Identification and Characterization of Reference Conditions within USEPA Region 7 using EMAP methodology.

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INTRODUCTION

Aquatic ecosystems throughout the United States are subject to increasing disturbance (Hughes *et al*., 2000; USEPA, 2000). In order to assess the impacts of these disturbances, scientists have begun to identify sites that experience relatively minimal levels of disturbance and therefore represent "healthy or acceptable" conditions for a particular region (Bailey *et al*., 2004). These reference conditions can then be used as benchmarks for ecosystem health in the development of bioindicators and biocriteria (Barbour *et al*., 1995; Hughes *et al*., 1995; Barbour *et al*., 1999; Reynoldson *et al*., 1997; Bailey *et al*., 2004; Dodds and Oakes, 2004). Unfortunately, reference conditions have not been effectively characterized for aquatic ecosystems (i.e. waterbody types) in many regions of the United States (Dodds and Oaks, 2004). The USEPA Region 7 Biological Technical Assistance Group (BTAG) was formed in 2000 to bring regional scientists from Nebraska, Missouri, Iowa, and Kansas together to address these issues and to develop a core list of factors to consider when choosing reference streams: Wastewater treatment plants (and other point sources); Confined Animal Feeding Operations; Instream habitat; Riparian habitat; Land Use and Land Cover, broadscale; Land Use and Land Cover, site-specific; Physical and chemical parameters; Biological metrics; Faunal assemblages; Representativeness; Altered hydrologic regime (Huggins 2005; Appendix 1).

The Central Plains Center for BioAssessment (CPCB) at the Kansas Biological Survey (KBS) assembled a regional stream database for the BTAG to examine (USEPA awards X7-98749601, X7-98740901). In addition, the BTAG used their best professional judgment (Hughes, 1995) to identify candidate reference sites in this database, using existing water quality, habitat and/or watershed data to aid in their selection of candidate reference sites and streams. However the quality and quantity of data for the selection factors varied among contributing members (http://www.cpcb.ku.edu/progwg/html/biologicalwg.htm). Thus the goal of this project was to standardize and enhance data from reference sites by choosing 75 reference streams from which to collect data for a suite of physical, chemical, and biological "indictors" (Table 1).

Table 1. Number of candidate reference stream sites in USEPA Region 7, and availability of data collected and analyzed using EMAP methods. The numbers indicate 199 sites that have no EMAP data, one-third of which is the target number to sample for this project. This is not the table presented in the original proposal but a modification after we received Missouri 2002 REMAP data for inclusion in the regional database.

	STATE					
	IA	KS	MO	NE	Total	%
Number of reference sites	**111**	**75**	**62**	**50**	**298**	**100**
# sampled by EMAP for all (fish, macroinvertebrates, chemistry, habitat)	32	1	17	50	69	23
# sampled by EMAP for all parameters except fish	4	3	6	0	13	4
# not sampled by EMAP for any parameters	**75**	**71**	**31**	**0**	**199**	**72**

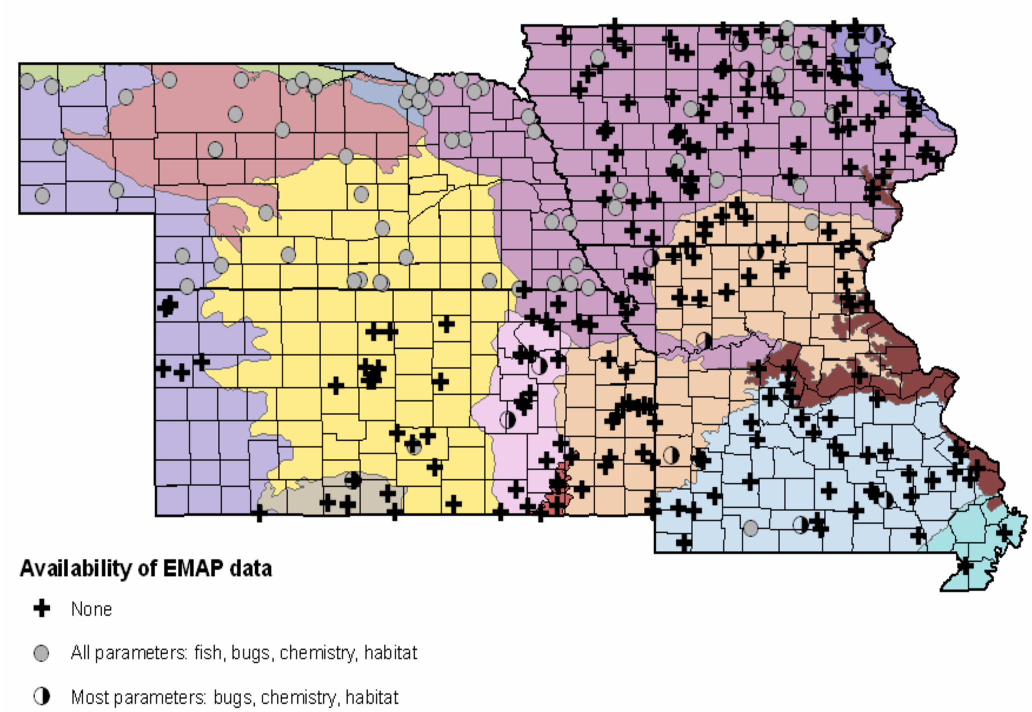

Figure 1. Map of USEPA Region 7 with Omernik Level III ecoregions shaded and reference stream sites marked as to the availability of EMAP data for that site.

The resulting regional reference database will be made available to the state agencies within the region so that they can compare the results collected using EMAP methodology to their own data collected from the same reference sites to determine if different sampling methodologies produce similar results. Overall, the proposed characterization of reference conditions using EMAP sampling procedures will provide information on the Least Disturbed Conditions within the region that can be used to facilitate the development of indicators and biocriteria using data collected from EMAP probability surveys for wadeable streams within Region 7. In addition to more fully characterizing the Least Disturbed Conditions within the region, this project will allow examination of potential interstate differences in reference conditions associated with state specific reference selection and sampling methods. Existing reference site data within and between states and ecoregions varies greatly in how, when, and what was collected. This project will use a restricted temporal indexing period (i.e. maximum 2-year data spread) and uniform methods (i.e. EMAP) to begin development of a regional database with consistent data quality attributes. This effort will also be used to demonstrate and encourage states and tribes to adopt, when possible, more consistent methodologies to allow more meaningful use of regional reference sites and conditions when within-state sites are limiting or non-existent.

OBJECTIVES

The seven objectives of the proposal, as follows, are reviewed here in four parts.

Part I. USEPA Region 7 Stream Database

Part I was to examine existing data which had been merged into the USEPA Region 7 database. From this set of data we proposed to 1. Review current regional biocriteria databases as relevant to reference sites and conditions; 2. Identify and define biotic and abiotic indicators (macroinvertebrate, fish, water chemistry, habitat, watershed, LU/LC) associated with reference sites; 3. Characterize candidate reference sites using indicator variables and factors that include the eleven core factors identified by the Central Plains Biocriteria Workgroup (Appendix 1).

To assist both the BTAG and the USEPA Region 7 Technical Assistance Group (RTAG) who was charged with developing nutrient criteria for streams and rivers in Region 7, the CPCB compiled available water quality and biological data for streams and rivers in Iowa, Kansas, Missouri, and Nebraska, including 298 reference sites. Selection of reference sites by BPJ was described in the introduction, and is detailed in the fourth coming Stream Nutrient Criteria document. For Objectives 1 and 2 of this study we examined this regional database to determine where data from reference streams was lacking in both quality and quantity.

The data in the regional database were collected between 1965 and 2003 by a variety of agencies and individuals with established internal quality assurance procedures. All data were combined into a single Microsoft Access® relational database, resulting in 54,393 records of water chemistry for 2,400 streams and rivers, 2,369 fish sampling events at 1,325 sites, and 1,874 macroinvertebrate sampling events at 1,151 sites (Fig 2). The database is available for download at http://www.cpcb.ku.edu/progwg/html/nutrientwg.htm. Details of database creation and application will be found in the Stream Nutrient Criteria document.

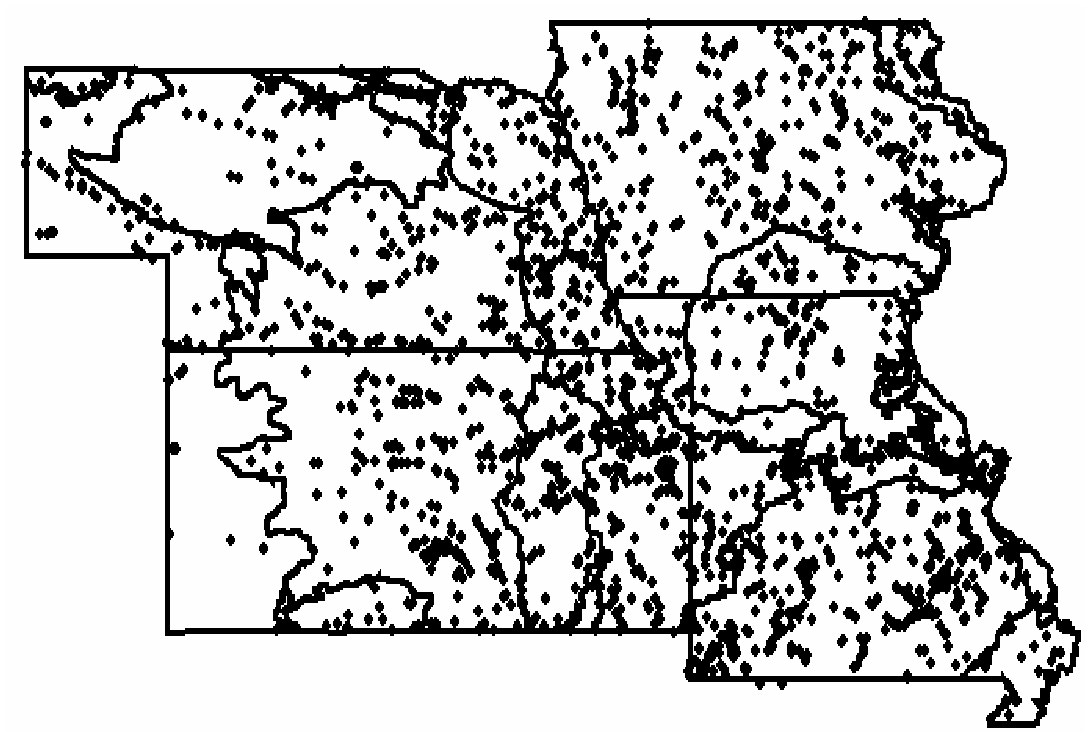

Figure 2. Water quality and biological monitoring stations for streams and rivers within USEPA Region 7 which comprise the regional database examined for this study. Omernik's Level III ecoregions are outlined.

Part II 2005-2006 collection event

Part II is the focus of this report and consisted of Objective 4 which was to sample 65-75 streams using EMAP procedures to create a regional reference database.

Part III Merging the Regional and 2005-2006 data

Part III of the study consists of merging the existing data with the newly collected data. We proposed to analyze the resulting dataset and for Objective 5 use the results of the analyses in collaboration with regional scientists to propose regional reference benchmark values for selected macroinvertebrate, fish, and watershed indicators. However, for this report we decided not to address the meshing of the newly acquired data of this study with the existing regional stream database, but to focus on data summary and trends of the newly acquired data.

