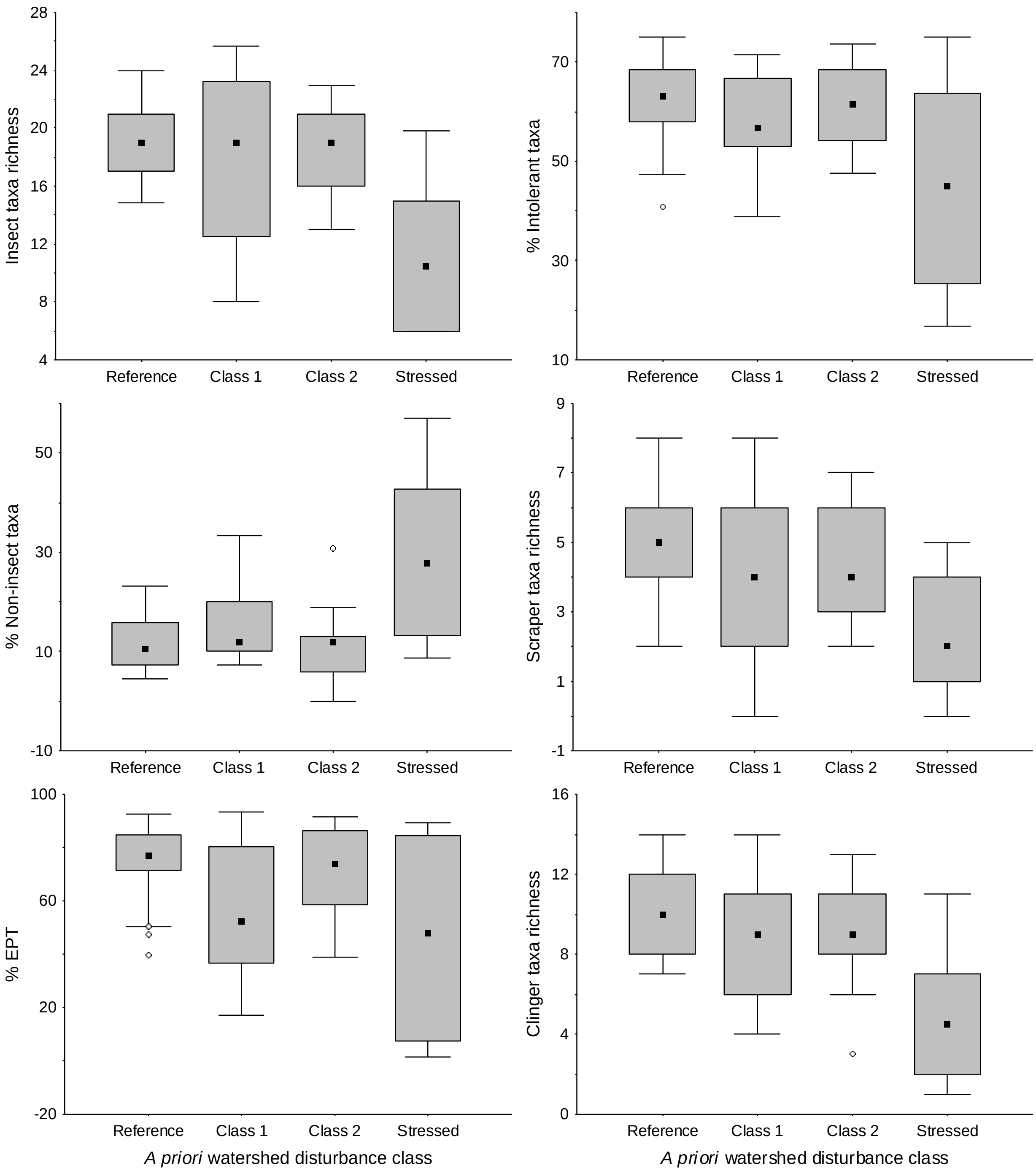

Figure 5. Distributions of metric values across the four *a priori* watershed disturbance classes for those metrics included in the final multimetric index (data from Reference calibration and verification sites were combined). Black squares represent median values, gray boxes represent 25th and 75th percentiles, and whiskers represent 5th and 95th percentiles.

Figure 6. Distributions of final multimetric index scores for the *a priori* watershed disturbance classes and Medvejie Creek, a validation site with a salmon hatchery upstream of the sampling site. Black squares represent median values, gray boxes represent 25th and 75th percentiles, and whiskers represent 5th and 95th percentiles. Reference sites were divided into sites used for index calibration and sites used for index verification.

Table 1. Metrics and scoring formulae for the final multimetric index (with Chironomidae identified to the family level).

Index Metrics	Metric Category	Scoring Formula
Insect taxa	Richness	100****X***/25
Non-Insect % taxa	Richness	100*(60- ***X***)/55.5
% EPT	Composition	100* ***X*** /92
Scraper taxa	Feeding Group	100* ***X*** /8
Clinger taxa	Habit	100* ***X*** /14
Intolerant % taxa	Tolerance	100* ***X*** /75

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Appendices

Appendix 1. Maps showing stream sites in the areas sampled: Juneau, Admiralty Island, and Couverden (Figure 1), Ketchikan Area (Figure 2), Juneau Area (Figure 3), and Admiralty Island (Figure 4).

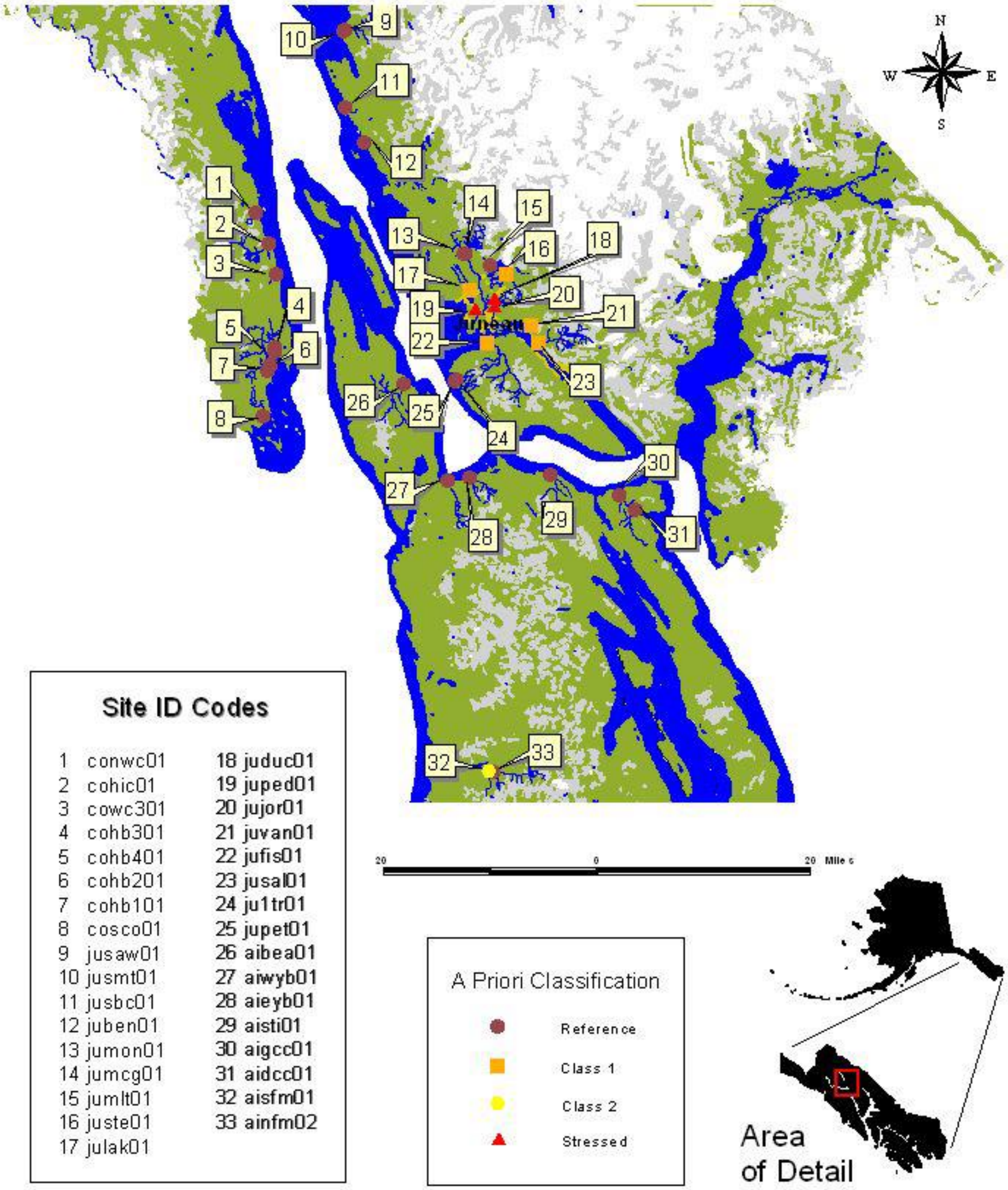

Figure 1. Juneau, Admiralty Island, and Couverden area sites.

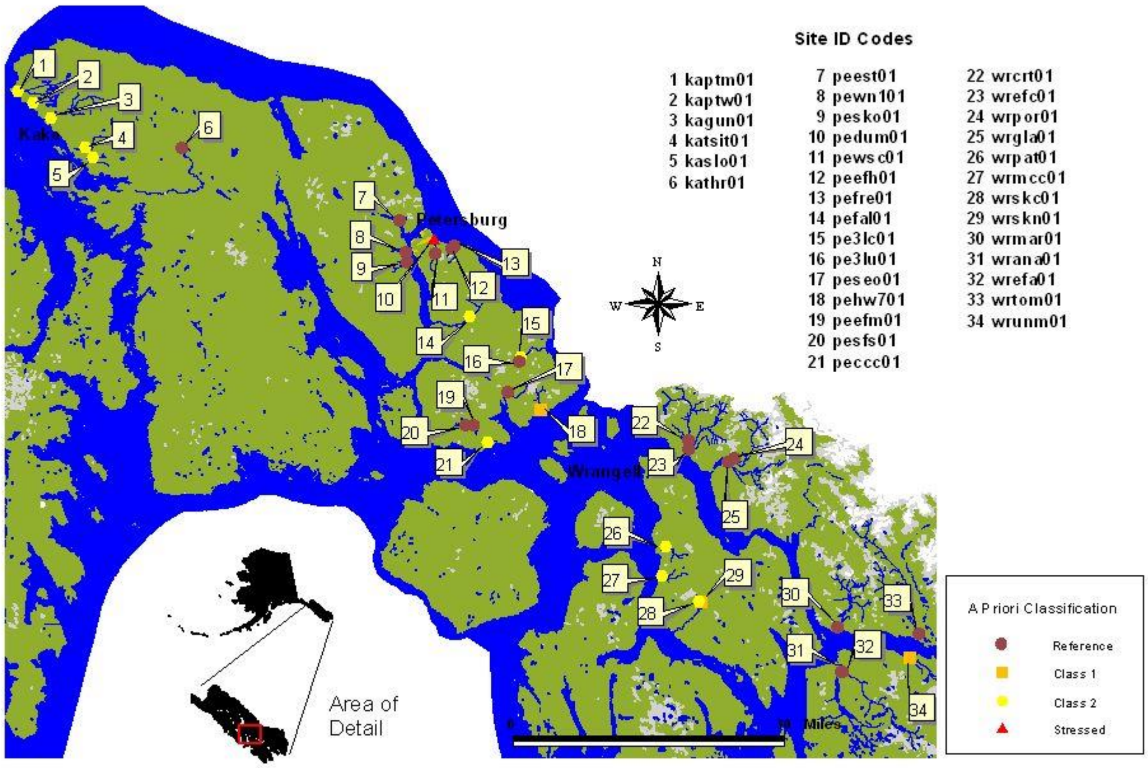

Figure 2. Kake, Petersburg, and Wrangell area sites.