Part IV Information transfer

Part IV consists of information transfer to regional scientists by (Objective 6) developing an on-line shared database for regional reference conditions and sites for use by multiple state collaborators; and (Objective 7) conducting two workshops on the description, uses and functions of the regional reference database. The database has been posted on the project webpage at http://www.cpcb.ku.edu/research/html/refstream.htm. We propose to host one workshop on the development and use of this database.

FIELD AND DATA METHODS

Site selection

To select sites to sample for this project, we solicited advice from the Nutrient Criteria RTAG members located in Nebraska, Iowa, Kansas, and Missouri. We sent them the list of 298 candidate reference sites and asked them to select the best third of the sites from each of the larger ecoregions (Central Great Plains, Central Irregular Plains, Flint Hills, Ozark Highlands, Western Cornbelt Plains, and Western High Plains) in their states (see Appendix 2 for resulting lists). We provided the members with the list generated by the BTAG of the aforementioned eleven core factors for Reference Site Designation. We also requested documentation of their agencies' reference site selection process. See Appendix 2 for our inquiry and state responses.

The Iowa Department of Natural Resources (IDNR) provided a list of 22 sites, 15 of which we obtained landowner permission and sampled in 2005 (Table 2). Nebraska Department of Environmental Quality (NDEQ) chose its reference sites based on sites that had already been sampled using REMAP methods, so at the time we thought that we would not pursue sampling in Nebraska (this later changed). Gary Welker at USEPA Region 7 sampled two Kansas reference sites (sites 187 and 1637), however field sheet data and fish and macroinvertebrates are not available from these visits. BTAG members in Kansas (Kansas Dept. of Health and Environment KDHE) and Missouri (Missouri Department of Natural Resources MDNR) were not as forthcoming with suggestions for sites, so we were not able to continue sampling in 2005.

Table 2. The 17 reference stream sites sampled in 2005. ER3 = Omernik Level III ecoregion. See Table 7 for abbreviations.

State	ER3	Date	IDCPCB	Stream Name	County	LAT	LONG
IA	CIP	28-jul-2005	1530	Chequest Creek	Van Buren	40.7610	-92.0171
IA	CIP	06-aug-2005	1263	Long Creek	Decatur	40.8356	-93.8570
IA	DA	14-jul-2005	1411	Canoe Creek	Winneshiek	43.3671	-91.6182
IA	DA	15-jul-2005	1585	Middle Bear Creek	Winneshiek	43.4760	-91.6448
IA	WCB	23-jul-2005	1331	Lizard Creek	Webster	42.5413	-94.3448
IA	WCB	23-jul-2005	1324	Maynes Creek	Franklin	42.6627	-93.2305
IA	WCB	27-jul-2005	1379	Big Creek	Crawford	42.0808	-95.3694

State	ER3	Date	IDCPCB	Stream Name	County	LAT	LONG
IA	WCB	28-jul-2005	1308	Waterman Creek	O'Brien	42.9793	-95.4277
IA	WCB	29-jul-2005	1359	Buffalo Creek	Linn	42.2057	-91.4458
IA	WCB	29-jul-2005	1516b	Buffington Creek	Louisa	41.2050	-91.3989
IA	WCB	03-aug-2005	1360	Wapsipinicon River	Mitchell	43.4630	-92.6304
IA	WCB	05-aug-2005	1352	Deer Creek	Mitchell	43.4242	-93.0222
IA	WCB	06-aug-2005	1351	Volga River	Fayette	42.8192	-91.8847
IA	WCB	07-aug-2005	1364	Little Turkey River	Fayette	43.0091	-91.9587
IA	WCB	07-aug-2005	1382	Rock Creek	Cedar	41.7316	-91.1508
KS	CIP	14-oct-2005	187	Buck Creek	Jefferson	39.0533	-95.2911
KS	WCB	08-nov-2005	1637	Straight Creek	Jackson	39.5447	-95.7296

Responses from the KDHE were delayed such that we could not sample during the 2005 field season. Not wanting further delay so that we could contact landowners before the 2006 season, in the fall of 2005, Don Huggins, who is familiar with Kansas streams, selected (with input from KDHE) 34 sites that he believed to be the best. During the spring of 2006 we acquired landowner permission to sample 14 sites, but had to delay sampling until we met with KDHE about the sites we plan to sample. We finally met with KDHE on 09 May 2006 to coordinate sampling efforts and acquired permission to sample an additional 5 sites. KDHE expressed concerned about their relationship with landowners and assisted with obtaining permissions. At the end of the season it was apparent that we would come up short of sites, so we added Kings Creek site 900a which is a long-term monitoring site by Kansas State University and The Nature Conservancy on the Konza Prairie Biological Station in Kansas (we obtained a Permit for Research Use for this site). Thus a total of 20 sites were sampled in Kansas.

The Missouri Dept. of Conservation was cooperative and recommended 24 sites for sampling, but as with Nebraska, these had already been sampled using REMAP methods in 2002. With further inquiry they suggested 4 sites that were new to their reference site sampling program, and 2 from the 2002 REMAP season that they thought should be resampled. This left us short of sites in Missouri, so we contacted the MDNR for more site recommendations. Unfortunately, this appeared to rouse political conflict and we decided it be best not to pursue any sampling in Missouri.

With being short of sites, we followed the suggestion of the Project Officer and pursued resampling the best of the Nebraska REMAP sites, as the only REMAP sites repeatedly sampled are those randomly chosen. Thus, repeat sampling of Nebraska's reference sites would yield valuable information on the measured variability one might expect at least disturbed reference sites. NDEQ provided a list of 16 sites they consider the best (Appendix 2). We sampled 11 of these sites.

Table 3. The 31 reference stream sites sampled in 2006. (site 187 is a repeat of 2005). ER3 = Omernik Level III ecoregion. See Table 7 for abbreviations.

State	ER3	Date	IDCPCB	Stream Name	County	LAT	LONG
KS	CGP	6/14/2006	1597b	North Fork Ninnescah River	Reno	37.94	-98.22
KS	CGP	6/14/2006	1656	Chikaskia River	Sumner	37.13	-97.60
KS	CGP	7/6/2006	1623	Salt Creek	Russell	38.95	-98.92
KS	CIP	6/6/2006	1651	Middle Creek	Miami	38.41	-94.86

State	ER3	Date	IDCPCB	Stream Name	County	LAT	LONG
KS	CIP	6/6/2006	1652	Upper Elm Creek	Miami	38.43	-94.68
KS	CIP	6/6/2006	187	Buck Creek	Jefferson	39.09	-95.29
KS	CIP	6/20/2006	1657	Big Creek	Allen	37.75	-95.27
KS	CIP	6/21/2006	33	Verdigris River	Montgomery	37.33	-95.68
KS	CIP	7/13/2006	6031	Marmaton River	Bourbon	37.82	-94.78
KS	COT	6/20/2006	1655	Sandy Creek	Woodson	37.76	-95.85
KS	FH	6/14/2006	1462a	Otter Creek	Greenwood	37.71	-96.22
KS	FH	6/14/2006	1555	Grouse Creek 2	Cowley	37.33	-96.67
KS	FH	6/14/2006	1563	Cedar Creek	Chautauqua	37.10	-96.51
KS	FH	6/28/2006	6025	Palmer Creek	Chase	38.49	-96.58
KS	FH	10/2/2006	900a	Kings Creek	Riley	39.11	-96.61
KS	ST	7/5/2006	1595	Nescatunga Creek	Comanche	37.12	-99.17
KS	WCB	6/13/2006	905	North Elm Creek	Marshall	39.99	-96.55
KS	WCB	6/14/2006	8	French Creek	Nemaha	39.57	-96.22
KS	WHP	6/27/2006	1618	South Fork Republican River	Cheyenne	39.77	-101.82
KS	WHP	6/28/2006	865	Willow Creek	Wallace	38.94	-101.96
NE	CGP	8/27/2006	8034	Cottonwood Creek	Franklin	40.10	-99.07
NE	NSH	8/26/2006	8123	Goose Creek	Brown	42.12	-100.14
NE	NSH	8/26/2006	339	Big Creek	Cherry	42.32	-100.84
NE	NSH	9/16/2006	8047	Niobrara River (B)	Sheridan	42.56	-102.47
NE	WCB	9/23/2006	8136	Battle Creek	Madison	41.98	-97.61
NE	WCB	9/24/2006	1284	Omaha Creek	Dakota	42.29	-96.49
NE	WCB	9/27/2006	347	Rattlesnake Creek	Richardson	40.07	-95.86
NE	WHP	8/8/2006	1590	Monroe Creek	Sioux	42.77	-103.93
NE	WHP	8/9/2006	8007	Middle Fork Soldier Creek	Sioux	42.70	-103.57
NE	WHP	9/16/2006	1596	Ninemile Creek	Scottsbluff	41.89	-103.43
NE	WHP	9/17/2006	8041	Rush Creek	Garden	41.32	-102.60

In summary, we had a list of 72 sites to possibly sample. Landowners granted us permission to sample 44 of the sites. Three sites were additionally sampled (Buck Creek 187 and Straight Creek 1637 by EPA, Kings Creek 900a added by CPCB) to total 47 sites sampled. One site, 187, was sampled twice to total 48 sampling events. However, the 2 sampling events by EPA Region 7 do not have associated field data. Thus we have habitat and macroinvertebrate metrics from 46 sites and fish metrics from 44 sites. Resulting data from CPCB labs were sent to landowners of 13 sites who requested the data (Appendix 3).

This left us short of our goal of 65-75 sites, so we modified the scope of work to identify the chironomids from 15 sites from the IDNR 2002 REMAP study. The IDNR only identifies this taxon to family. We identified these chironomid specimens to the genus level as is done in the Kansas, Missouri, and Nebraska resource agencies. Chironomidae is a rich family with diverse genera, thus a lot of ecological information is lost if specimens are not identified past family. Identifying the chironomids past family renders the taxonomic data comparable to other REMAP samples. During the summer of 2007 CPCB identified 64 chironomid subsamples from 16 sites, including 2 reference streams already in CPCB's Regional database, the North River (IDCPCB 1400) and Yellow River (IDCPCB 1651). The taxonomic data were entered into CPCB's database, and are available in the table tbl_IDNRmidges in the project database.

Field protocols

Sampling methods followed the EMAP protocols used for USEPA's National Wadeable Streams Assessment (WSA) project (http://www.epa.gov/owow/monitoring/wsa/materials.html#field). CPCB crews had been trained by in WSA protocols by environmental consulting firm TetraTech and audited by USEPA Region 7 personnel. We followed the QAPP approved for the WSA project. In brief, the protocols require habitat data, macroinvertebrates, and sediment to be collected at eleven transects along the stream reach that is 40 times the average wetted width. Water samples were collected at the center transect. *In situ* measurements were taken with a Horiba® Water Checker Model 10 that was calibrated at least once a week. At each site we also collected periphyton samples for chlorophyll analyses, using both EMAP methodology which composited the samples from each transect (Peck *et al*., 2006) and a procedure developed by CPCB that entailed collecting a sample from 5 transects and analyzing each transect separately. CPCB methods are available in the document 'Description and Protocol for Two Quantitative Periphyton Samplers Used for Multihabitat Stream Sampling' (http://www.cpcb.ku.edu/datalibrary/assets/library/reportspresentations/Periphyton.pdf). Results from the two different methodologies will be compared for data compatibility since a number of streams throughout the region were previously sampled using CPCB methodology in the WSA project.

At each of the eleven transects fish were collected using electrofishing techniques outlined in Peck *et al*. (2006). Target electrofishing effort was 45 to 180 minutes at each site. Seining was also done. Fish were identified in the field when possible or returned to the lab for identification. We do not recognize hybrids, and identified a specimen to the 'dominant' species it appeared to be. A voucher collection created for each site is housed at CPCB.

Lab protocols

Water samples were returned to the CPCB lab and analyzed for total nitrogen, total phosphorus, and chlorophyll *a* (suspended and benthic) (Table 4). Samples were handled and analyzed in accordance to CPCB QAPPs approved for past USEPA grants (USEPA awards X-99790401-4, X-9871820-0). Additional water and sediment samples were sent to the USEPA Region 7 laboratory to be analyzed for a suite of pesticides, metals, and cations and anions. Periphyton collected in the five vials at each site using CPCB methods were averaged for inclusion in statistical analyses. All laboratory analyses and procedures followed Standard Methods 20th Edition or USEPA procedures.

Macroinvertebrates were returned to the laboratory and processed using CPCB methods (http://www.cpcb.ku.edu/datalibrary/assets/library/protocols/BenthicLabSOP2009.pdf) based on EMAP protocols (500 count randomly selected using a Caton tray). A macroinvertebrate voucher collection was created for each site. Six of the 46 sorted samples came out to >600 organisms (more than the required 500 +/- 20%) so we randomly removed organisms from the data to reduce counts to 600. We removed from the final dataset nondistinct taxa, or those specimens not identified to lowest possible taxon that could possibly represent a taxon already in the sample. This prevents taxa richness from being inflated. Thus the final dataset analyzed included only those organisms marked as distinct taxa.

Table 4. Water quality and biological parameters assessed in the study.

Parameter	Instrument/Method	Method Citation	Method Detection Limit	Container and Holding time	Preservative
pH	Horiba U-10 Water Quality Checker (measured *in situ)*	Horiba, 1991 APHA, 1998; 4500-H A	0.1 SU	N/A	N/A
Conductivity	Horiba U-10 Water Quality Checker (measured *in situ)*	Horiba, 1991 APHA, 1998; 2510 A-B	1 μS cm^{-1}	N/A	N/A
Dissolved Oxygen (DO)	Horiba U-10 Water Quality Checker (measured *in situ)*	Horiba, 1991 APHA, 1998; 4500-O G	0.1 mg L^{-1}	N/A	N/A
Turbidity	Horiba U-10 Water Quality Checker (measured *in situ)*	Horiba, 1991 APHA, 1998; 2130 B	1.0 NTU	N/A	N/A
Air and Water Temperature	Horiba U-10 Water Quality Checker (measured *in situ)*	Horiba, 1991 APHA, 1998; 2550 B	0.1 ˚C	N/A	N/A
Total Phosphorus (TP)	Lachat 48 Place Digester, Lachat QuikChem 4200 Flow Injection Analyzer	Ebina et al., 1983	5 μg L^{-1}	1L amber glass, 28 days	Chill to 4˚ C, Store in dark
Total Nitrogen (TN)	Lachat 48 place digester, Lachat QuikChem 4200 Flow Injection Analyzer	Ebina et al., 1983	0.01 mg L^{-1}	1L amber glass, 28 days	Chill to 4˚ C, Store in dark
Ammonium (NH_4^+)	Lachat QuikChem 4200 Flow Injection Analyzer	APHA, 1998 4500-NH3 G	1 μg L^{-1}	1L amber glass, 28 day	Chill to 4˚ C, Store in dark
Nitrate + nitrite (NO_3^- and NO_2^-)	Lachat QuikChem 4200 Flow Injection Analyzer	APHA, 1998 4500-NO3 G	0.01 mg L^{-1}	1L amber glass, 28 days	Chill to 4˚ C, Store in dark
Columnar Chlorophyll *a* and Phaeophytin *a*	Optical Tech. Devices®, Ratio-2 System Filter Fluorometer	APHA, 1998 10200 H	1.0 μg L^{-1}	1L amber glass, 1-3 months after extraction	Chill to 4˚ C, Store in freezer
Macroinvertebrates	Travel kick method with D-framed net (500 micron mesh)	See WSA website for protocols	Genus or species-level identification	480 ml plastic jar	95% alcohol
Fish	Electrofishing	Peck et al. 2006	Species-level identification	Non-field identified, return in plastic jar	95% alcohol
Periphyton Chlorophyll *a* and Phaeophytin *a*	Optical Tech. Devices®, Ratio-2 System Filter	APHA, 1998 10200 H	1.0 μg L^{-1}	40 ml vials, 1-3 months	Chill to 4˚ C, Store in freezer
Flow Velocity	Swoffer® Model 2100 Flow Meter	Swoffer Model 2100 Operation Manual	0.01-0.03 m/sec	N/A	N/A

Data handling

CPCB laboratories

CPCB used its own field data sheets for periphyton and fish samples. Fish and macroinvertebrate data were entered directly into relational tables using MSAccess® software. Laboratory data were entered into MSExcel files in which calculations were performed for periphyton and suspended chla, and then imported into the same MSAccess database as the site and biological data. CPCB data entry procedures were based on a two-person process where each record entered was checked by the database manager to assure consistency and accuracy in the data transcription process. CPCB calculated fish and macroinvertebrate metrics using EcoMeas (CPCB 2008) except for the following which were calculated using queries in MSAccess.

Macroinvertebrate indices calculations:

Total Taxa Richness: Count of all taxa found at that site on that date.

Proportion EPT: Count of all EPT taxa found at that site on that date/total taxa richness.

Proportion Sensitive: Count of all sensitive taxa found at that site on that date/total taxa that had a known sensitivity score. Sensitivity was assigned based on values taken from Appendix B: Regional Tolerance Values in Barbour *et al.* (1999). In that document, for five geographic regions taxa were assigned tolerance values on a scale from 0 (extremely sensitive or not tolerant) to 10 (tolerant). We averaged the literature scores for each taxon and the divided each mean taxa tolerance value by three (3) to reduce the scaling back to three tolerance classes as used in the tolerance scheme for fishes (see below). Therefore the re-scaling of the macroinvertebrate tolerance scores produced the following tolerance scheme: ≤ 3.67 indicated sensitive taxa; the intermediate class was 3.68 to 7.34 and taxa having adjusted tolerances scores greater than 7.35 were considered to be pollution tolerant taxa.

Proportion Dominance: Number of individuals in the most populous taxon divided by the total number of individuals in the sample.

Fish indices calculations:

Total Taxa Richness: Count of all taxa found at that site on that date.

Proportion Sensitive: Count of all sensitive taxa found at that site on that date/total taxa richness of those that had a sensitivity score. Taxa were marked as sensitive based on two documents that list fish sensitive values: The first list was Appendix C: Tolerance and Trophic Guilds of Selected Fish Species in Barbour *et al.* (1999) EPA Rapid BioAssessment Protocols for Use in Wadeable Streams and Rivers. In this document, taxa were assigned tolerance values of I = intolerant (sensitive), M = intermediate, or T = tolerant. The second list was the Autecology table developed by Dave Peck of USEPA's Western Ecology Division Laboratory in Corvallis, OR. Mr. Peck compiled information for this table on the autecology of North American fishes for use in EPA's EMAP program studies. If the tolerance values for the two lists differed for a taxon, the more sensitive category or the category for the "corn belt" region was selected for use in our analyses.

USEPS Region 7 Laboratory

Sediment and water chemistry data were provided by the USEPA Region 7 in one MSExcel file for each year of sampling, 2005 and 2006. For data reformatting, CPCB imported the raw MSExcel files into the CPCB database. R7 identified samples by their own sample numbers (provided on the sample container labels) rather than the CPCB site code. In addition, sediment data were denoted with sample numbers of < 100 and water data were denoted with sample numbers of 100 and greater. In most cases a stream name and CPCB site code was provided in other fields, but not in such a way as to match up R7 data with CPCB lab data by site code. Thus CPCB had to create a 'lookup' table that served to link R7 data with the remainder of the data tables. The R7 2005 and 2006 data tables were merged into one file, and the data run through a crosstab query to have each row as a unique sampling event with each chemical field as a column.

USEPA Corvallis, OR

As with the WSA project, habitat and chemistry field data were recorded on field sheets that were sent to the USEPA National Health and Environmental Research Laboratory/ORD Western Ecology Division in Corvallis, Oregon at the end of each field season in 2005 and 2006. NHERL scanned the field sheets and processed the data, computed habitat metrics, and in December 2007 returned the data to CPCB. The raw data was in both SAS and as MSExcel Comma Separated Values format, while the metric output data was a SAS .lst file (kan_metric_data_output.lst) (Table 5). Extensive reformatting of the data was required to import it into MSAccess to make it compatible with the CPCB and USEPA data. For example, the metrics file kan_metric_data_output.lst was saved as a text file by CPCB, then opened in MSExcel using white space as the delimiter. In MSExcel, data were parsed into 9 categories of metrics (Table 5), and each category imported into MSAccess as its own table. Imported data were compared with original .lst file to verify accuracy. The raw data files were also imported into the same MSAccess database (available at http://www.cpcb.ku.edu/progwg/html/biologicalwg.htm). The field data were identifiable by the CPCB site code that was used (after minor reformatting) to link the data with data from other labs. These data were retained in a single database, while the metric tables were also copied into the master project database to be merged with the chemistry and biological data.

Table 5. Metrics and raw data provided by Corvallis Oregon from the scanned field sheets.

MSAccess table	Type	Original file name	Description
BankAngleUndercut	metric	kan_metric_data_output.lst	Bank angle and stream undercut
BankHtWidthIncised	metric	kan_metric_data_output.lst	Bank heights, widths and incised calculations
CanopyDensiometer	metric	kan_metric_data_output.lst	Canopy densiometer
CanopyMidLayer	metric	kan_metric_data_output.lst	Canopy and mid layer types
HabitatClass	metric	kan_metric_data_output.lst	Habitat class metrics (% glide, riffle, fast, slow, etc.)
InvasivePlants	metric	kan_metric_data_output.lst	Invasive plants
LegacyTree	metric	kan_metric_data_output.lst	Legacy tree
PctSubstrate	metric	kan_metric_data_output.lst	Percent substrate
SlopeBearing	metric	kan_metric_data_output.lst	Slope and bearing
ThalwegAndChannel	metric	kan_metric_data_output.lst	Thalweg and channel metrics
canpycov	raw	*.sas7bdat	Canopy cover
constrt	raw	*.sas7bdat	Channel constraint
fishcov	raw	*.sas7bdat	Fish cover
inplnt	raw	*.sas7bdat	Invasive plants
lgtree	raw	*.sas7bdat	Legacy Trees
lgwoody	raw	*.sas7bdat	Large woody debris
mesosub	raw	*.sas7bdat	
pctsub	raw	*.sas7bdat	Percent substrate
phab_comments	raw	*.sas7bdat	Comment
raphabas	raw	*.sas7bdat	

MSAccess table	Type	Original file name	Description
riparian	raw	*.sas7bdat	Riparian
strmver	raw	*.sas7bdat	Stream verification?
sub_bank	raw	*.sas7bdat	Bank substrate?
thalweg	raw	*.sas7bdat	Thalweg measurements
torrent	raw	*.sas7bdat	Evidence of torrent

Final database

All data for analyses were housed in a single MSAccess database, available for download at http://www.cpcb.ku.edu/research/html/refstream.htm. Relational structure is shown in Figure 3. Because the data were housed in many tables, for analyses we used a query to create a flatfile of the variables of interest. The file was imported into Number Cruncher Statistical System (NCSS 2004). Analyses explored basic trends of the reference sites within and among ecoregions.