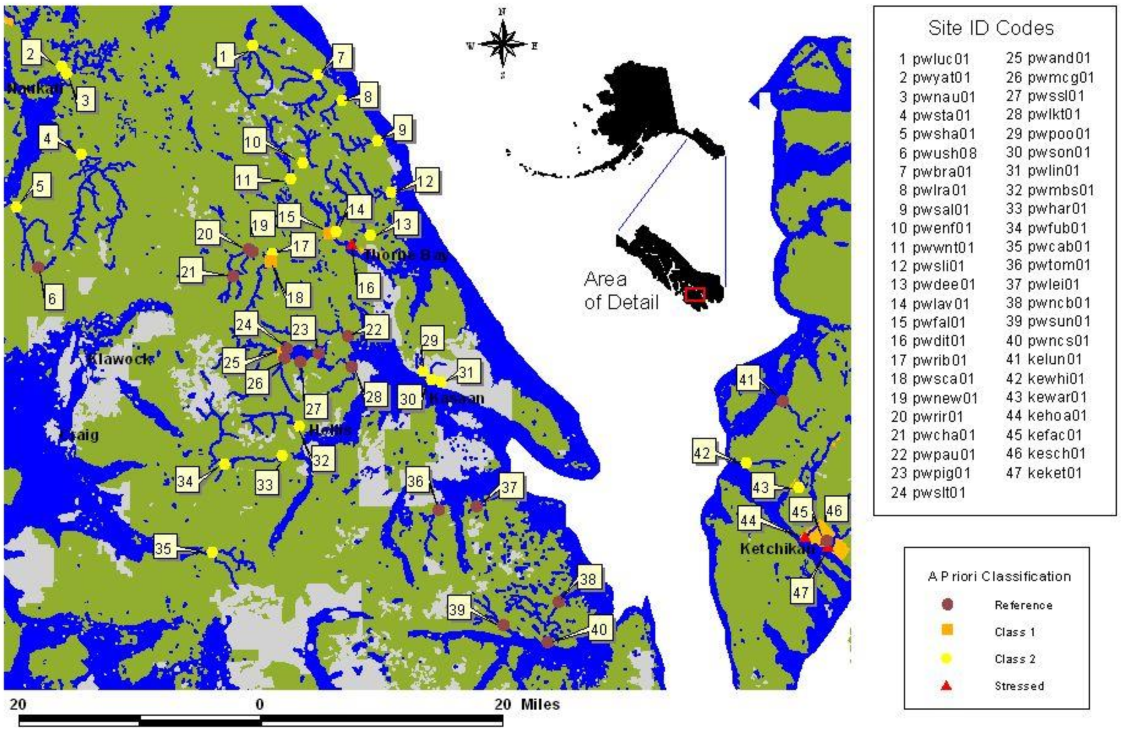

Figure 3. Ketchikan and Prince of Wales Island area sites.

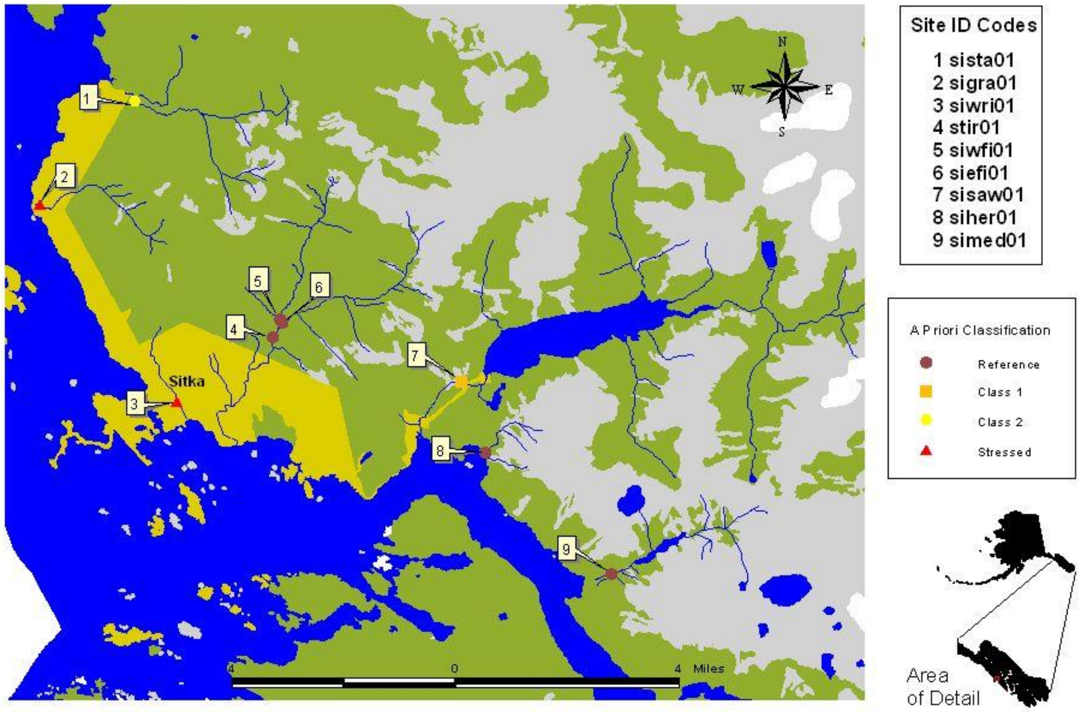

Figure 4. Sitka area sites.

Appendix 2. Names and descriptions of stream sites.

Stream name	Region	Station ID	*A priori* disturbance class	Basin area (ha)	Latitude	Longitude
Bear Creek	Admiralty Island	aibea01	Reference	2939	58.27796	-134.78566
Doty's Creek	Admiralty Island	aidcc01	Reference	1346	58.12620	-134.24251
NNT to East Young Bay	Admiralty Island	aieyb01	Reference	1036	58.16407	-134.62732
NNT to Green Cove	Admiralty Island	aigcc01	Reference	870	58.14359	-134.27766
North Fork Michael Creek	Admiralty Island	ainfm02	Reference	1832	57.80103	-134.56212
South Fork Michael Creek	Admiralty Island	aisfm01	Class 2	2412	57.80023	-134.57327
Stink Creek	Admiralty Island	aisti01	Reference	1475	58.16727	-134.43843
NNT to West Young Bay	Admiralty Island	aiwyb01	Reference	1109	58.15828	-134.67686
NNT (West Howard Bay Creek) to Howard Bay	Couverden	cohb101	Reference	926	58.29197	-135.10367
NNT (NW Howard Bay Creek) to Howard Bay	Couverden	cohb201	Reference	858	58.29922	-135.09772
Howard Bay Creek	Couverden	cohb301	Reference	726	58.31982	-135.08835
Point Howard Creek	Couverden	cohb401	Reference	1724	58.31530	-135.0901
NNT (South Golub Creek) to W Lynn Canal	Couverden	cohic01	Reference	1580	58.44942	-135.10959
NNT (South Lynn Sisters Creek) to W Lynn Canal	Couverden	conwc01	Reference	247	58.48705	-135.13881
NNT (Dick's Creek) to Swanson Harbor	Couverden	cosco01	Reference	1014	58.23549	-135.11293
NNT (2 miles N of Robinson Creek) to W Lynn Canal	Couverden	cowc301	Reference	201	58.41168	-135.08968
Peterson Creek, tributary 1	Juneau	ju1tr01	Reference	193	58.28432	-134.65973
NNT (1 mile NE of Benjamin Island) to E Lynn Canal	Juneau	juben01	Reference	142	58.57645	-134.89148
Duck Creek	Juneau	juduc01	Stressed	97	58.38513	-134.57633
Fish Creek	Juneau	jufis01	Class 1	3488	58.33040	-134.59240
Jordan Creek	Juneau	jujor01	Stressed	692	58.37532	-134.57474
Lake Creek	Juneau	julak01	Class 1	724	58.39558	-134.63286
McGinnis Creek	Juneau	jumcg01	Reference	1665	58.44013	-134.64613
NNT to West Mendenhall Lake	Juneau	jumlt01	Reference	94	58.42640	-134.58532
Montana Creek	Juneau	jumon01	Reference	962	58.44067	-134.64726
Pederson Hill Creek	Juneau	juped01	Class 2	70	58.37132	-134.6203
Peterson Creek	Juneau	jupet01	Reference	602	58.28263	-134.66592
Salmon Creek	Juneau	jusal01	Class 1	2520	58.33186	-134.46875
Sawmill Creek	Juneau	jusaw01	Reference	2184	58.71427	-134.94062
NNT to South Bridget Cove	Juneau	jusbc01	Reference	238	58.61870	-134.93385
NNT to Sawmill Creek	Juneau	jusmt01	Reference	125	58.71176	-134.93860
Steep Creek	Juneau	juste01	Class 1	532	58.41585	-134.54842
Vanderbilt Creek	Juneau	juvan01	Class 1	93	58.35343	-134.48833
Gunnuk Creek	Kake	kagun01	Class 2	3765	56.98000	-133.92912
Point Macartney Creek	Kake	kaptm01	Class 2	3339	57.01801	-134.01448
Point White Creek	Kake	kaptw01	Class 2	310	57.00159	-133.97719
Sitkum Creek	Kake	kasit01	Class 2	1356	56.93719	-133.83636
Slo Duc Creek	Kake	kaslo01	Class 2	1524	56.92312	-133.81987
NNT to the Hamilton River	Kake	kathr03	Reference	191	56.93744	-133.58392

Fairy Chasm Creek	Ketchikan	kefac01	Stressed	60	55.35125	-131.64520
Hoadley Creek	Ketchikan	kehoa01	Class 2	260	55.35627	-131.68458
Ketchikan Creek	Ketchikan	keket01	Class 1	3577	55.34422	-131.64002
Lunch Creek	Ketchikan	kelun01	Reference	1455	55.50782	-131.71883
Schoenbar (Laskawanda) Creek	Ketchikan	kesch01	Reference	272	55.35122	-131.64500
Ward Creek	Ketchikan	kewar01	Class 2	3917	55.41237	-131.69582
Whipple Creek	Ketchikan	kewhi01	Class 2	1375	55.44045	-131.79765
NNT (3 Lakes Cut) to Dry Strait	Petersburg	pe3lc01	Class 2	26	56.63043	-132.69518
NNT (3 Lakes Uncut) to Dry Strait	Petersburg	pe3lu01	Reference	39	56.62656	-132.69731
NNT (Clear Cut Creek) to Sumner Strait	Petersburg	peccc01	Class 2	76	56.50939	-132.78336
Dump Creek	Petersburg	pedum01	Stressed	115	56.80347	-132.91846
East Fork Hobo Creek	Petersburg	peefh01	Reference	106	56.79119	-132.87172
South Fork of the South Fork of Sumner Creek	Petersburg	peefm01	Reference	135	56.53527	-132.82080
NNT to Petersburg Creek	Petersburg	peest01	Reference	82	56.83157	-133.01006
Falls Creek	Petersburg	pefal01	Class 2	1790	56.69140	-132.82896
NNT (0.3 miles E of Hobo Creek) to Frederick Sound	Petersburg	pefre01	Reference	459	56.79339	-132.86465
Wilson Creek	Petersburg	pehw701	Class 1	1040	56.55529	-132.64621
Southeast Fork of Ohmer Creek	Petersburg	peseo01	Reference	816	56.58265	-132.72980
NNT to Sumner Creek	Petersburg	pesfs01	Reference	408	56.53406	-132.84138
Skoags Creek	Petersburg	pesko01	Reference	531	56.76995	-132.99066
Old Man Creek	Petersburg	pewn101	Reference	418	56.78628	-132.99516
City Creek	Petersburg	pewsc01	Reference	738	56.78322	-132.91513
Andersen Creek	Prince of Wales I.	pwand01	Class 1	5091	55.5754	-132.70973
Big Ratz Creek	Prince of Wales I.	pwbra01	Class 2	4171	55.88747	-132.63510
Cable Creek	Prince of Wales I.	pwcab01	Class 2	2263	55.35255	-132.85610
Chanterelle	Prince of Wales I.	pwcha01	Reference	407	55.66381	-132.80890
Deer Creek	Prince of Wales I.	pwdee01	Stressed	340	55.70630	-132.53425
Ditch Creek	Prince of Wales I.	pwdit01	Stressed	66	55.69692	-132.56854
East Fork of the North Fork of the Thorne River	Prince of Wales I.	pwenf01	Class 2	2006	55.78820	-132.66809
Falls Creek	Prince of Wales I.	pwfal01	Class 1	984	55.70930	-132.61450
Fubar Creek	Prince of Wales I.	pwfub01	Class 2	1086	55.45148	-132.82932
Harris River	Prince of Wales I.	pwhar01	Class 2	7171	55.45992	-132.71543
Lava (Gravelly) Creek	Prince of Wales I.	pwlav01	Class 2	2736	55.70983	-132.60263
NNT (Leighton Creek) to Saltry Cove	Prince of Wales I.	pwlei01	Reference	96	55.39902	-132.33366
Linkum Creek	Prince of Wales I.	pwlin01	Stressed	328	55.53981	-132.40022
NNT to lower Karta River	Prince of Wales I.	pwlkt01	Reference	458	55.55770	-132.57552
Little Ratz Creek	Prince of Wales I.	pwlra01	Class 2	1072	55.85862	-132.58769
Luck Creek	Prince of Wales I.	pwluc01	Class 2	4761	55.92060	-132.76424
Maybeso Creek	Prince of Wales I.	pwmbs01	Class 2	3620	55.49202	-132.68080
McGillvery Creek	Prince of Wales I.	pwmcg01	Reference	3484	55.56862	-132.71022
Naukati Creek	Prince of Wales I.	pwnau01	Class 2	3126	55.89200	-133.13750
NNT to Clover Bay	Prince of Wales I.	pwncb01	Reference	2395	55.28979	-132.17627
NNT to Cholmondeley Sound	Prince of Wales I.	pwncs01	Reference	71	55.24420	-132.19858
Newlunberry Creek	Prince of Wales I.	pwnew01	Reference	438	55.69022	-132.76993
Paul Young Creek	Prince of Wales I.	pwpau01	Reference	1351	55.59336	-132.58188

Piggyback Creek	Prince of Wales I.	pwpig01	Reference	2394	55.57480	-132.64068
Poor Man (Label) Creek	Prince of Wales I.	pwpoo01	Class 2	492	55.55161	-132.43539
Rio Beaver	Prince of Wales I.	pwrib01	Class 2	3216	55.68680	-132.72992
Rio Roberts	Prince of Wales I.	pwrir01	Class 1	2158	55.69390	-132.77665
Sal Creek	Prince of Wales I.	pwsal01	Class 2	1693	55.81222	-132.51693
Scary Creek	Prince of Wales I.	pwsca01	Class 1	564	55.67904	-132.73300
Shaheen Creek	Prince of Wales I.	pwsha01	Class 2	4525	55.74208	-133.24000
Slide Creek	Prince of Wales I.	pwsli01	Class 2	2621	55.75325	-132.49200
NNT to NW end of Salmon Lake	Prince of Wales I.	pwslt01	Reference	150	55.57987	-132.70322
Son In Hat Creek	Prince of Wales I.	pwson01	Class 2	493	55.54222	-132.41920
NNT to South side of Salmom Lake	Prince of Wales I.	pwssl01	Reference	319	55.56599	-132.67834
Staney Creek	Prince of Wales I.	pwsta01	Class 2	12794	55.80147	-133.10992
Sunny Creek	Prince of Wales I.	pwsun01	Reference	1908	55.26488	-132.28641
Old Tom Creek	Prince of Wales I.	pwtom01	Reference	1612	55.39590	-132.40645
Upper Shaheen Creek	Prince of Wales I.	pwush08	Reference	407	55.67406	-133.19470
West Fork of the North Fork of the Thorne River	Prince of Wales I.	pwwnt01	Class 2	3407	55.77008	-132.69120
Yatuk Creek	Prince of Wales I.	pwyat01	Class 2	1511	55.90015	-133.14687
East Fork of the Indian River	Sitka	siefi01	Reference	1274	57.07490	-135.28850
Granite Creek	Sitka	sigra01	Class 2	541	57.10091	-135.39740
NNT to Herring Cove	Sitka	siher01	Reference	204	57.04533	-135.19896
Medvejie Creek	Sitka	simed01		1826	57.01720	-135.14020
Sawmill Creek	Sitka	sisaw02	Class 1	9743	57.06097	-135.21133
Starrigavan Creek	Sitka	sista01	Class 2	1367	57.12609	-135.35609
NNT to the Indian River	Sitka	sitir01	Reference	46	57.07149	-135.29456
West Fork of the Indian River	Sitka	siwfi01	Reference	1068	57.07547	-135.29172
Wrinkleneck Creek	Sitka	siwri01	Class 2	250	57.05539	-135.33487
Anan Creek	Wrangell	wrana01	Reference	7297	56.16838	-131.87450
Crittenden Creek	Wrangell	wrcrt01	Reference	5193	56.50817	-132.26102
East Fork of Anan Creek	Wrangell	wrefa01	Reference	6431	56.16781	-131.87350
East Fork of Crittenden Creek	Wrangell	wrefc01	Reference	4209	56.49541	-132.25751
Glacier Creek	Wrangell	wrgla01	Reference	3659	56.47489	-132.15530
Marten Creek	Wrangell	wrmar01	Reference	5626	56.23251	-131.88393
McCormack Creek	Wrangell	wrmcc01	Class 2	1125	56.31193	-132.33801
Pat Creek	Wrangell	wrpat01	Class 2	1348	56.35378	-132.32445
Porterfield Creek	Wrangell	wrpor01	Reference	5132	56.48002	-132.13990
NNT to Skip Creek (Cut)	Wrangell	wrskc01	Class 2	130	56.27282	-132.24567
NNT to Skip Creek (Uncut)	Wrangell	wrskn01	Class 1	64	56.27389	-132.23439
Tom Creek	Wrangell	wrtom01	Reference	7800	56.22120	-131.67441
NNT to Bradfield Canal (East of Hoya Creek)	Wrangell	wrunm01	Class 1	1589	56.18607	-131.69728

*WGS84 datum

Appendix 3. Physical characteristics of sample streams.

Stream name	Region	Station ID	Date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Discharge (cfs)	Channel slope (%)	Rosgen stream class	USFS channel type	Water color
Bear Creek	Admiralty Island	aibea01	05-15-2003		15	60	15	10			44.61	1	F3	LC1	stained
Doty's Creek	Admiralty Island	aidcc01	05-16-2003		10	60	25	5			10.42	1.5	C3	LC1	stained
NNT to East Young Bay	Admiralty Island	aieyb01	05-15-2003			10	80	10			17.80	0.75	C4	FP3	stained
NNT to Green Cove	Admiralty Island	aigcc01	05-16-2003		15	55	30				7.79	2.5	B3	FP3	stained
NNT to West Young Bay	Admiralty Island	aiwyb01	05-15-2003		10	70	15	5			18.44	4	B3	FP4	stained
North Fork Michael Creek	Admiralty Island	ainfm02	05-07-2002		70	25	5				10.22	2.5	B2	MC2	clear
South Fork Michael Creek	Admiralty Island	aisfm01	05-07-2002		65	25	10				4.84	4	B2	MM1	clear
Stink Creek	Admiralty Island	aisti01	05-15-2003			45	50	5			29.25	1.5	C4	FP3	stained
Howard Bay Creek	Couverden	cohb301	05-11-2004	25	1	24	50				9.03	2	B4	MC2	clear
NNT (2 miles N of Robinson Creek) to W Lynn Canal	Couverden	cowc301	05-10-2004	1	10	48	40	1			13.48	3	B3	HC3	clear
NNT (Dick's Creek) to Swanson Harbor	Couverden	cosco01	05-11-2004	7	10	26	55	2			2.68	2.5	B4	LC1	stained
NNT (NW Howard Bay Creek) to Howard Bay	Couverden	cohb201	05-11-2004	15	7	20	58				21.20	4	A4	MC2	clear
NNT (South Golub Creek) to W Lynn Canal	Couverden	cohic01	05-10-2004	30	10	35	20	5			74.20	3	B3	LC1	clear
NNT (South Lynn Sisters Creek) to W Lynn Canal	Couverden	conwc01	05-10-2004		15	45	39	1			13.30	5	A4	HC3	clear
NNT (West Howard Bay Creek) to Howard Bay	Couverden	cohb101	05-11-2004		7	15	76	2			20.20	2	B4	MC2	clear
Point Howard Creek	Couverden	cohb401	05-11-2004		1	25	73	1			85.00	2.5	B4	LC1	clear
Duck Creek	Juneau	juduc01	05-08-2002		2	3	30	10	55		0.12	0.5		FP3	slightly turbid
Duck Creek	Juneau	juduc01	05-13-2004			9	40	1	50		0.50	1		FP3	turbid
Fish Creek	Juneau	jufis01	05-06-2002		50	30	10	10			22.78	2	B2	LC2	clear
Jordan Creek	Juneau	jujor01	05-13-2003				10	70	20		0.86	0.5	C5	PA1	clear
Lake Creek	Juneau	julak01	05-15-2004		15	55	30				15.63	3	B3	MC2	clear
McGinnis Creek	Juneau	jumcg01	05-05-2002		30	60	10				14.11	1.5	B3	FP4	clear
McGinnis Creek	Juneau	jumcg01	05-14-2003		5	60	25	10			43.76	2	G3	FP4	clear
McGinnis Creek	Juneau	jumcg01	05-13-2004		1	48	50	1			74.55	3	B4	FP4	clear
Montana Creek	Juneau	jumon01	05-05-2002		30	60	10				11.34	2	B3	MM2	clear
Montana Creek	Juneau	jumon01	05-14-2003		5	70	22	3			18.96	1.5	B/C3	MM2	clear
Montana Creek	Juneau	jumon01	05-13-2004		5	44	50	1			18.42	2	C4	MM2	clear

NNT (1 mile NE of Benjamin Island) to E Lynn Canal	Juneau	juben01	05-03-2002	60	10	15	15				0.58	20	A1	HC5	clear
NNT to Sawmill Creek	Juneau	jusmt01	05-03-2002		30	50	20				1.90	3	B3	MC1	stained
NNT to South Bridget Cove	Juneau	jusbc01	05-03-2002			60	30	10			1.47	2	B3	MC2	stained
NNT to West Mendenhall Lake	Juneau	jumlt01	05-05-2002		50	40	10				44.62	4	B2	MC1	clear
Pederson Hill Creek	Juneau	juped01	05-05-2002		2	5	73	20			10.43	1.5	C4	PA1	clear
Peterson Creek	Juneau	jupet01	05-06-2002				60	40			17.90	0.5	C4	FP3	clear
Peterson Creek, tributary 1	Juneau	ju1tr01	05-06-2002		5	50	40	5			7.80	4.5	G3	MC1	clear
Salmon Creek	Juneau	jusal01	05-14-2004	1	10	40	44	5			18.45	2	B4	MM2	clear
Sawmill Creek	Juneau	jusaw01	05-03-2002		5	77	15	3			10.22	1	B3	MC2	clear
Steep Creek	Juneau	juste01	05-15-2004		2	25	68	5			4.84	3	B4	FP3	clear
Vanderbilt Creek	Juneau	juvan01	05-13-2003			5	40	35	20		29.26	0.5	C4	FP3	clear
Gunnuk Creek	Kake	kagun01	05-04-2004	25	10	34	30	1			9.04	1.5	B3	LC2	stained
NNT to the Hamilton River	Kake	kathr03	05-05-2004	35	5	25	35				13.49	4	B1	MC1	stained
Point Macartney Creek	Kake	kaptm01	05-04-2004	2	4	12	80	2			2.69	1	C4	LC2	clear
Point White Creek	Kake	kaptw01	05-04-2004	5	10	40	42	1	2		21.30	4	B4	MC1	clear
Sitkum Creek	Kake	kasit01	05-05-2004		2	23	70	5			74.30	2.5	C4	FP4	stained
Slo Duc Creek	Kake	kaslo01	05-05-2004	5	5	38	50	1	1		13.40	2	B4	FP4	stained
Fairy Chasm Creek	Ketchikan	kefac01	05-01-2002			60	40				20.30	2	C3	MM1	slightly turbid
Hoadley Creek	Ketchikan	kehoa01	05-01-2002		30	60	10				12.13	2.5	A3	MM1	clear
Ketchikan Creek	Ketchikan	keket01	05-01-2002			50	45	5			61.18	0.9	C3	FP5	clear
Lunch Creek	Ketchikan	kelun01	04-30-2002		35	25	5	35			30.74	1	B2	MC1	stained
Schoenbar (Laskawanda) Creek	Ketchikan	kesch01	05-01-2002	5	55	40					5.53	2.5	B2	MM1	clear
Ward Creek	Ketchikan	kewar01	04-30-2002			40	50	10			151.32	0.9	C4	FP5	stained
Whipple Creek	Ketchikan	kewhi01	05-01-2002		20	70	10				31.24	1	B3	FP3	stained
City Creek	Petersburg	pewsc01	05-03-2004		40	20	25	15			21.02	2.5	B2	MM1	stained slightly
Dump Creek	Petersburg	pedum01	05-09-2003		60	35	5				0.05	8	A2	MM1	clear
East Fork Hobo Creek	Petersburg	peefh01	05-10-2003		20	60	5	15			0.92	3	A3	MC1	clear
Falls Creek	Petersburg	pefal01	05-10-2003		2	28	40	30			8.25	1.5	C4	FP4	clear
NNT (0.3 miles E of Hobo Creek) to Frederick Sound	Petersburg	pefre01	05-08-2003			40	50	8	2		12.49	5	B3	MM1	stained
NNT (3 Lakes Cut) to Dry Strait	Petersburg	pe3lc01	05-10-2003			40	40	20			0.12	6	A3	HC2	clear
NNT (3 Lakes Uncut) to Dry Strait	Petersburg	pe3lu01	05-10-2003		3	75	20	2			1.39	5	B3	MM1	clear
NNT (Clear Cut Creek) to Sumner Strait	Petersburg	peccc01	05-09-2003	2	40	50	8				0.04	7	A3	HC2	clear