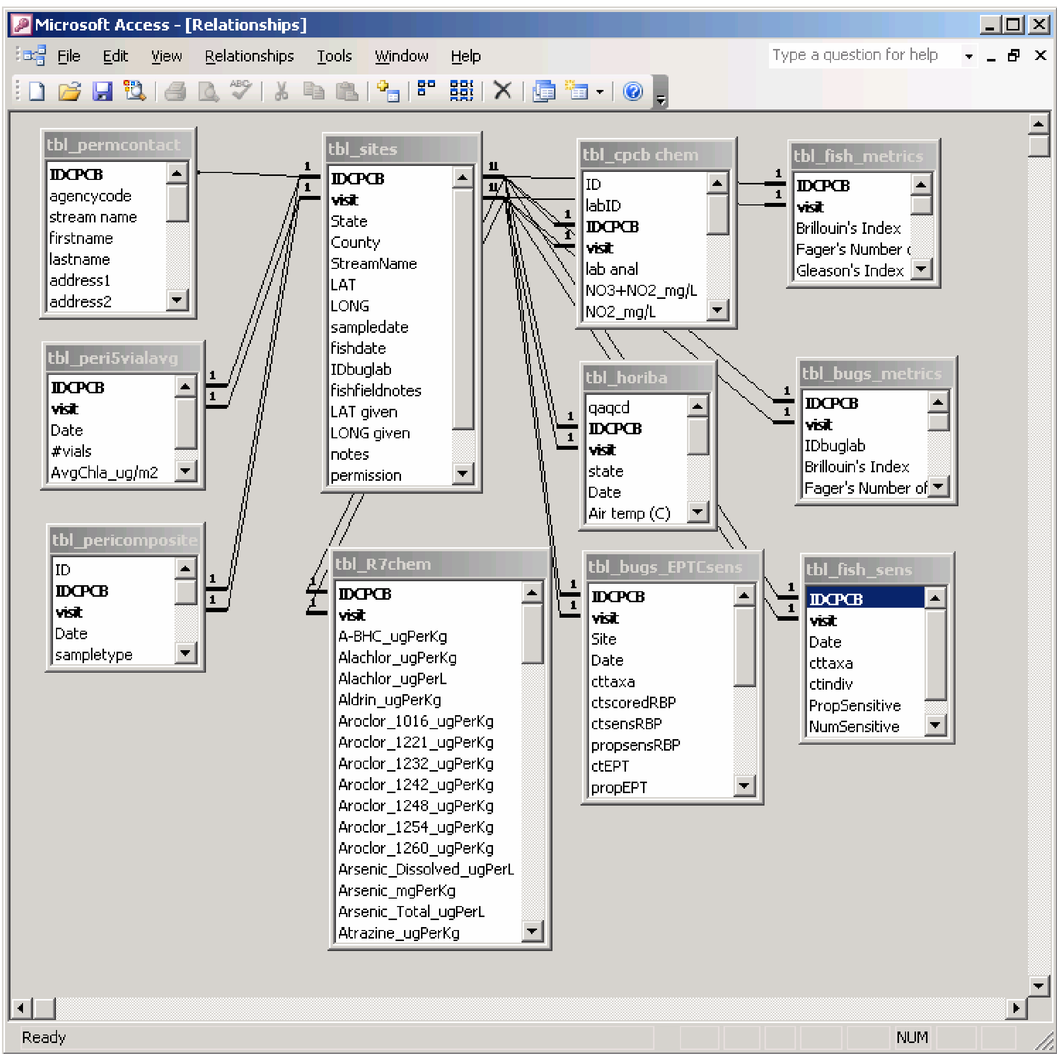

Figure 3. Relational structure of the MSAccess database created for this study (Corvallis habitat metric tables not shown). Variables of interest were merged with the habitat data into a flatfile for statistical analyses.

RESULTS AND DISCUSSION

Sampling summary

There were 48 sampling events at 47 sites. However not all sites or events have data, as described in Table 6. While many more reference streams have been identified and sampled to a lesser extent by individual states, until this project no effort has been made to examine reference condition across geopolitical bounders or using the same methodologies. In this study we were able to sample at least one reference stream in nine of the 14 ecoregions occurring in USEPA Region 7 (Table 7). Three or more reference streams were sampled in six of these nine ecoregions. For these ecoregions GLM ANOVA tests or the analog non-parametric tests were performed to determine possible ecoregional differences among a selected number of physical habitat, water quality and biological variables. The variables that exhibited a high frequency of zero or non-detect values were not included in statistical analyses but were included in graphical comparisons (i.e. box and violin plots). Statistical and graphical assessments were made using NCSS statistical software (NCSS 2007).

Table 6. Number of sampling events and sites for the 2005-2006 study, with explanations of missing data.

Variable	Events	Sites	Comments
field sheets - metrics	46	46	USEPA Region 7 did not provide field sheets (sites 187 and 1637).
macroinvertebrates	46	46	USEPA Region 7 did not collect (sites 187 and 1637).
fish	44	44	USEPA Region 7 did not collect (sites 187 and 1637). Sites 865 and 1623 not fishable.
in situ	48	47	
periphyton – 5 vial CPCB method	48	47	
periphyton – composite method of EMAP	48	47	
suspended chla	47	47	IA1360 no value - Higher chl b and/or chl c ratio is present, thus interfering chl a reading.
nutrients	48	47	
R7 water chem			
R7 sediment chem			

Table 7. Number of sampling events and sites for the 2005-2006 study, by Omernik Level III Ecoregions.

Ecoregion	Abbr.	Events	Sites
Central Great Plains	CGP	4	4
Central Irregular Plains	CIP	9	8
Central Oklahoma/Texas Plains	COT	1	1
Driftless Area	DA	2	2
Flint Hills	FH	5	5
Nebraska Sandhills	NSH	3	3
Southwestern Tablelands	ST	1	1
Western Corn Belt Plains	WCB	17	17
Western High Plains	WHP	6	6
	Total	48	47

Characterization of reference streams

A very large number of the variables describing various aspects of the reference streams examined in this project are available in Appendix 4. A selected number of variables in each of three general classes are described in more detail in this section. These variables include instream, water quality, and biological (i.e. fish and macroinvertebrate) variables. Summary tables of the entire database are presented here by variable category, while summaries by ecoregion can be found in Appendices 5-8.

Instream conditions

At each site, instream condition was evaluated at 11 transects evenly distributed along a reach-length that was 40 times the average wetted width of the site. From the field sheets scanned by the Corvallis lab, metrics were calculated and those of interest are presented in Table 8. Descriptive statistics by ecoregion are available in Appendix 5. As a group these reference streams typically have few riffles and pools, limited large woody debris, and moderately incised channels. There were significant ecoregional differences for a large number of these physical habitat condition variables (see the Comparisons section of this report).

Water quality and sediment

At each site pH, conductivity, turbidity, and dissolved oxygen were measured *in situ*. Water samples were collected and returned to the lab for measurement of nutrients, pesticides, metals, and suspended chlorophyll *a*. Sediment was analyzed for metals and pesticides. Benthic chlorophyll was measured two ways: the average of 5 samples collected from only the left or right bank; or a composite of samples collected at all 11 transects (from either the left or right bank or stream center). Descriptive statistics of these water quality parameters are presented in Table 9 and Table 10. Descriptive statistics by ecoregion are available in Appendices 6 and 7. In general the water quality of these streams appeared to be good relative to most streams in this region. Median values for nutrient were at or below proposed benchmark levels that will soon be published by EPA Regional 7 RTAG. Legacy pesticides, mercury, zinc, atrazine, and alachlor among other contaminants were found in the sediment of many reference streams (Table 9). Both chlorophyll and pheophytin values varied greatly in these streams, however median concentrations were below 4 µg/L (Table 10).

Fish and Macroinvertebrate metrics

Fish were collected by electrofishing or seining the entire reach at 44 sites. At each of the 11 transects at 46 sites, a 30-second kick sample of macroinvertebrates was collected and composited. From taxa counts the metrics presented in Table 11 were calculated. Descriptive statistics by ecoregion are available in Appendix 8. In general these reference streams displayed moderate to low diversity values and median richness values were 12.5 for fish and 45 for macroinvertebrate.

Table 8. Descriptive statistics of instream condition metrics for 46 stream sites in USEPA Region 7.

Parameter	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
XBKF_W: Bankfull Width--Mean (m)	46	13.17	9.19	1.36	2.69	44.58	9.90	7.28	15.87
xdepth: Thalweg Mean Depth (cm)	46	48.61	21.72	3.20	6.89	104.04	45.38	33.44	60.31
xwidth: Wetted Width -- Mean (m)	46	10.53	8.72	1.29	1.42	42.13	7.28	4.99	12.89
sinu: Number of X/east dists for sinuosity	46	1.29	0.29	0.04	1.02	2.38	1.20	1.07	1.41
xslope: Channel Slope -- reach mean (%)	46	0.52	0.51	0.07	0.09	2.07	0.39	0.11	0.67
xembed: Mean Embeddedness--Channel+Margin (%)	46	72.80	23.20	3.42	31.80	100.00	75.09	52.40	97.27
bfwd_rat: Mean bankfull width/depth ratio (m/m)	46	13.82	9.41	1.39	4.67	58.55	12.32	6.99	17.23
pfc_lwd: Large Woody Debris Presence (% Reach)	46	0.23	0.20	0.03	0.00	0.69	0.27	0.00	0.36
pfc_all: Any Type Fish Cover Present (% Reach)	46	0.98	0.05	0.01	0.73	1.00	1.00	1.00	1.00
PCT_CB: Substrate Cobbles -- 64-250 mm (%)	46	15.80	16.50	2.43	0.00	57.58	11.51	0.00	29.74
PCT_SA: Substrate Sand -- .06-2 mm (%)	46	17.83	29.91	4.41	0.00	100.00	0.95	0.00	30.95
pct_RI: Riffle (% of reach)	46	8.52	11.37	1.68	0.00	53.00	5.00	0.00	11.25
pct_pool: Pools -- All Types (% of reach)	46	3.03	9.33	1.38	0.00	56.00	0.00	0.00	0.00
XINC_H: Channel Incision Ht.-Mean (m)	46	2.04	1.47	0.22	0.57	8.00	1.69	0.96	2.60

Table 9. Descriptive statistics of water quality and sediment parameters for 42 to 48 stream sites in USEPA Region 7.