NNT to Petersburg Creek	Petersburg	peest01	05-12-2003		15	75	7	3			1.09	13	A3	HC6	clear
NNT to Sumner Creek	Petersburg	pesfs01	05-09-2003	3	30	60	7				1.27	4	B3	MM1	clear
Old Man Creek	Petersburg	pewn101	05-11-2003	52	20	20	5	3			0.34	2.5	F1	MM1	clear
Skoags Creek	Petersburg	pesko01	05-11-2003	25		10	40	25			0.53	0.5	F4	MC1	clear
South Fork of the South Fork of Sumner Creek	Petersburg	peefm01	05-03-2004		39	35	25	1			5.50	8	A2	HC5	clear
Southeast Fork of Ohmer Creek	Petersburg	peseo01	05-09-2003		50	45	5				3.03	4	A2	FP3	clear
Wilson Creek	Petersburg	pehw701	05-10-2003		40	30	15	15			4.06	7	B2	MM1	clear
Andersen Creek	Prince of Wales I.	pwand01	04-27-2002		5	60	35				77.22	0.4	B3	LC1	stained
Andersen Creek	Prince of Wales I.	pwand01	04-26-2003			50	48	2			103.87	1.5	B3c	LC1	clear
Andersen Creek	Prince of Wales I.	pwand01	04-28-2004		1	47	50	2			97.28	1	C3	LC1	stained
Big Ratz Creek	Prince of Wales I.	pwbra01	04-26-2002		35	50	10	5			59.65	1	B3	LC1	stained
Big Ratz Creek	Prince of Wales I.	pwbra01	05-02-2003		10	80	10				34.82	1	B3	LC1	stained
Cable Creek	Prince of Wales I.	pwcab01	04-22-2002			22	70	8			38.25	0.75	B4	FP4	stained
Chanterelle	Prince of Wales I.	pwcha01	05-07-2004		10	50	30	5	5			2	B3	HC4	clear
Deer Creek	Prince of Wales I.	pwdee01	04-26-2002		10	70	15	5			3.92	2	B3	PA1	stained
Ditch Creek	Prince of Wales I.	pwdit01	05-01-2003		5	20	55	20			0.27	1	C4	MM1	clear
East Fork of the North Fork of the Thorne River	Prince of Wales I.	pwenf01	05-02-2003			5	80	15			30.97	1	C4	FP5	stained
Falls Creek	Prince of Wales I.	pwfal01	04-25-2002	2	45	48	5				9.17	2	B3	MM2	stained
Fubar Creek	Prince of Wales I.	pwfub01	04-22-2002			47	50	3			26.14	1	C4	FP4	stained
Harris River	Prince of Wales I.	pwhar01	04-22-2002	5	5	39	50	1			144.99	0.5	B4	FP5	slightly stained
Lava (Gravelly) Creek	Prince of Wales I.	pwlav01	04-25-2002		50	45	5				30.30	2	B2	FP5	stained
Linkum Creek	Prince of Wales I.	pwlin01	05-01-2004		15	45	40				4.20	3.5	B3	MC3	clear
Little Ratz Creek	Prince of Wales I.	pwlra01	04-26-2002		50	25	15	10			13.05	1.5	B2	FP4	stained
Little Ratz Creek	Prince of Wales I.	pwlra01	05-02-2003		15	50	25	10			10.55	1	B3	FP4	stained
Luck Creek	Prince of Wales I.	pwluc01	05-02-2003			10	75	15			51.38	1	C4	FP5	clear
Maybeso Creek	Prince of Wales I.	pwmbs01	04-22-2002			50	50				74.22	2.5	C3	FP5	slightly stained
McGillvery Creek	Prince of Wales I.	pwmcg01	04-26-2003		<1	5	90	5			88.45	1	C4	FP5	clear
McGillvery Creek	Prince of Wales I.	pwmcg01	04-27-2004			50	48	2			82.90	1	C3	FP5	clear
Naukati Creek	Prince of Wales I.	pwnau01	04-24-2002	40	30	20	10				37.07	1.5	B2	FP4	stained
Newlunberry Creek	Prince of Wales I.	pwnew01	04-23-2002	5	40	45	10				6.86	2.5	B3	MC1	stained
Newlunberry Creek	Prince of Wales I.	pwnew01	05-01-2003	2	45	35	18				0.75	2	G2	MC1	stained
Newlunberry Creek	Prince of Wales I.	pwnew01	05-01-2004	5	15	50	30				1.00	2	B3	MC1	stained
NNT (Leighton Creek) to Saltry Cove	Prince of Wales I.	pwlei01	04-30-2003	5	45	35	15				0.51	7	A2	HC5	stained
NNT to Cholmondeley Sound	Prince of Wales I.	pwncs01	04-29-2003	10	35	45	10				0.08	4	B3	MM1	clear

NNT to Clover Bay	Prince of Wales I.	pwncb01	04-29-2003		70	25	5				17.98	3.5	B2	LC2	stained
NNT to lower Karta River	Prince of Wales I.	pwlkt01	04-28-2002	2	20	36	36	6			12.42	1.5	C3	FP4	stained
NNT to lower Karta River	Prince of Wales I.	pwlkt01	04-27-2003	15	15	25	30	15			5.51	1.25	C3	FP4	clear
NNT to lower Karta River	Prince of Wales I.	pwlkt01	04-26-2004		10	50	38	2			25.80	1.5	C3b	FP4	stained
NNT to NW end of Salmon Lake	Prince of Wales I.	pwslt01	04-27-2002		2	48	50				2.73	2	C4	MM1	stained
NNT to NW end of Salmon Lake	Prince of Wales I.	pwslt01	04-26-2003			5	80	15			0.48	1.75	C3	MM1	stained
NNT to NW end of Salmon Lake	Prince of Wales I.	pwslt01	04-28-2004			40	54	5	1		1.10	2	C3	MM1	stained
NNT to South side of Salmom Lake	Prince of Wales I.	pwssl01	04-26-2003		30	60	10				3.63	6	A3	MC1	clear
NNT to South side of Salmom Lake	Prince of Wales I.	pwssl01	04-27-2004		20	50	28	2			5.20	3.5	A3	MC1	clear
Old Tom Creek	Prince of Wales I.	pwtom01	04-30-2003		5	50	40	5			18.61	0.5	B3	FP4	clear
Paul Young Creek	Prince of Wales I.	pwpau01	04-26-2004		25	69	5	1			48.60	2	B3	LC2	clear
Piggyback Creek	Prince of Wales I.	pwpig01	04-28-2002		55	30	12	3			78.55	1	B2	FP5	stained
Piggyback Creek	Prince of Wales I.	pwpig01	04-27-2003	50	35	10	5				20.14	3	A1	FP5	clear
Piggyback Creek	Prince of Wales I.	pwpig01	04-28-2004	50	20	20	10				19.80	4	A1	FP5	stained
Poor Man (Label) Creek	Prince of Wales I.	pwpoo01	04-26-2004	15	25	30	30				7.20	2.5	A3	FP3	stained
Rio Beaver	Prince of Wales I.	pwrib01	04-23-2002	5	20	50	20	5			40.86	2	B3	LC1	stained
Rio Roberts	Prince of Wales I.	pwrir01	04-23-2002	10	60	20	8	2			31.76	2.2	B2	MC2	stained
Sal Creek	Prince of Wales I.	pwsal01	04-26-2002	1		47	50			2	23.32	1	C4	FP4	stained
Sal Creek	Prince of Wales I.	pwsal01	04-29-2004		5	30	55	10			19.20	1	C4	FP4	clear
Scary Creek	Prince of Wales I.	pwsca01	04-30-2004	5	5	50	39	1			5.35	2	C3	MM1	clear
Shaheen Creek	Prince of Wales I.	pwsha01	04-24-2002		60	30	5	5			32.94	1	B2	LC1	stained
Slide Creek	Prince of Wales I.	pwsli01	04-26-2002		30	30	30	10			36.19	1.5	B2	FP5	stained
Son In Hat Creek	Prince of Wales I.	pwson01	05-01-2004			7	90	3			1.50	4	C4	HC6	clear
Staney Creek	Prince of Wales I.	pwsta01	04-24-2002		45	35	20				130.42	1	B2	FP5	stained
Sunny Creek	Prince of Wales I.	pwsun01	04-28-2003		55	40	5				19.18	1.25	B2	FP4	clear
Upper Shaheen Creek	Prince of Wales I.	pwush08	04-30-2004	20	7	35	30	8			6.10	7	A3	MC3	clear
West Fork of the North Fork of the Thorne River	Prince of Wales I.	pwwnt01	04-25-2002				80	20			30.00	0.5	C4	FP5	stained
Yatuk Creek	Prince of Wales I.	pwyat01	04-24-2002		5	50	40	5			8.17	2	B3	MM2	stained
East Fork of the Indian River	Sitka	siefi01	05-08-2004		10	40	47	3			28.90	2	B4	FP4	clear
Granite Creek	Sitka	sigra01	05-09-2004		10	75	15				5.45	2.5	B3	MM2	clear
Medvejie Creek	Sitka	simed01	05-07-2004		50	40	10				16.40	6	A2	MM2	clear
NNT to Herring Cove	Sitka	siher01	05-07-2004		1	38	60	1			4.40	5	B4	MM1	clear
NNT to the Indian River	Sitka	sitir01	05-08-2004		2	35	60	2	1		0.77	2.5	B4	MM1	clear
Sawmill Creek	Sitka	sisaw02	05-07-2004		5	45	50				66.70	2	B3	LC2	clear

Starrigavan Creek	Sitka	sista01	05-09-2004			19	80	1			21.83	2.5	B4	FP4	clear
West Fork of the Indian River	Sitka	siwfi01	05-08-2004		10	30	50	10			33.10	1	B4	FP4	clear
Wrinkleneck Creek	Sitka	siwri01	05-08-2004			5	90	1	4		0.20	1	C4	FP3	turbid
Anan Creek	Wrangell	wrana01	05-07-2003		35	60	5				30.70	4	B3	LC2	stained
Crittenden Creek	Wrangell	wrcrt01	05-06-2003	40	5	40	15				31.10	1.5	C1	LC1	clear
East Fork of Anan Creek	Wrangell	wrefa01	05-07-2003	5	20	40	20	15			38.35	2	C3	FP5	stained
East Fork of Crittenden Creek	Wrangell	wrefc01	05-06-2003	20	25	45	9	1			40.89	3.5	B3	HC6	clear
Glacier Creek	Wrangell	wrgla01	05-06-2003		10	50	30	10			70.07	1	B3	LC1	clear
Marten Creek	Wrangell	wrmar01	05-07-2003		60	20	10	10			58.16	2	B2	FP4	clear
McCormack Creek	Wrangell	wrmcc01	05-05-2003	15	20	50	12	3			4.63	2	G3	MM2	clear
NNT to Bradfield Canal (East of Hoya Creek)	Wrangell	wrunm01	05-07-2003		55	40	5				4.29	2	B2	LC2	clear
NNT to Skip Creek (Cut)	Wrangell	wrskc01	05-05-2003		60	30	8	2			0.18	13	A2	HC2	clear
NNT to Skip Creek (Uncut)	Wrangell	wrskn01	05-05-2003		60	30	10				0.09	14	A2	HC2	clear
Pat Creek	Wrangell	wrpat01	05-05-2003			45	50	5			3.96	1	C4	FP3	clear
Porterfield Creek	Wrangell	wrpor01	05-06-2003			20	65	15			47.94	1	C4	FP4	clear
Tom Creek	Wrangell	wrtom01	05-07-2003		15	35	15	35			135.92	1	B3	FP5	clear

Appendix 4. Physicochemical data from study streams.