Parameter	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
pH	48	8.05	0.42	0.06	6.26	8.72	8.14	7.79	8.29
Conductivity__mS_cm_	48	1.38	5.95	0.86	0.08	41.70	0.51	0.42	0.67
Turbidity__NTU_	45	44.22	56.75	8.46	2.00	275.00	25.00	10.00	51.50
DO__mg_l_	44	7.53	2.27	0.34	2.28	12.66	7.68	5.83	9.26
NO3_NO2_mg_L	48	1.52	2.37	0.34	0.01	11.60	0.38	0.11	1.95
NO2_mg_L	48	0.02	0.02	0.00	0.00	0.13	0.01	0.00	0.02
NH3_ug_L	48	66.47	86.94	12.55	5.73	437.00	42.98	19.00	81.98
TN__mg_L	48	2.08	2.60	0.38	0.18	13.00	0.86	0.55	2.57
PO4_ug_L	47	50.94	64.39	9.39	4.19	293.00	26.60	14.20	61.40
TP_ug_L	48	116.16	105.41	15.22	12.20	510.00	74.50	47.70	139.50
Mercury_Dissolved_ugPerL	48	1.89	8.25	1.19	0.20	45.50	0.20	0.20	0.20
Mercury_mgPerKg (sediment)	48	0.02	0.02	0.00	0.00	0.10	0.01	0.01	0.02
Mercury_Total_ugPerL	48	1.36	5.64	0.81	0.20	29.40	0.20	0.20	0.20
Atrazine_ugPerKg (sediment)	44	210.14	360.37	54.33	90.00	2520.00	144.00	122.50	180.00
Atrazine_ugPerL	48	4.04	3.71	0.54	3.00	29.00	4.00	3.00	4.00
Alachlor_ugPerKg (sediment)	48	9.57	17.45	2.52	3.40	126.00	7.20	4.10	9.00

Parameter	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
Alachlor_ugPerL	48	0.20	0.00	0.00	0.20	0.20	0.20	0.20	0.20
p_p__DDE_ugPerKg (sediment)	48	3.19	5.82	0.84	1.10	42.00	2.40	1.40	3.00
Diazinon_ugPerL	48	0.40	0.00	0.00	0.40	0.40	0.40	0.40	0.40
Dieldrin_ugPerKg (sediment)	48	1.90	3.49	0.50	0.68	25.20	1.44	0.81	1.80
Zinc_Dissolved_ugPerL	48	13.38	19.18	2.77	4.00	83.60	4.00	4.00	10.70
Zinc_mgPerKg (sediment)	48	31.09	31.24	4.51	5.00	203.00	23.80	12.75	45.33
Zinc_Total_ugPerL	48	34.09	25.66	3.70	25.00	141.00	25.00	25.00	25.00

Table 10. Descriptive statistics of chlorophyll (chla) and pheophytin (pheo) a measured at 44 or 48 stream sites in USEPA Region 7.

Parameter	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
chla_ug_L: suspended chlorophyll *a*	44	12.31	20.72	3.12	1.00	88.40	3.86	2.15	12.05
pheo_ug_L: suspended pheophytin *a*	42	6.27	8.79	1.36	0.98	39.82	3.34	2.27	5.11
AvgChla_ug_m2: benthic chla, ave 5 transects	48	22398.58	24856.05	3587.66	2556.84	123793.50	15119.96	7237.71	23937.05
AvgPheo_ug_m2: benthic pheo, ave 5 transects	48	6420.44	4569.71	659.58	779.52	22308.06	5067.44	3256.39	8832.27
comp_chla_ug_m2: benthic chla, 11 transects	48	15400.55	19575.14	2825.43	1445.83	108956.10	8474.36	5767.41	16343.41
comp_pheo_ug_m2: benthic pheo, 11 transects	48	4446.45	3434.71	495.76	542.80	20047.92	3469.16	2304.06	5768.86

Table 11. Descriptive statistics of fish and macroinvertebrate metrics for 44 to 46 stream sites in USEPA Region 7.

Parameter	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
fish sensitivity	44	0.18	0.14	0.02	0.00	0.50	0.18	0.00	0.29
fish Brillouin's Index	44	0.67	0.29	0.04	0.00	1.12	0.72	0.50	0.90
fish Gleason's Index	44	5.25	2.35	0.35	0.83	9.61	5.56	3.33	6.96
fish Margalef's Index	44	2.08	1.07	0.16	0.00	4.03	2.25	1.25	2.86
fish Shannon's Index (H')	44	0.71	0.30	0.05	0.00	1.14	0.76	0.53	0.94
fish Simpson's Index	44	0.32	0.24	0.04	0.10	1.00	0.25	0.15	0.42
fish Taxa Richness	44	13.05	7.20	1.09	1.00	30.00	12.50	8.00	19.50
bug sensitivity	46	0.13	0.08	0.01	0.00	0.33	0.12	0.08	0.17
bug proportion EPT	46	0.22	0.10	0.02	0.00	0.48	0.22	0.14	0.27
bug Brillouin's Index	46	1.04	0.24	0.04	0.35	1.39	1.09	0.91	1.20
bug Gleason's Index	46	16.43	4.21	0.62	5.85	25.29	16.86	13.86	18.81
bug Margalef's Index	46	6.97	1.83	0.27	2.37	10.82	7.16	5.86	8.01
bug Shannon's Index (H')	46	1.10	0.25	0.04	0.38	1.47	1.15	0.97	1.27
bug Simpson's Index	46	0.18	0.14	0.02	0.06	0.70	0.13	0.09	0.21
bug Taxa Richness	46	43.46	11.79	1.74	15.00	69.00	45.00	35.50	51.75

Comparisons of reference conditions within selected ecoregions

Where appropriate for analysis, indicators of dimension (i.e., depth, width, height, concentration) were log10 transformed, and proportional indicators (i.e., percents and sinuosity) were arcsine transformed. Only those ecoregions having 3 or more observations (CGP, CIP, FH, NSH, WCB, WHP) were included in the analysis. Violin plots were generated for ecoregions with five or more observations (CIP, FH, WCB, WHP). Significance was defined by the p=0.05 level.

Instream Conditions

A subset of measured physical habitat indicators were selected to examine potential habitat differences among ecoregions: *large-scale channel geometry* (sinuosity, mean channel slope (%)); *reach-scale channel geometry* (mean bankfull width, mean wetted width, mean thalweg depth, mean incised height, and ratio of bankfull width to depth); *substrate* (percent cobble, percent sand, mean embeddedness (%)); *habitat type* (percent pool, percent riffle); and *microhabitat* (percent fish cover, percent of large woody debris presence).

Significant differences in large-scale channel geometry between ecoregions were not observed (Figure 4 - Figure 5). However, reach-scale geometry differences were observed. The bankfull widths of three ecoregions (CIP, FH, WCB) were significantly higher (p=0.010) than those in WHP (Figure 6), and wetted widths were also significantly higher (p=0.028) in CIP than in WHP (Figure 7). Similarly, incised heights were significantly larger (p=0.002) in CIP than in WHP and NSH (Figure 8). No statistical differences were observed in mean thalweg depth or bankfull width to depth ratio (Figure 9 - Figure 10).

Highly significant differences in all three substrate indicators were also observed. Percent cobble was significantly higher (p=0.005) in CIP and FH than CGP (Figure 11), while percent sand was significantly higher in NSH (p<0.001) than the other ecoregions (CGP, CIP, FH, WCB, WHP) (Figure 12). Mean embeddedness was significantly higher (p<0.001) in CGP, NSH, WCB and WHP than in CIP and FH (Figure 13).

No significant differences were observed among ecoregions in the habitat type or microhabitat indicators selected for analysis (Figure 14 - Figure 17).

However, there appear to be enough physical habitat differences to suggest that reference conditions should be considered on a ecoregional basis. This is further supported by observed ecoregional differences found in both water quality and biological variables (see following sections).

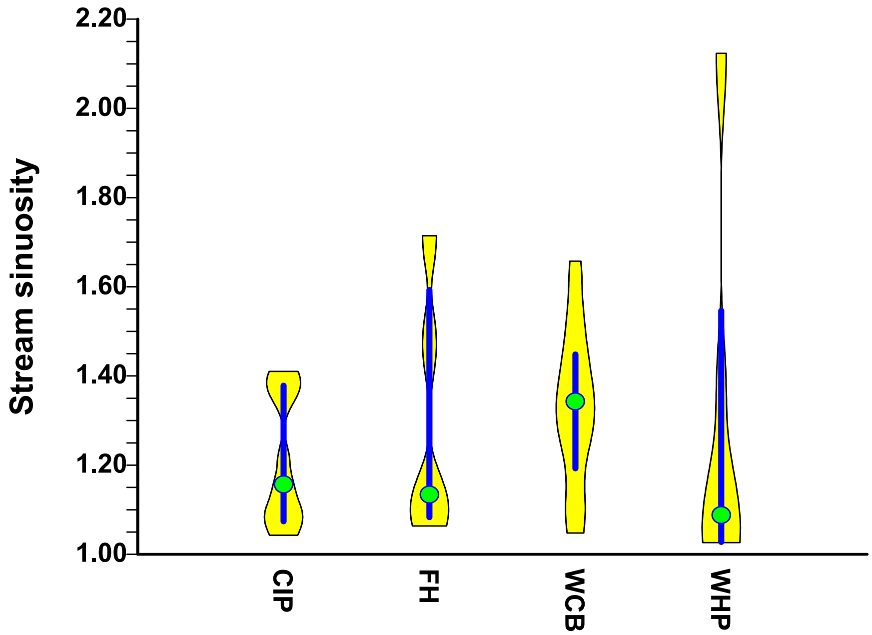

Figure 4. Stream sinuosity by ecoregion.

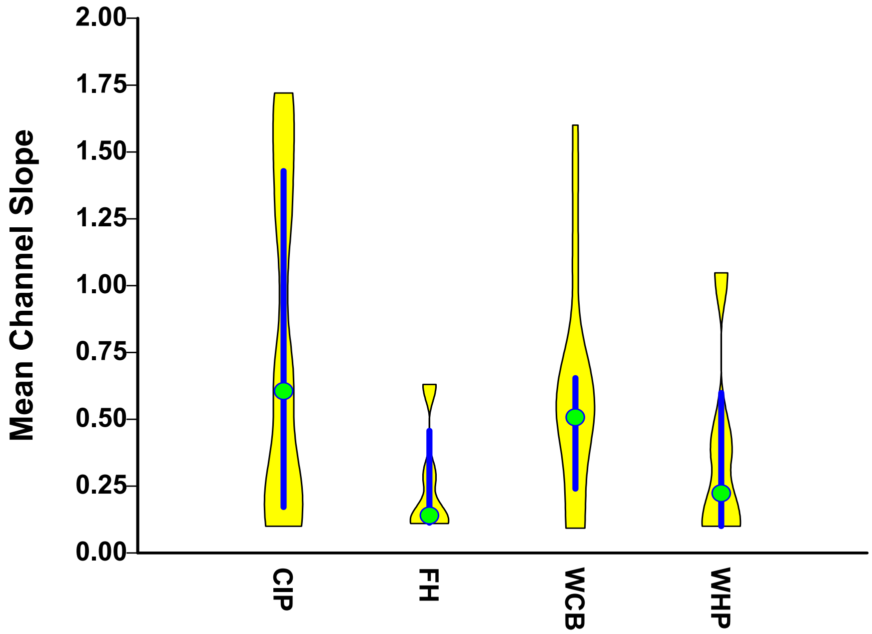

Figure 5. Mean slope of channel reach (m/m) by ecoregion.

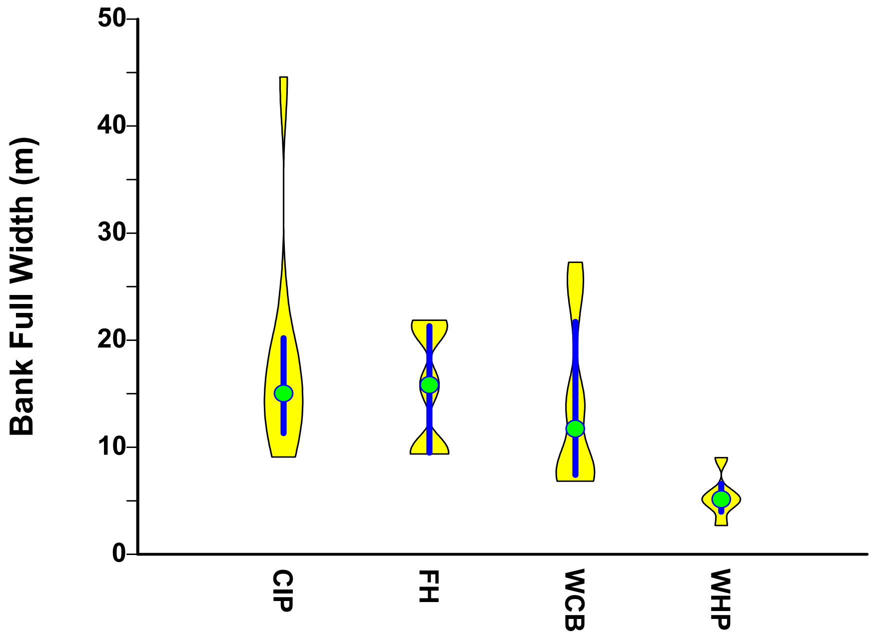

Figure 6. Mean bankfull width of channel reach (m) by ecoregion.

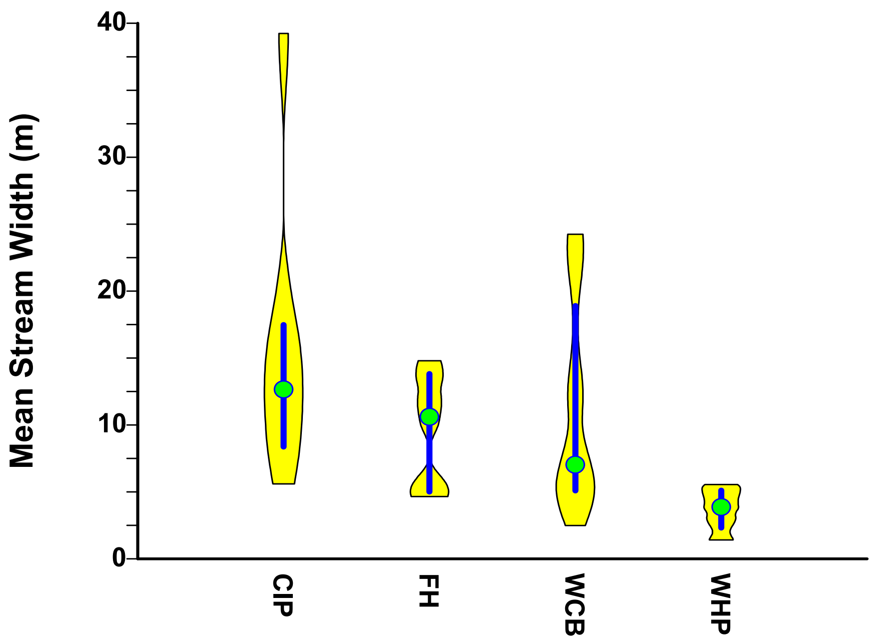

Figure 7. Mean wetted width of channel reach (m) by ecoregion.

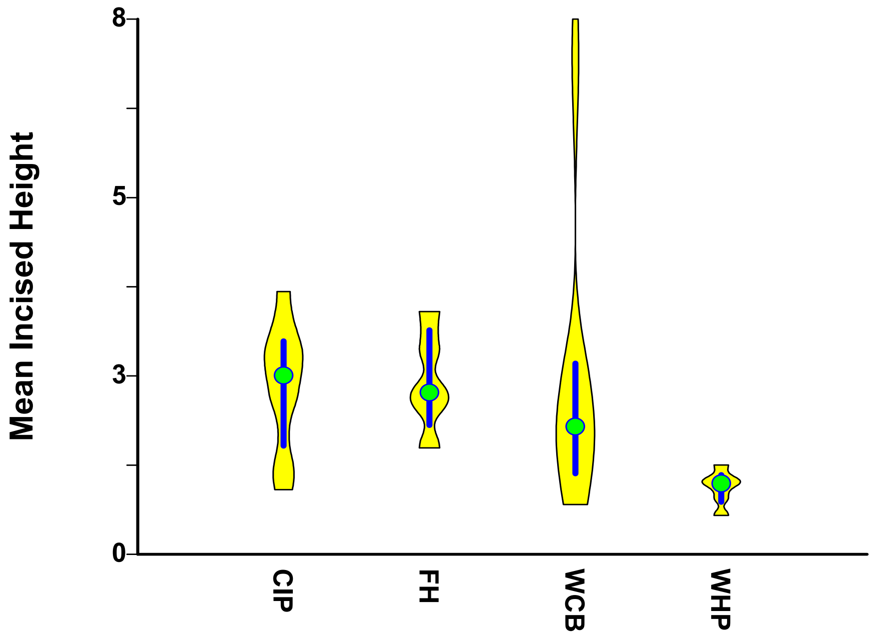

Figure 8. Mean incised height of reach (m) by ecoregion.

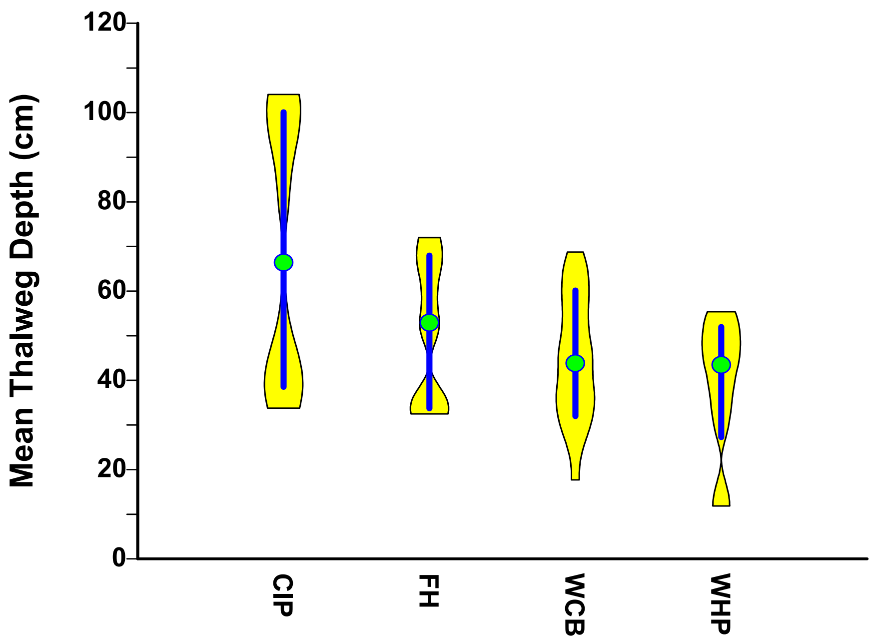

Figure 9. Mean thalweg depth of reach (cm) by ecoregion.

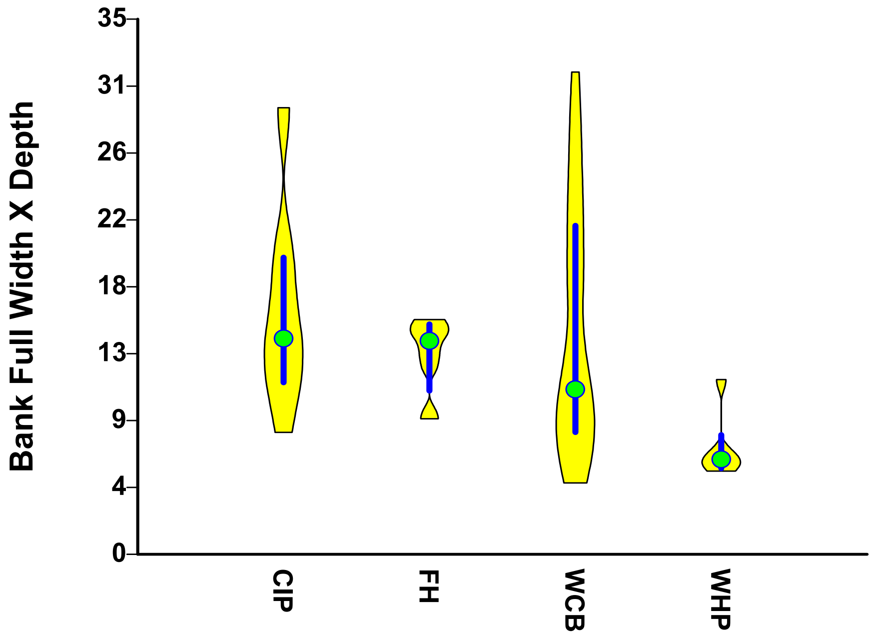

Figure 10. Ratio of bankfull width to depth by ecoregion.

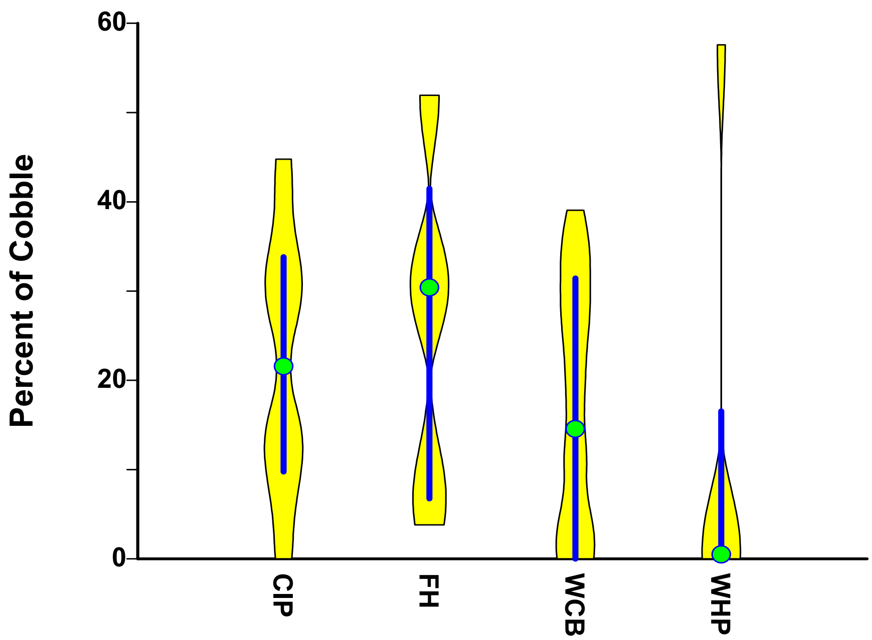

Figure 11. Percent of substrate characterized as cobble by ecoregion.