Stream name	Region	Station ID	Date	Conductivity (ųs/cm)	Dissolved oxygen (% saturation)	Dissolved oxygen (mg/L)	pH	Water temperature (ºC)
Bear Creek	Admiralty Island	aibea01	05-15-2003	50.3	100.4	13.90	8.0	3.84
Doty's Creek	Admiralty Island	aidcc01	05-16-2003	17.7	100.7	13.05	5.7	4.42
NNT to East Young Bay	Admiralty Island	aieyb01	05-15-2003	64.0	96.7	12.78	7.9	3.66
NNT to Green Cove	Admiralty Island	aigcc01	05-16-2003	27.0	n.a.	n.a.	6.7	3.55
NNT to West Young Bay	Admiralty Island	aiwyb01	05-15-2003	75.6	101.5	13.53	7.8	3.35
North Fork Michael Creek	Admiralty Island	ainfm02	05-07-2002	61.5	93.1	12.32	7.6	3.46
South Fork Michael Creek	Admiralty Island	aisfm01	05-07-2002	43.1	93.7	12.98	7.3	1.74
Stink Creek	Admiralty Island	aisti01	05-15-2003	69.9	100.4	12.91	7.7	n.a.
Howard Bay Creek	Couverden	cohb301	05-11-2004	161.3	96.2	12.03	8.1	5.72
NNT (2 miles N of Robinson Creek) to W Lynn Canal	Couverden	cowc301	05-10-2004	124.0	94.8	12.38	7.9	4.20
NNT (Dick's Creek) to Swanson Harbor	Couverden	cosco01	05-11-2004	66.5	96.2	12.14	7.7	5.44
NNT (NW Howard Bay Creek) to Howard Bay	Couverden	cohb201	05-11-2004	152.8	96.1	11.61	8.0	7.20
NNT (South Golub Creek) to W Lynn Canal	Couverden	cohic01	05-10-2004	63.2	99.6	12.45	7.6	5.89
NNT (South Lynn Sisters Creek) to W Lynn Canal	Couverden	conwc01	05-10-2004	136.7	96.8	12.23	7.9	5.35
NNT (West Howard Bay Creek) to Howard Bay	Couverden	cohb101	05-11-2004	125.6	94.8	11.88	7.9	5.75
Point Howard Creek	Couverden	cohb401	05-11-2004	123.8	96.2	12.20	8.0	5.26
Duck Creek	Juneau	juduc01	05-08-2002	194.0	74.3	8.89	7.5	7.53
Duck Creek	Juneau	juduc01	05-13-2004	241.1	81.6	8.30	7.2	14.37
Fish Creek	Juneau	jufis01	05-06-2002	41.3	93.7	12.87	7.7	2.26
Jordan Creek	Juneau	jujor01	05-13-2003	78.6	89.8	11.20	7.2	5.92
Lake Creek	Juneau	julak01	05-15-2004	4.1	103.4	12.60	7.4	6.33
McGinnis Creek	Juneau	jumcg01	05-05-2002	41.4	92.7	12.37	6.9	3.27
McGinnis Creek	Juneau	jumcg01	05-14-2003	45.4	93.7	12.36	7.1	3.78
McGinnis Creek	Juneau	jumcg01	05-13-2004	42.8	97.3	12.31	7.3	5.22
Montana Creek	Juneau	jumon01	05-05-2002	31.0	92.7	12.96	7.1	1.56
Montana Creek	Juneau	jumon01	05-13-2003	32.1	96.4	12.92	7.3	3.08
Montana Creek	Juneau	jumon01	05-12-2004	39.2	95.4	12.31	7.5	4.55
NNT (1 mile NE of Benjamin Island) to E Lynn Canal	Juneau	juben01	05-03-2002	58.5	91.4	13.06	7.3	0.78
NNT to Sawmill Creek	Juneau	jusmt01	05-03-2002	21.3	89.3	12.63	6.9	1.17
NNT to South Bridget Cove	Juneau	jusbc01	05-03-2002	46.0	89.6	12.43	7.4	1.85
NNT to West Mendenhall Lake	Juneau	jumlt01	05-05-2002	38.6	98.8	14.19	6.2	0.59
Pederson Hill Creek	Juneau	juped01	05-05-2002	105.5	85.3	11.92	6.8	1.55
Peterson Creek	Juneau	jupet01	05-06-2002	38.8	88.4	12.40	6.8	1.50
Peterson Creek, tributary 1	Juneau	ju1tr01	05-06-2002	43.6	95.7	13.52	7.4	1.19
Salmon Creek	Juneau	jusal01	05-14-2004	48.7	95.4	12.10	7.5	5.22
Sawmill Creek	Juneau	jusaw01	05-03-2002	64.1	91.0	12.33	7.4	2.74
Steep Creek	Juneau	juste01	05-15-2004	36.0	95.8	12.90	7.5	3.00
Vanderbilt Creek	Juneau	juvan01	05-13-2003	57.7	85.5	10.68	6.8	5.90
Gunnuk Creek	Kake	kagun01	05-04-2004	31.7	95.9	11.85	7.3	6.22
NNT to the Hamilton River	Kake	kathr03	05-05-2004	4.4	87.6	10.22	6.2	8.61
Point Macartney Creek	Kake	kaptm01	05-04-2004	33.6	93.7	10.89	7.3	8.81
Point White Creek	Kake	kaptw01	05-04-2004	55.0	91.1	10.37	7.5	9.62

Sitkum Creek	Kake	kasit01	05-05-2004	26.0	92.4	11.17	7.1	7.22
Slo Duc Creek	Kake	kaslo01	05-05-2004	23.5	88.1	10.44	7.0	7.92
Fairy Chasm Creek	Ketchikan	kefac01	05-01-2002	94.5	90.9	11.32	7.1	5.93
Hoadley Creek	Ketchikan	kehoa01	05-01-2002	11.8	93.6	12.16	6.4	4.33
Ketchikan Creek	Ketchikan	keket01	05-01-2002	15.7	92.1	11.91	6.9	4.40
Lunch Creek	Ketchikan	kelun01	04-30-2002	11.5	90.1	12.06	7.0	3.40
Schoenbar (Laskawanda) Creek	Ketchikan	kesch01	05-01-2002	16.0	88.0	11.17	7.1	5.30
Ward Creek	Ketchikan	kewar01	04-30-2002	16.7	92.0	11.04	6.7	7.60
Whipple Creek	Ketchikan	kewhi01	05-01-2002	23.9	94.3	11.36	6.7	7.21
City Creek	Petersburg	pewsc01	05-03-2004	0.1	95.6	12.64	6.8	3.69
Dump Creek	Petersburg	pedum01	05-09-2003	126.7	90.8	11.17	7.1	6.72
East Fork Hobo Creek	Petersburg	peefh01	05-10-2003	4.2	96.5	12.06	6.1	5.73
Falls Creek	Petersburg	pefal01	05-10-2003	26.0	95.3	10.52	7.0	10.93
NNT (0.3 miles E of Hobo Creek) to Frederick Sound	Petersburg	pefre01	05-08-2003	7.0	96.7	12.54	6.4	4.40
NNT (3 Lakes Cut) to Dry Strait	Petersburg	pe3lc01	05-10-2003	3.5	96.2	11.86	6.4	6.37
NNT (3 Lakes Uncut) to Dry Strait	Petersburg	pe3lu01	05-10-2003	3.4	93.8	11.85	5.6	5.45
NNT (Clear Cut Creek) to Sumner Strait	Petersburg	peccc01	05-09-2003	12.6	90.4	10.60	7.1	8.42
NNT to Petersburg Creek	Petersburg	peest01	05-12-2003	13.6	95.8	12.22	6.9	4.98
NNT to Sumner Creek	Petersburg	pesfs01	05-09-2003	7.6	93.2	11.87	6.7	5.10
Old Man Creek	Petersburg	pewn101	05-11-2003	38.0	98.9	12.12	7.2	6.57
Skoags Creek	Petersburg	pesko01	05-11-2003	31.4	95.6	11.39	7.1	7.65
South Fork of the South Fork of Sumner Creek	Petersburg	peefm01	05-03-2004	1.8	98.3	12.68	6.2	4.56
Southeast Fork of Ohmer Creek	Petersburg	peseo01	05-09-2003	6.5	92.5	11.50	6.4	6.10
Wilson Creek	Petersburg	pehw701	05-10-2003	6.9	99.4	12.69	7.0	5.00
Andersen Creek	Prince of Wales I.	pwand01	04-27-2002	21.8	79.4	12.32	7.5	5.56
Andersen Creek	Prince of Wales I.	pwand01	04-26-2003	16.0	97.4	11.29	7.2	8.90
Andersen Creek	Prince of Wales I.	pwand01	04-28-2004	14.4	97.0	11.82	7.1	6.81
Big Ratz Creek	Prince of Wales I.	pwbra01	04-26-2002	9.7	95.3	11.81	6.9	6.17
Big Ratz Creek	Prince of Wales I.	pwbra01	05-02-2003	25.2	90.8	10.30	7.2	10.30
Cable Creek	Prince of Wales I.	pwcab01	04-22-2002	104.2	93.6	12.82	7.6	0.30
Chanterelle	Prince of Wales I.	pwcha01	05-07-2004	n.a.	n.a.	n.a.	n.a.	6.00
Deer Creek	Prince of Wales I.	pwdee01	04-26-2002	17.2	n.a.	n.a.	6.9	1.91
Ditch Creek	Prince of Wales I.	pwdit01	05-01-2003	114.2	87.0	10.29	7.1	8.00
East Fork of the North Fork of the Thorne River	Prince of Wales I.	pwenf01	05-02-2003	28.2	87.7	10.96	7.0	5.85
Falls Creek	Prince of Wales I.	pwfal01	04-25-2002	22.5	n.a.		7.4	3.80
Fubar Creek	Prince of Wales I.	pwfub01	04-22-2002	29.2	95.2	13.06	7.8	2.25
Harris River	Prince of Wales I.	pwhar01	04-22-2002	32.8	98.0	12.34	7.2	5.54
Lava (Gravelly) Creek	Prince of Wales I.	pwlav01	04-25-2002	22.6	n.a.	n.a.	7.4	4.71
Linkum Creek	Prince of Wales I.	pwlin01	05-01-2004	31.1	95.4	11.54	7.3	7.12
Little Ratz Creek	Prince of Wales I.	pwlra01	04-26-2002	16.7	93.6	12.53	6.8	3.12
Little Ratz Creek	Prince of Wales I.	pwlra01	05-02-2003	35.6	95.3	12.11	7.4	5.11
Luck Creek	Prince of Wales I.	pwluc01	05-02-2003	56.5	93.1	11.35	7.3	6.80
Maybeso Creek	Prince of Wales I.	pwmbs01	04-23-2002	38.0	94.8	12.57	7.0	3.50
McGillvery Creek	Prince of Wales I.	pwmcg01	04-26-2003	23.1	97.7	11.97	7.0	6.69
McGillvery Creek	Prince of Wales I.	pwmcg01	04-27-2004	22.8	90.3	11.28	6.8	5.95
Naukati Creek	Prince of Wales I.	pwnau01	04-24-2002	85.1	95.2	11.64	7.4	6.59
Newlunberry Creek	Prince of Wales I.	pwnew01	04-23-2002	8.3	97.1	13.45	6.2	1.94