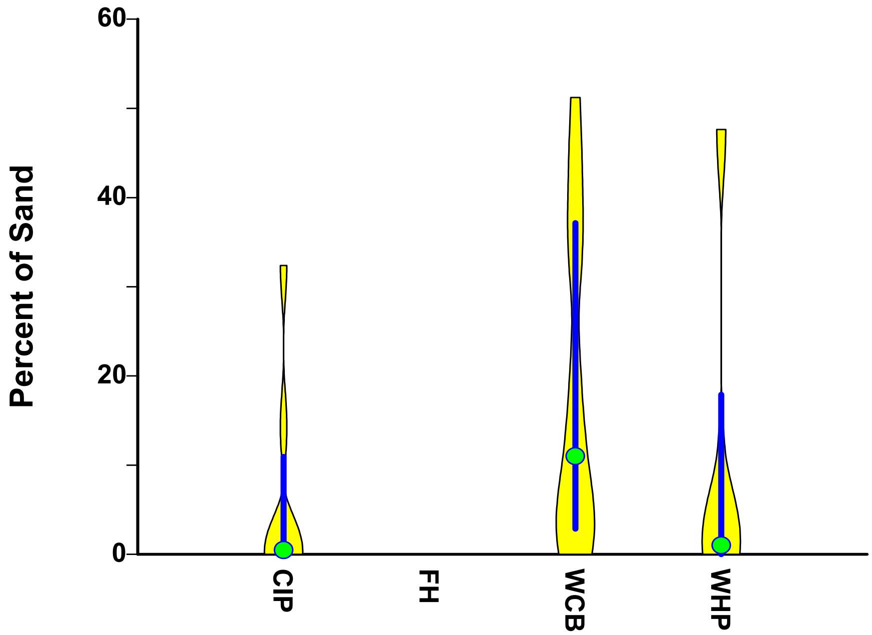

Figure 12. Percent of substrate characterized as sand by ecoregion.

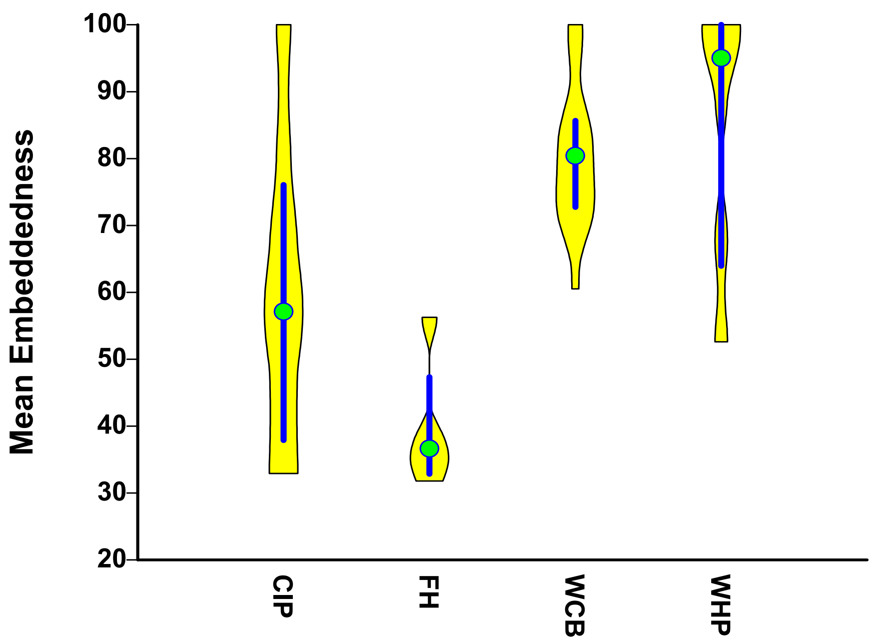

Figure 13. Mean embeddedness (%) of substrate by ecoregion. Note sand and fines were recorded as 100% embedded, while bedrock and hardpan were recorded as 0% embedded.

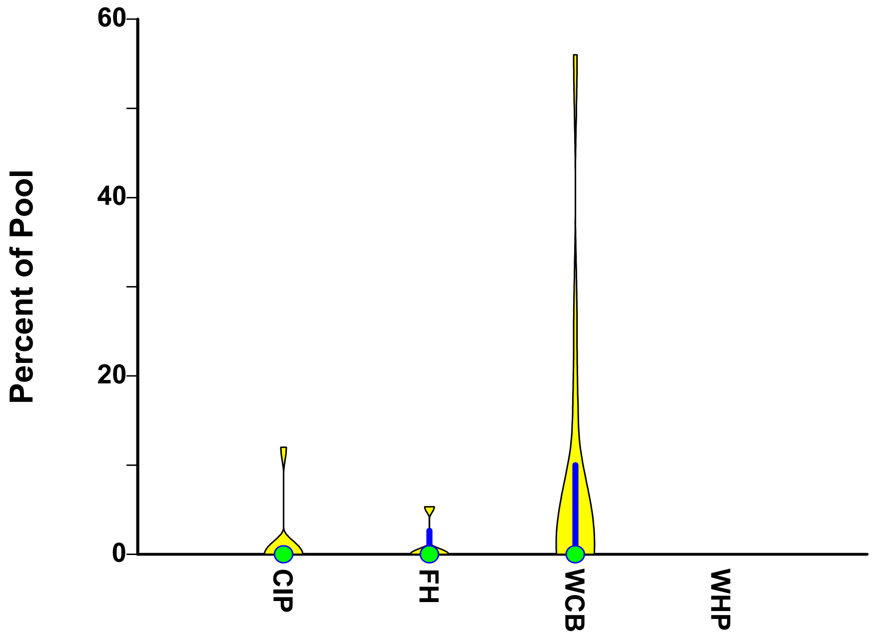

Figure 14. Percent of channel reach length in pools by ecoregion.

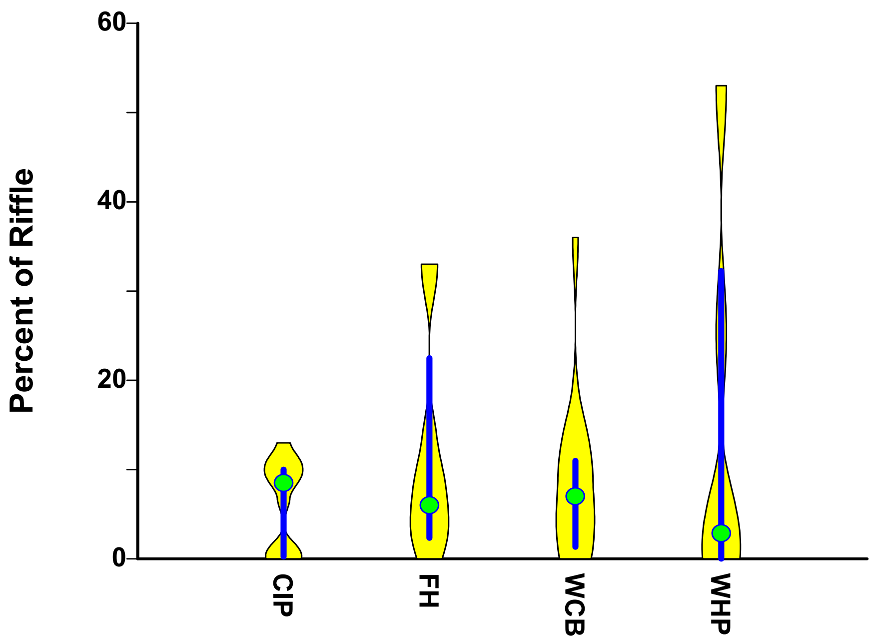

Figure 15. Percent of channel reach length in riffles by ecoregion.

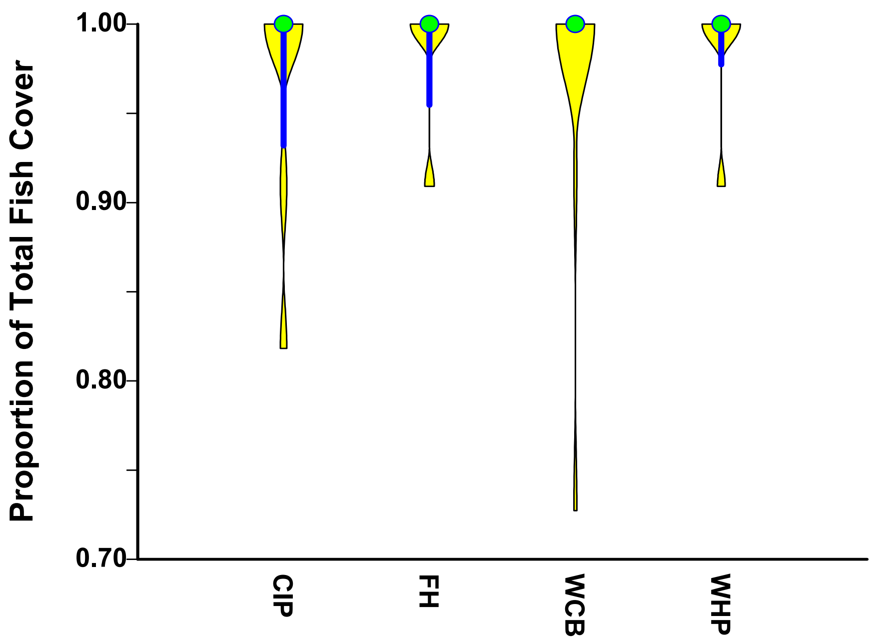

Figure 16. Percent of transects with fish cover present by ecoregion.

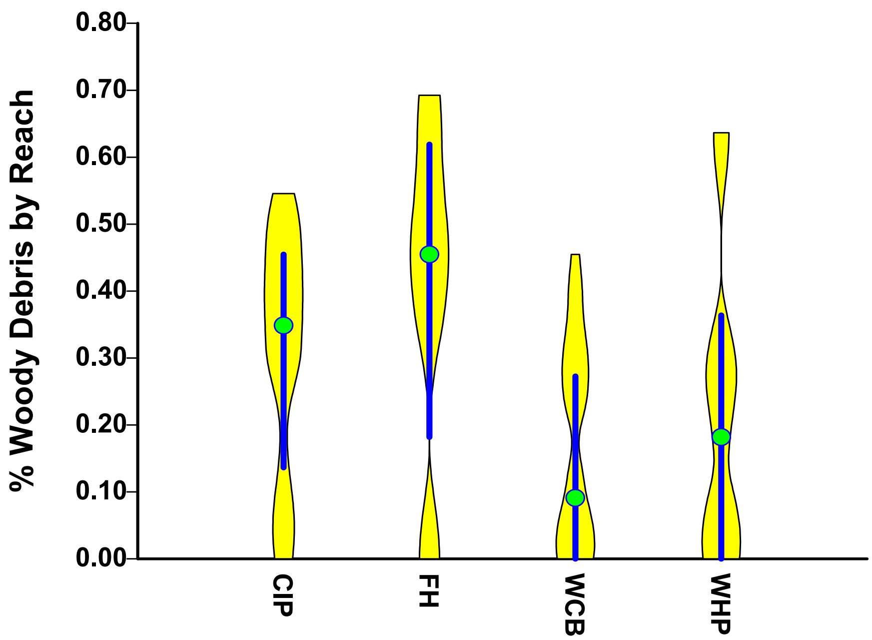

Figure 17. Percent of transects with large woody debris present by ecoregion.

Water Quality
Seven priority pollutants were selected for statistical analysis: two *metals* (mercury and zinc) and five *organic contaminants* (alachlor, atrazine, diazinon, dieldrin, and p,p' DDE). These pollutants were selected because of their known persistence, their known potential for harmful effects in surface water, and their potential for differential occurrence between ecoregions. Additionally, indicators of *water chemistry* (pH, dissolved oxygen, conductivity, turbidity, chlorophyll by CPCB 5 sample method, chlorophyll by EMAP composite method) and *nutrients* (nitrate/nitrite nitrogen, total nitrogen, phosphate, total phosphorus) were also analyzed for ecoregional differences.