Newlunberry Creek	Prince of Wales I.	pwnew01	05-01-2003	11.5	90.8	11.29	6.4	6.44
Newlunberry Creek	Prince of Wales I.	pwnew01	05-01-2004	5.0	92.1	10.93	6.4	7.90
NNT (Leighton Creek) to Saltry Cove	Prince of Wales I.	pwlei01	04-30-2003	11.2	94.9	11.86	7.0	5.96
NNT to Cholmondeley Sound	Prince of Wales I.	pwncs01	04-29-2003	36.8	93.8	10.90	7.3	8.83
NNT to Clover Bay	Prince of Wales I.	pwncb01	04-29-2003	14.0	96.6	10.10	6.7	13.29
NNT to lower Karta River	Prince of Wales I.	pwlkt01	04-28-2002	8.2	94.6	12.67	6.3	3.15
NNT to lower Karta River	Prince of Wales I.	pwlkt01	04-27-2003	8.1	78.3	9.63	6.4	6.81
NNT to lower Karta River	Prince of Wales I.	pwlkt01	04-26-2004	2.9	94.5	11.64	5.6	6.40
NNT to NW end of Salmon Lake	Prince of Wales I.	pwslt01	04-27-2002	19.9	95.5	12.62	6.8	3.61
NNT to NW end of Salmon Lake	Prince of Wales I.	pwslt01	04-26-2003	26.0	82.4	10.18	7.4	6.26
NNT to NW end of Salmon Lake	Prince of Wales I.	pwslt01	04-28-2004	26.7	90.2	11.27	6.6	5.81
NNT to South side of Salmom Lake	Prince of Wales I.	pwssl01	04-26-2003	7.5	98.7	12.36	6.4	5.77
NNT to South side of Salmom Lake	Prince of Wales I.	pwssl01	04-27-2004	3.0	95.1	12.32	6.6	4.31
Old Tom Creek	Prince of Wales I.	pwtom01	04-30-2003	28.1	89.2	10.48	7.5	8.40
Paul Young Creek	Prince of Wales I.	pwpau01	04-26-2004	11.6	93.7	11.44	6.4	6.79
Piggyback Creek	Prince of Wales I.	pwpig01	04-28-2002	20.4	95.5	13.30	6.9	1.71
Piggyback Creek	Prince of Wales I.	pwpig01	04-27-2003	24.3	94.8	11.65	7.3	6.47
Piggyback Creek	Prince of Wales I.	pwpig01	04-28-2004	25.0	95.3	11.17	7.0	8.36
Poor Man (Label) Creek	Prince of Wales I.	pwpoo01	04-26-2004	55.5	93.4	11.19	7.3	7.49
Rio Beaver	Prince of Wales I.	pwrib01	04-23-2002	38.2	95.8	12.97	7.2	2.79
Rio Roberts	Prince of Wales I.	pwrir01	04-23-2002	22.0	96.2	13.49	7.1	1.55
Sal Creek	Prince of Wales I.	pwsal01	04-26-2002	13.0	95.1	12.46	6.6	3.97
Sal Creek	Prince of Wales I.	pwsal01	04-29-2004	27.7	88.5	10.31	6.8	8.72
Scary Creek	Prince of Wales I.	pwsca01	04-30-2004	24.9	98.4	11.76	7.3	7.58
Shaheen Creek	Prince of Wales I.	pwsha01	04-24-2002	45.6	98.5	13.12	7.5	3.30
Slide Creek	Prince of Wales I.	pwsli01	04-26-2002	n.a.	96.3	13.54	5.9	1.37
Son In Hat Creek	Prince of Wales I.	pwson01	05-01-2004	88.6	92.5	10.83	7.5	8.54
Staney Creek	Prince of Wales I.	pwsta01	04-24-2002	47.8	100.8	n.a.	7.3	4.62
Sunny Creek	Prince of Wales I.	pwsun01	04-29-2003	28.8	90.0	10.43	7.6	8.31
Upper Shaheen Creek	Prince of Wales I.	pwush08	04-30-2004	45.3	n.a.	n.a.	7.6	6.00
West Fork of the North Fork of the Thorne River	Prince of Wales I.	pwwnt01	04-25-2002	35.5	92.3	12.04	7.6	3.78
Yatuk Creek	Prince of Wales I.	pwyat01	04-24-2002	119.6	95.7	12.54	7.5	4.11
East Fork of the Indian River	Sitka	siefi01	05-08-2004	32.3	88.8	11.40	7.3	4.75
Granite Creek	Sitka	sigra01	05-09-2004	32.4	87.5	11.00	7.3	5.69
Medvejie Creek	Sitka	simed01	05-07-2004	10.6	89.3	10.97	6.8	6.52
NNT to Herring Cove	Sitka	siher01	05-09-2004	48.2	89.3	11.50	7.3	4.63
NNT to the Indian River	Sitka	sitir01	05-08-2004	0.0	88.1	10.86	7.5	6.38
Sawmill Creek	Sitka	sisaw02	05-07-2004	25.9	88.4	11.57	7.0	4.09
Starrigavan Creek	Sitka	sista01	05-09-2004	49.0	85.5	10.92	7.2	5.05
West Fork of the Indian River	Sitka	siwfi01	05-08-2004	41.1	88.1	11.31	6.9	4.73
Wrinkleneck Creek	Sitka	siwri01	05-08-2004	58.7	82.1	9.72	7.5	7.16
Anan Creek	Wrangell	wrana01	05-07-2003	0.1	95.0	11.22	5.8	7.94
Crittenden Creek	Wrangell	wrcrt01	05-06-2003	0.1	99.8	13.05	6.6	3.96
East Fork of Anan Creek	Wrangell	wrefa01	05-07-2003	0.1	94.6	10.99	6.4	8.76
East Fork of Crittenden Creek	Wrangell	wrefc01	05-06-2003	58.8	124.4	16.16	7.4	4.33
Glacier Creek	Wrangell	wrgla01	05-06-2003	25.8	97.7	12.25	6.9	5.74
Marten Creek	Wrangell	wrmar01	05-08-2003	7.9	92.2	11.33	6.4	6.49

McCormack Creek	Wrangell	wrmcc01	05-05-2003	24.2	91.9	11.60	7.2	5.43
NNT to Bradfield Canal (East of Hoya Creek)	Wrangell	wrunm01	05-07-2003	5.8	95.2	12.36	6.1	4.35
NNT to Skip Creek (Cut)	Wrangell	wrskc01	05-05-2003	1.2	92.7	11.95	5.0	4.69
NNT to Skip Creek (Uncut)	Wrangell	wrskn01	05-05-2003	4.6	87.5	11.69	6.4	3.30
Pat Creek	Wrangell	wrpat01	05-05-2003	9.7	89.0	11.28	6.4	5.40
Porterfield Creek	Wrangell	wrpor01	05-06-2003	21.8	94.9	12.41	6.6	4.06
Tom Creek	Wrangell	wrtom01	05-07-2003	13.6	99.1	12.41	6.6	5.74

Appendix 5. Visual habitat assessment data for study streams (method from Barbour et al. 1999).

Station ID	Date	Total score	Epifaunal substrate/ available cover	Embeddedness/ pool substrate	Velocity depth regime/ pool variability	Sediment deposition	Channel flow status	Channel alteration	Frequency of riffles or bends/ channel sinuousity	Bank stability (left bank)	Bank stability (right bank)	Vegetative protection (left bank)	Vegetative protection (right bank)	Riparian vegetative zone width (left bank)	Riparian vegetative zone width (right bank)
aibea01	05-15-2003	176	15	16	19	15	17	20	20	10	10	10	10	7	7
aidcc01	05-16-2003	190	18	18	17	19	18	20	20	10	10	10	10	10	10
aieyb01	05-15-2003	183	19	18	20	16	10	20	20	10	10	10	10	10	10
aigcc01	05-16-2003	192	19	18	17	20	18	20	20	10	10	10	10	10	10
aiwyb01	05-15-2003	189	19	17	18	18	17	20	20	10	10	10	10	10	10
ainfm02	05-07-2002	182	19	11	17	18	18	20	19	10	10	10	10	10	10
aisfm01	05-07-2002	168	19	17	15	20	18	19	20	9	9	7	7	4	4
aisti01	05-15-2003	194	20	18	20	18	18	20	20	10	10	10	10	10	10
cohb301	05-11-2004	189	19	18	16	19	18	20	19	10	10	10	10	10	10
cowc301	05-10-2004	182	18	18	10	20	18	20	20	9	10	9	10	10	10
cosco01	05-11-2004	185	18	17	16	19	15	20	20	10	10	10	10	10	10
cohb201	05-11-2004	190	18	17	18	20	19	20	20	9	10	9	10	10	10
cohic01	05-10-2004	190	16	18	18	19	19	20	20	10	10	10	10	10	10
conwc01	05-10-2004	186	19	17	13	19	18	20	20	10	10	10	10	10	10
cohb101	05-11-2004	184	19	16	16	17	16	20	20	10	10	10	10	10	10
cohb401	05-11-2004	191	20	15	16	20	20	20	20	10	10	10	10	10	10
juduc01	05-08-2002	97	5	5	14	3	18	8	10	7	7	6	6	3	5
juduc01	05-13-2004	83	6	11	6	4	8	8	8	7	7	7	7	1	3
jufis01	05-06-2002	185	18	16	19	19	17	19	19	10	10	10	10	9	9
jujor01	05-13-2003	128	5	5	13	3	20	19	14	9	8	9	5	10	8
julak01	05-15-2004	181	19	20	20	19	15	20	20	7	7	7	7	10	10
jumcg01	05-05-2002	186	15	19	15	19	19	20	19	10	10	10	10	10	10
jumcg01	05-14-2003	176	15	18	20	15	16	20	20	7	9	7	9	10	10
jumcg01	05-13-2004	176	16	14	16	16	16	20	20	9	10	9	10	10	10
jumon01	05-02-2002	191	20	20	18	19	18	19	20	10	10	10	10	9	8
jumon01	05-13-2003	182	19	18	18	19	13	20	20	9	9	9	9	10	9
jumon01	05-13-2004	181	17	14	19	18	15	20	20	9	10	9	10	10	10

juben01	05-03-2002	195	19	19	19	20	20	20	20	10	10	10	10	9	9
jusmt01	05-03-2002	193	19	17	19	19	19	20	20	10	10	10	10	10	10
jusbc01	05-03-2002	183	19	16	16	15	20	19	20	10	10	10	10	9	9
jumlt01	05-05-2002	191	17	17	17	20	20	20	20	10	10	10	10	10	10
juped01	05-05-2002	160	15	13	15	10	16	17	19	10	10	10	10	7	8
jupet01	05-06-2002	182	15	17	19	18	19	19	15	10	10	10	10	10	10
ju1tr01	05-06-2002	188	19	18	15	19	18	20	19	10	10	10	10	10	10
jusal01	05-14-2004	168	18	12	16	18	19	16	20	10	10	10	10	2	7
jusaw01	05-03-2002	187	20	16	18	18	19	20	20	9	9	9	9	10	10
juste01	05-15-2004	191	19	16	20	19	20	20	20	10	10	10	10	10	7
juvan01	05-13-2003	132	11	6	14	10	19	10	18	8	8	8	8	8	4
kagun01	05-04-2004	124	14	13	14	17	14	10	19	3	2	2	2	5	9
kathr03	05-05-2004	193	19	20	20	20	14	20	20	10	10	10	10	10	10
kaptm01	05-04-2004	174	14	16	18	16	14	19	18	10	10	10	10	9	10
kaptw01	05-01-2004	172	18	17	18	15	15	20	19	10	10	10	10	5	5
kasit01	05-05-2004	171	17	14	19	18	14	20	19	10	10	10	10	5	5
kaslo01	05-05-2004	165	16	13	18	16	15	19	20	8	8	8	8	8	8
kefac01	05-01-2002	183	19	19	15	19	19	20	19	10	10	10	10	8	5
kehoa01	05-01-2002	160	15	18	18	19	19	11	19	7	8	7	8	5	6
keket01	05-01-2002	158	16	18	15	16	17	18	13	7	9	9	9	4	7
kelun01	04-30-2002	177	19	14	12	13	20	20	19	10	10	10	10	10	10
kesch01	05-01-2002	192	17	20	15	20	20	20	20	10	10	10	10	10	10
kewar01	04-30-2002	151	15	11	6	17	20	19	11	9	9	9	9	8	8
kewhi01	05-01-2002	156	16	15	14	16	18	19	17	7	7	7	7	6	7
pewsc01	05-03-2004	175	17	14	16	13	19	17	20	9	10	10	10	10	10
pedum01	05-09-2003	170	18	16	15	14	15	18	20	10	10	10	10	7	7
peefh01	05-10-2003	189	18	17	20	16	19	19	20	10	10	10	10	10	10
pefal01	05-10-2003	160	14	11	19	11	15	19	17	10	10	10	10	5	9
pefre01	05-08-2003	190	19	19	18	19	18	19	20	10	10	10	10	9	9
pe3lc01	05-10-2003	171	19	16	15	15	19	18	19	10	10	10	10	5	5
pe3lu01	05-10-2003	194	20	19	20	19	19	19	20	10	10	10	10	9	9
peccc01	05-09-2003	165	19	20	12	19	13	13	20	10	10	10	10	4	5
peest01	05-12-2003	193	19	19	16	20	19	20	20	10	10	10	10	10	10

pesfs01	05-09-2003	187	19	20	18	20	14	18	20	10	10	10	10	9	9
pewn101	05-11-2003	166	14	16	15	15	16	20	20	10	10	10	10		10
pesko01	05-11-2003	158	11	10	10	13	16	20	18	10	10	10	10	10	10
peefm01	05-03-2004	185	18	16	16	20	15	20	20	10	10	10	10	10	10
peseo01	05-09-2003	189	17	20	18	20	16	20	20	10	10	10	10	9	9
pehw701	05-10-2003	177	18	12	20	15	15	19	20	10	10	10	10	9	9
pwand01	04-27-2002	184	17	17	18	20	18	20	18	9	9	9	9	10	10
pwand01	04-26-2003	184	17	18	17	19	16	20	17	10	10	10	10	10	10
pwand01	04-28-2004	174	18	17	20	16	18	20	17	7	7	7	7	10	10
pwbra01	04-26-2002	180	18	16	15	19	18	18	20	9	10	9	10	9	9
pwbra01	05-02-2003	183	17	16	17	18	20	18	19	10	10	10	10	9	9
pwcab01	04-22-2002	174	14	18	18	13	18	19	18	8	8	10	10	10	10
pwcha01	05-07-2004	175	19	19	15	15	15	18	19	7	8	10	10	10	10
pwdee01	04-26-2002	162	17	17	9	19	18	11	19	10	10	10	10	3	9
pwdit01	05-01-2003	160	18	16	15	13	18	13	18	9	9	9	9	7	6
pwenf01	05-02-2003	169	12	19	20	14	14	18	20	9	10	9	10	7	7
pwfal01	04-25-2002	184	17	20	16	20	18	18	19	9	9	9	9	10	10
pwfub01	04-22-2002	161	15	18	16	17	11	15	19	7	7	9	9	9	9
pwhar01	04-22-2002	176	16	18	18	17	19	20	16	7	7	9	9	10	10
pwlav01	04-25-2002	186	17	20	16	20	18	18	19	10	10	10	10	9	9
pwlin01	05-01-2004	129	11	11	15	18	13	15	20	4	4	4	4	6	4
pwlra01	04-26-2002	164	16	12	10	16	19	19	18	9	9	9	9	9	9
pwlra01	05-02-2003	165	15	11	10	16	18	18	19	10	10	9	9	10	10
pwluc01	05-02-2003	169	12	15	19	12	16	19	20	9	10	9	10	9	9
pwmbs01	04-22-2002	168	15	19	13	20	13	20	14	8	8	9	9	10	10
pwmcg01	04-26-2003	182	19	19	20	19	15	20	20	8	7	8	7	10	10
pwmcg01	04-27-2004	164	17	18	19	17	15	20	16	4	10	4	4	10	10
pwnau01	04-24-2002	174	18	17	15	18	19	19	18	8	8	8	8	9	9
pwnew01	04-23-2002	191	18	20	15	20	19	20	19	10	10	10	10	10	10
pwnew01	05-01-2003	168	16	19	15	20	10	17	19	8	9	8	9	9	9
pwnew01	05-01-2004	183	17	20	15	20	11	20	20	10	10	10	10	10	10
pwlei01	04-30-2003	179	18	19	15	19	10	18	20	10	10	10	10	10	10
pwncs01	04-29-2003	186	18	19	15	19	16	20	19	10	10	10	10	10	10

pwncb01	04-29-2003	193	17	20	18	20	18	20	20	10	10	10	10	10	10
pwlkt01	04-28-2002	192	20	16	19	18	19	20	20	10	10	10	10	10	10
pwlkt01	04-27-2003	191	17	19	20	18	19	20	20	10	9	10	9	10	10
pwlkt01	04-26-2004	197	19	20	20	19	19	20	20	10	10	10	10	10	10
pwslt01	04-27-2002	196	20	19	20	19	18	20	20	10	10	10	10	10	10
pwslt01	04-26-2003	185	19	17	20	15	15	20	19	10	10	10	10	10	10
pwslt01	04-28-2004	182	20	16	15	16	15	20	20	10	10	10	10	10	10
pwssl01	04-26-2003	194	19	20	15	20	20	20	20	10	10	10	10	10	10
pwssl01	04-27-2004	195	20	20	15	20	20	20	20	10	10	10	10	10	10
pwtom01	04-30-2003	183	19	17	15	17	19	20	20	9	9	9	9	10	10
pwpau01	04-26-2004	192	17	19	16	20	20	20	20	10	10	10	10	10	10
pwpig01	04-28-2002	189	16	15	19	20	19	20	20	10	10	10	10	10	10
pwpig01	04-27-2003	189	15	20	19	20	19	20	20	10	8	10	8	10	10
pwpig01	04-28-2004	179	16	16	19	18	20	20	20	5	10	5	10	10	10
pwpoo01	04-26-2004	166	18	14	15	18	16	20	20	8	7	7	7	8	8
pwrib01	04-23-2002	179	15	16	18	17	18	20	19	9	9	9	9	10	10
pwrir01	04-23-2002	194	15	20	19	20	20	20	20	10	10	10	10	10	10
pwsal01	04-26-2002	181	18	18	19	18	17	18	19	9	9	9	9	9	9
pwsal01	04-29-2004	128	13	13	16	18	11	8	19	7	3	7	3	5	5
pwsca01	04-30-2004	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
pwsha01	04-24-2002	157	13	16	20	16	18	16	20	5	5	5	5	9	9
pwsli01	04-26-2002	180	18	15	20	16	19	16	20	10	10	10	10	7	9
pwson01	05-01-2004	161	14	14	14	17	13	20	20	9	9	9	9	10	3
pwsta01	04-24-2002	176	12	19	14	20	19	18	18	9	9	9	9	10	10
pwsun01	04-29-2003	189	16	19	17	19	19	20	19	10	10	10	10	10	10
pwush08	04-30-2004	183	20	15	20	19	13	20	20	8	8	10	10	10	10
pwwnt01	04-25-2002	162	10	13	20	17	15	20	19	6	6	8	8	10	10
pwyat01	04-24-2002	153	15	15	10	14	17	13	18	8	10	9	9	6	9
siefi01	05-08-2004	185	19	14	17	18	17	20	20	10	10	10	10	10	10
sigra01	05-09-2004	143	13	20	5	20	12	14	20	9	7	9	7	6	1
simed01	05-07-2004	195	18	20	19	20	18	20	20	10	10	10	10	10	10
siher01	05-07-2004	189	20	16	19	19	15	20	20	10	10	10	10	10	10
sitir01	05-08-2004	186	20	18	15	19	14	20	20	10	10	10	10	10	10

sisaw02	05-07-2004	179	18	19	20	20	17	11	18	10	10	10	10	9	7
sista01	05-09-2004	169	15	19	20	19	6	20	20	9	9	9	9	7	7
siwfi01	05-08-2004	184	19	13	20	15	17	20	20	10	10	10	10	10	10
siwri01	05-08-2004	111	6	9	13	3	17	13	18	9	9	6	6	1	1
wrana01	05-07-2003	191	19	18	19	18	17	20	20	10	10	10	10	10	10
wrcrt01	05-06-2003	183	16	19	19	18	14	20	20	10	9	10	8	10	10
wrefa01	05-07-2003	185	18	16	20	13	18	20	20	10	10	10	10	10	10
wrefc01	05-06-2003	189	18	19	20	17	15	20	20	10	10	10	10	10	10
wrgla01	05-06-2003	174	17	10	17	14	16	20	20	10	10	10	10	10	10
wrmar01	08-07-2003	190	19	17	20	16	18	20	20	10	10	10	10	10	10
wrmcc01	05-05-2003	166	15	19	15	17	10	18	20	9	9	9	9	8	8
wrunm01	05-07-2003	192	18	20	18	20	16	20	20	10	10	10	10	10	10
wrskc01	05-05-2003	168	16	19	15	18	18	18	20	10	10	10	10	2	2
wrskn01	05-05-2003	184	16	20	15	20	17	18	20	10	10	10	10	9	9
wrpat01	05-05-2003	173	19	17	16	16	10	19	19	10	10	10	10	9	8
wrpor01	05-06-2003	172	15	13	20	13	15	20	20	9	9	9	9	10	10
wrtom01	05-07-2003	169	17	8	17	12	20	20	19	9	9	9	9	10	10

Appendix 6. Multimetric index, individual metric scores, and predictive model observed/expected scores for study streams.

Station	Date	*A priori* disturbance class	Multimetric Index	Insect taxa	Noninsect % taxa	% EPT	Scraper taxa	Clinger taxa	Intolerant % taxa	Predictive model O/E
aibea01	5/15/03	Reference	67.2	16	11.1	50.4	4	8	66.7	0.92
aidcc01	5/16/03	Reference	65.7	24	22.6	50.3	3	11	45.2	1.35
aieyb01	5/15/03	Reference	73.1	18	10.0	75.8	4	8	65.0	1.07
aigcc01	5/16/03	Reference	64.2	18	18.2	71.4	3	7	54.6	1.05
aigcc01	5/16/03	Reference	79.1	25	13.8	68.2	5	12	51.7	1.15
ainfm02	5/7/02	Reference	82.7	19	9.5	79.1	6	12	61.9	0.92
aisfm01	5/7/02	Class 2	92.9	27	0.0	81.5	6	15	70.4	1.10
aisti01	5/15/03	Reference	93.5	22	4.4	92.6	7	13	69.6	1.04
aiwyb01	5/15/03	Reference	90.2	21	4.6	91.9	6	12	72.7	1.02
cohb101	5/11/04	Reference	75.6	19	13.6	81.3	5	9	59.1	1.15
cohb201	5/11/04	Reference	78.9	19	9.5	83.0	5	10	61.9	1.04
cohb301	5/24/04	Reference	80.6	21	19.2	81.5	6	12	57.7	1.25
cohb401	5/12/04	Reference	83.2	18	18.2	86.2	7	12	63.6	1.18
cohic01	5/10/04	Reference	87.0	19	5.0	81.4	8	11	60.0	0.95
conwc01	5/10/04	Reference	74.5	15	6.3	87.6	3	8	75.0	0.83
cosco01	5/11/04	Reference	67.9	16	5.9	67.7	3	9	52.9	0.78
cowc301	5/10/04	Reference	85.3	19	5.0	89.2	6	10	70.0	1.00
ju1tr01	5/6/02	Reference	69.3	16	5.9	63.1	4	8	58.8	0.77
juben01	5/3/02	Reference	88.7	23	11.5	76.5	7	14	61.5	1.08
juduc01	5/8/02	Stressed	14.2	6	50.0	1.4	1	1	16.7	0.23
juduc01	5/8/02	Stressed	16.0	9	40.0	0.8	0	2	6.7	0.37
juduc01	5/13/04	Stressed	17.3	6	57.1	1.5	3	1	21.4	0.40
jufis01	5/6/02	Class 1	57.6	19	9.5	36.7	1	7	57.1	0.98
jufis01	5/6/02	Class 1	56.1	15	11.8	33.2	2	7	58.8	0.77
jujor01	5/13/03	Stressed	32.3	10	33.3	17.0	1	3	40.0	0.53
julak01	5/15/04	Class 1	88.7	20	16.7	90.0	8	13	62.5	
jumcg01	5/5/02	Reference	83.4	18	5.3	79.5	7	10	63.2	0.80
jumcg01	5/14/03	Reference	65.7	15	11.8	85.7	2	6	64.7	
jumcg01	5/14/03	Reference	83.0	15	6.3	92.8	5	11	75.0	0.78
jumcg01	5/13/04	Reference	72.5	15	21.1	91.3	4	10	63.2	0.98
jumlt01	5/5/02	Reference	86.8	24	7.7	75.9	6	12	65.4	1.23
jumon01	5/5/02	Reference	82.9	18	5.3	95.3	4	11	73.7	0.81
jumon01	5/14/03	Reference	80.1	17	10.5	92.3	6	9	63.2	0.87
jumon01	5/13/04	Reference	81.3	18	10.0	96.6	6	9	65.0	0.89
jumon01	5/13/04	Reference	76.1	12	0.0	98.9	5	8	66.7	0.63
juped01	5/5/02	Class 2	40.8	13	23.5	35.1	1	3	41.2	0.68
jupet01	5/6/02	Reference	58.9	18	10.0	39.8	2	6	60.0	0.92
jusal01	5/14/04	Class 1	78.0	18	10.0	84.7	5	10	60.0	
jusaw01	5/3/02	Reference	72.1	17	10.5	71.1	4	8	68.4	0.87
jusbc01	5/3/02	Reference	68.5	18	21.7	75.0	4	8	60.9	1.05
jusmt01	5/3/02	Reference	67.7	16	5.9	69.8	2	7	70.6	0.84
juste01	5/15/04	Class 1	79.2	27	10.0	64.4	6	9	56.7	1.18
juvan01	5/13/03	Class 1	43.7	14	22.2	16.9	2	6	38.9	0.67
kagun01	5/4/04	Class 2	96.7	22	0.0	91.4	8	13	77.3	1.01
kaptm01	5/5/04	Class 2	62.2	17	15.0	45.1	3	9	55.0	0.96

Station	Date	*A priori* disturbance class	Multimetric Index	Insect taxa	Noninsect % taxa	% EPT	Scraper taxa	Clinger taxa	Intolerant % taxa	Predictive model O/E
kaptw01	5/14/04	Class 2	86.3	22	15.4	86.6	7	12	61.5	1.05
kasit01	5/5/04	Class 2	85.8	18	5.3	91.5	6	10	73.7	0.99
kaslo01	5/5/04	Class 2	83.7	21	4.6	72.4	6	12	59.1	0.98
kaslo01	5/5/04	Class 2	89.2	22	4.4	87.6	6	11	73.9	1.09
kathr03	5/5/04	Reference	70.8	17	19.1	66.9	5	10	57.1	0.85
kefac01	5/1/02	Stressed	28.5	11	35.3	13.4	0	4	29.4	0.60
kehoa01	5/1/02	Class 2	69.9	16	5.9	63.7	3	8	70.6	0.78
keket01	5/1/02	Class 1	46.8	12	20.0	41.5	2	4	46.7	0.70
kelun01	4/30/02	Reference	75.0	19	9.5	72.8	4	10	61.9	0.96
kesch01	5/1/02	Reference	90.3	23	8.0	84.7	7	12	68.0	1.16
kewar01	4/30/02	Class 2	52.8	13	18.8	44.8	2	7	50.0	0.76
kewhi01	5/1/02	Class 2	85.3	19	5.0	89.7	6	9	75.0	0.88
kewhi01	5/1/02	Class 2	84.0	21	4.6	79.5	5	10	81.8	0.99
pe3lc01	5/10/03	Class 2	68.0	17	15.0	72.6	4	7	60.0	0.93
pe3lu01	5/10/03	Reference	74.8	20	16.7	74.4	5	9	62.5	1.14
peccc01	5/9/03	Class 2	76.6	21	12.5	55.3	6	10	62.5	1.06
pedum01	5/9/03	Stressed	57.1	7	22.2	89.2	2	5	66.7	0.42
peefh01	5/10/03	Reference	90.2	24	7.7	76.7	6	13	76.9	1.30
peefm01	5/3/04	Reference	83.9	16	0.0	85.4	6	10	75.0	0.71
peefm01	5/3/04	Reference	91.4	26	7.1	82.3	7	12	67.9	1.14
peest01	5/12/03	Reference	85.0	25	13.8	73.1	5	13	69.0	1.42
pefal01	5/10/03	Class 2	77.0	20	16.7	78.4	6	10	54.2	1.26
pefal01	5/10/03	Class 2	87.8	21	4.6	78.6	6	12	72.7	1.11
pefre01	5/8/03	Reference	95.6	26	10.3	92.2	7	15	72.4	1.42
pehw701	5/10/03	Class 1	82.8	20	13.0	90.4	5	11	69.6	1.14
peseo01	5/9/03	Reference	83.5	19	9.5	85.1	6	10	71.4	0.91
pesfs01	5/9/03	Reference	86.5	24	14.3	80.7	5	14	67.9	1.22
pesfs01	5/9/03	Reference	85.3	21	12.5	85.0	5	13	70.8	1.12
pesko01	5/11/03	Reference	82.2	23	11.5	75.3	5	13	57.7	1.17
pewn101	5/11/03	Reference	65.9	16	15.8	80.2	3	8	52.6	0.90
pewsc01	5/3/04	Reference	80.2	15	6.3	83.5	5	10	75.0	0.86
pewsc01	5/3/04	Reference	77.8	21	12.5	78.5	4	11	62.5	1.13
pwand01	4/27/02	Class 1	72.7	21	16.0	49.3	5	10	64.0	1.13
pwand01	4/26/03	Class 1	45.0	12	20.0	23.3	2	4	53.3	0.81
pwand01	4/28/04	Class 1	31.8	8	33.3	17.9	0	5	41.7	0.43
pwbra01	5/2/03	Class 2	63.3	19	13.6	53.3	2	9	54.6	1.02
pwcab01	4/22/02	Class 2	66.3	20	13.0	50.3	3	10	52.2	1.08
pwcha01	5/7/04	Reference	89.1	22	12.0	76.9	7	13	72.0	
pwdee01	4/26/02	Stressed	80.6	21	8.7	78.2	5	11	60.9	0.95
pwdit01	5/1/03	Stressed	59.5	15	16.7	84.5	2	5	50.0	0.80
pwenf01	5/4/03	Class 2	71.3	20	9.1	58.5	3	9	68.2	1.07
pwfal01	4/25/02	Class 1	60.6	15	11.8	52.2	2	9	52.9	0.78
pwfub01	4/22/02	Class 2	68.2	15	0.0	85.2	2	6	66.7	0.78
pwhar01	4/22/02	Class 2	70.4	18	14.3	88.2	3	10	47.6	1.03
pwlav01	4/25/02	Class 2	79.4	18	5.3	92.8	4	9	68.4	0.86
pwlei01	4/30/03	Reference	70.2	17	19.1	76.0	4	9	61.9	0.91
pwlei01	4/30/03	Reference	85.4	22	4.4	76.6	5	12	69.6	1.00
pwlin01	5/1/04	Stressed	80.2	18	10.0	84.7	5	9	75.0	0.95
pwlkt01	4/28/02	Reference	65.7	19	13.6	69.0	2	7	63.6	0.98

Station	Date	*A priori* disturbance class	Multimetric Index	Insect taxa	Noninsect % taxa	% EPT	Scraper taxa	Clinger taxa	Intolerant % taxa	Predictive model O/E
pwlkt01	4/27/03	Reference	69.2	20	9.1	80.6	2	9	50.0	0.97
pwlkt01	4/26/04	Reference	71.0	23	17.9	65.2	3	11	53.6	1.22
pwlra01	5/2/03	Class 2	81.9	25	10.7	64.5	7	11	50.0	1.35
pwluc01	5/2/03	Class 2	71.6	21	12.5	62.7	4	9	58.3	1.30
pwmbs01	4/23/02	Class 2	64.3	15	11.8	59.4	3	6	70.6	0.81
pwmcg01	4/26/03	Reference	68.2	16	11.1	85.7	2	7	66.7	0.97
pwmcg01	4/27/04	Reference	76.5	18	14.3	81.5	6	10	52.4	1.08
pwnau01	4/24/02	Class 2	60.8	16	15.8	38.9	3	10	52.6	0.86
pwncb01	4/29/04	Reference	68.8	17	22.7	75.7	4	11	50.0	1.03
pwncs01	4/29/03	Reference	67.8	18	18.2	71.7	5	9	40.9	0.99
pwnew01	4/23/02	Reference	73.0	20	13.0	53.9	5	10	60.9	0.96
pwnew01	5/1/03	Reference	73.5	13	7.1	72.7	5	8	71.4	0.67
pwnew01	5/1/04	Reference	83.8	20	4.8	85.8	5	11	66.7	0.91
pwpau01	4/2/04	Reference	68.7	21	8.7	65.2	2	9	56.5	0.99
pwpig01	4/28/02	Reference	56.4	16	23.8	65.7	3	6	42.9	1.02
pwpig01	4/28/04	Reference	77.1	18	14.3	91.2	5	9	61.9	1.03
pwpig01	4/27/03	Reference	78.8	19	5.0	71.0	5	10	65.0	0.86
pwpoo01	4/26/04	Class 2	78.6	21	8.7	92.1	5	8	56.5	1.02
pwrib01	4/23/02	Class 2	86.2	23	11.5	82.8	5	13	69.2	1.18
pwrib01	4/23/02	Class 2	87.4	22	12.0	88.8	5	14	68.0	1.24
pwrir01	4/23/02	Class 1	88.2	25	7.4	80.3	6	11	70.4	1.23
pwsal01	4/26/02	Class 2	66.1	19	9.5	72.7	2	6	61.9	1.11
pwsal01	4/29/04	Class 2	67.9	15	11.8	82.5	4	7	52.9	0.85
pwsca01	4/3/04	Class 1	88.4	24	11.1	89.6	6	14	55.6	1.11
pwsha01	4/24/02	Class 2	73.3	18	5.3	45.5	4	11	68.4	0.92
pwsli01	4/26/02	Class 2	78.3	20	4.8	74.6	5	9	61.9	0.91
pwslt01	4/27/02	Reference	70.9	17	10.5	77.3	4	7	63.2	0.86
pwslt01	4/26/03	Reference	71.7	18	10.0	75.8	5	7	55.0	0.77
pwslt01	4/28/04	Reference	87.0	22	8.3	90.6	6	11	66.7	1.07
pwson01	5/1/04	Class 2	73.9	16	11.1	87.9	4	8	66.7	0.78
pwssl01	4/26/03	Reference	76.6	18	18.2	86.8	5	9	68.2	0.94
pwssl01	4/27/04	Reference	92.2	20	9.1	83.1	8	14	68.2	0.95
pwsta01	4/4/02	Class 2	72.2	21	12.5	56.0	3	13	54.2	1.19
pwsun01	4/29/03	Reference	56.9	14	26.3	68.4	3	7	47.4	1.02
pwtom01	4/30/03	Reference	53.9	13	27.8	72.7	2	6	50.0	0.96
pwukt01	4/28/02	Class 1	57.6	16	15.8	66.7	3	5	42.1	
pwukt01	4/27/03	Class 1	79.2	18	5.3	91.0	4	9	68.4	
pwush08	4/30/04	Reference	92.4	20	0.0	81.3	8	12	75.0	0.71
pwwnt01	4/25/02	Class 2	74.8	21	12.5	65.9	5	11	50.0	1.24
pwyat01	4/24/02	Class 2	72.8	21	12.5	73.8	3	10	58.3	1.06
siefi01	5/8/04	Reference	80.5	17	5.6	79.7	5	11	66.7	0.89
sigra01	5/9/04	Class 2	66.3	14	12.5	86.4	3	7	56.3	0.55
siher01	5/7/04	Reference	85.4	19	17.4	85.2	8	12	60.9	1.10
simed01	5/7/04		31.9	10	16.7	4.2	2	3	16.7	0.57
sisaw02	5/7/04	Class 1	62.8	12	14.3	69.5	3	8	57.1	
sista01	5/9/04	Class 2	72.3	14	12.5	86.2	4	8	68.8	0.73
sitir01	5/10/04	Reference	66.1	21	12.5	50.4	3	8	58.3	1.26
siwfi01	5/8/04	Reference	84.4	17	10.5	82.8	6	12	73.7	0.96
siwri01	5/8/04	Class 2	41.0	9	30.8	32.3	2	5	46.2	0.48

Station	Date	*A priori* disturbance class	Multimetric Index	Insect taxa	Noninsect % taxa	% EPT	Scraper taxa	Clinger taxa	Intolerant % taxa	Predictive model O/E
wrana01	5/7/03	Reference	66.3	17	15.0	53.2	2	12	60.0	0.72
wrcrt01	5/6/04	Reference	87.8	25	7.4	82.9	5	12	70.4	1.34
wrefa01	5/7/03	Reference	83.4	23	23.3	76.0	6	14	63.3	1.34
wrefc01	5/6/03	Reference	80.9	19	13.6	79.4	4	13	72.7	0.98
wrgla01	5/6/03	Reference	62.1	21	8.7	47.5	2	7	52.2	1.14
wrmar01	5/7/03	Reference	81.3	21	4.6	75.9	4	13	59.1	1.08
wrmcc01	5/5/04	Class 2	89.2	21	8.7	88.8	6	14	65.2	1.13
wrmcc01	5/5/04	Class 2	84.7	20	9.1	90.4	5	11	72.7	1.02
wrpat01	5/5/03	Class 2	71.9	14	6.7	86.5	3	7	73.3	1.07
wrpat01	5/5/03	Class 2	75.1	21	12.5	80.3	4	10	54.2	0.71
wrpor01	5/6/03	Reference	70.1	17	10.5	72.8	4	8	57.9	0.98
wrskc01	5/5/03	Class 2	75.6	20	9.1	64.1	4	10	68.2	0.97
wrskn01	5/5/03	Class 1	91.0	24	11.1	67.2	8	14	66.7	1.26
wrtom01	5/7/03	Reference	71.0	19	17.4	70.3	4	10	56.5	0.98
wrunm01	5/7/03	Class 1	79.4	19	9.5	93.3	4	9	71.4	0.81