Sediment concentrations of alachlor (p=0.022, Figure 18), dieldrin (p=0.026, Figure 19), and p,p' DDE (p=0.023), were higher in CGP than WCB, while sediment concentrations of mercury (p=0.010, Figure 20) and zinc (p<0.001, Figure 21) were higher in CIP than CGP, NSH, and WHP. Water column dissolved zinc concentrations were significantly higher (p=0.013) in CIP than WCB. No significant differences were observed among ecoregions for sediment concentrations of atrazine or diazinon or for water column concentrations of alachlor, atrazine, p,p' DDE, total mercury, dissolved mercury, or total zinc. Water column diazinon was not detected in any ecoregion, and dieldrin was not measured in the water column.

Of the water chemistry indicators, conductivity was significantly higher (p=0.040) in CGP than CIP and WCB (Figure 22). No other statistical differences in the selected water chemistry parameters were observed among ecoregions (Figure 23 - Figure 25). Dissolved oxygen values on the whole were higher than the generally recommended criterion value (5mg/L) for aquatic life use. Also, there were no significant differences between chlorophyll and pheophytin values derived from the CPCB method (i.e., samples taken at the bank only on each of 5 transects, Figure 26, Figure 28) versus those derived from the EMAP method (i.e., composite of samples taken from each of 11 transects, including center channel sampling locations, Figure 27, Figure 29).

Water column levels of nitrate/nitrite nitrogen (p=0.025, Figure 30), total nitrogen (p=0.010, Figure 31), phosphate (p=0.032, Figure 32), and total phosphorus (p=0.006, Figure 33) are significantly higher in WCB than either CIP (the former three) or FH (the latter). Though watershed level indicators were originally used to select reference streams, land use/land cover patterns were not directly measured within the study. Observed differences in nutrient indicators may also reflect differences even within the land use/land cover patterns used for reference stream selection.

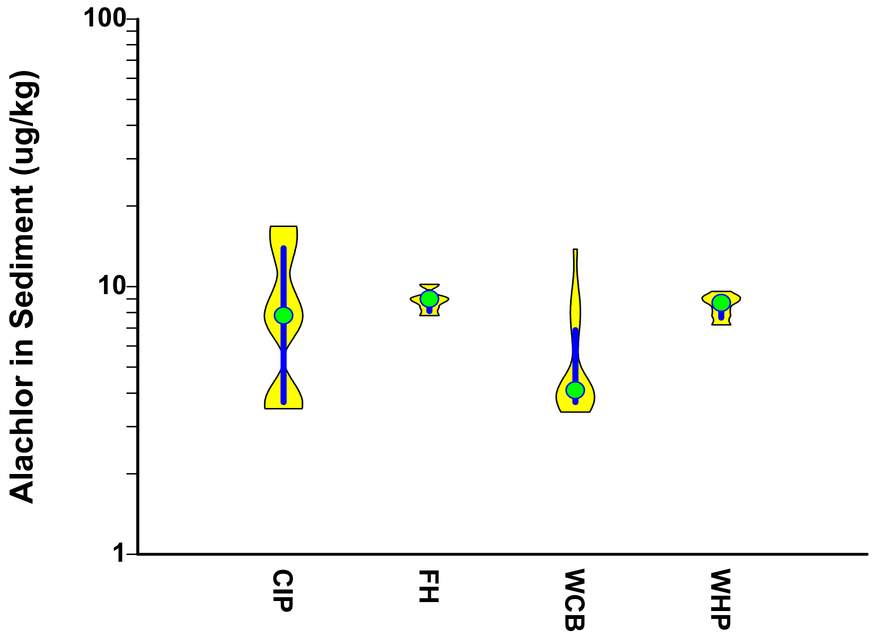

Figure 18. Alachlor (ug/kg) in stream sediment, by ecoregion.

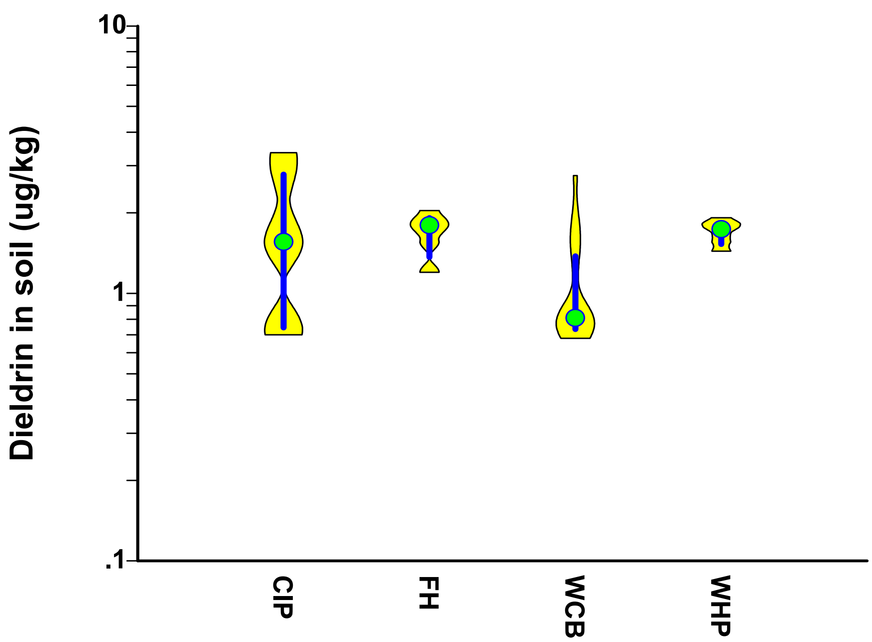

Figure 19. Dieldrin (ug/kg) in stream sediment, by ecoregion.

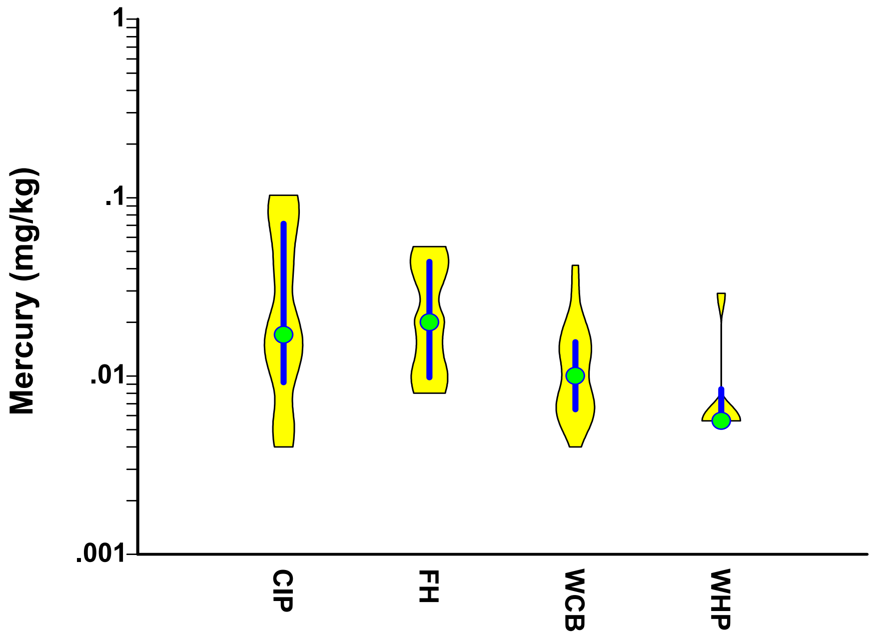

Figure 20. Mercury (mg/kg) in stream sediment, by ecoregion.

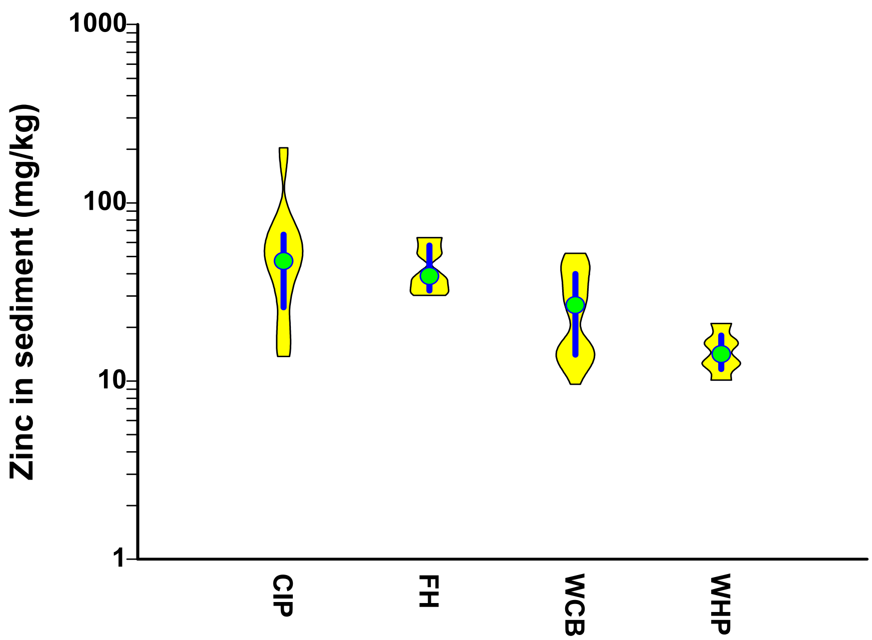

Figure 21. Zinc (mg/kg) in stream sediment, by ecoregion.

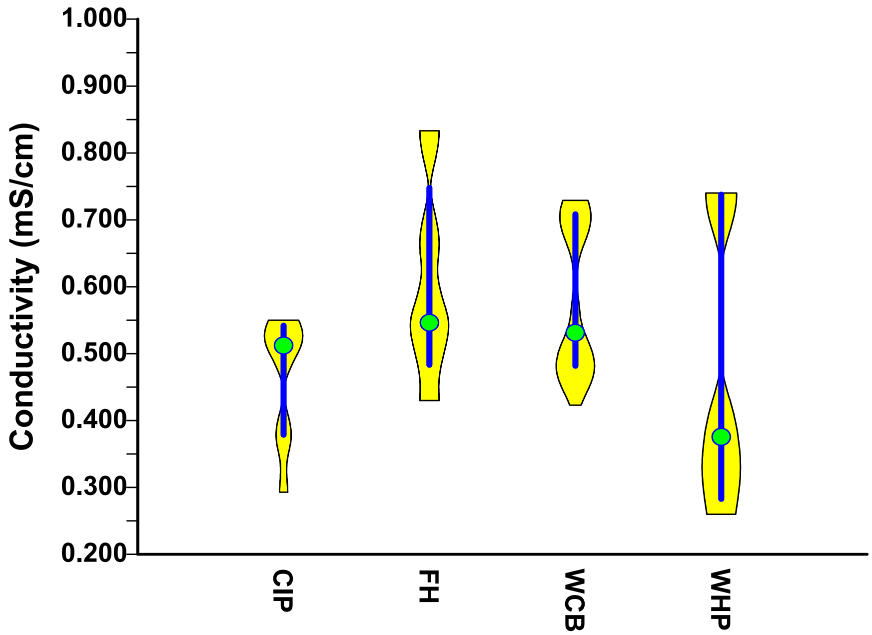

Figure 22. Conductivity (mS/cm), water, *in situ*, by ecoregion.

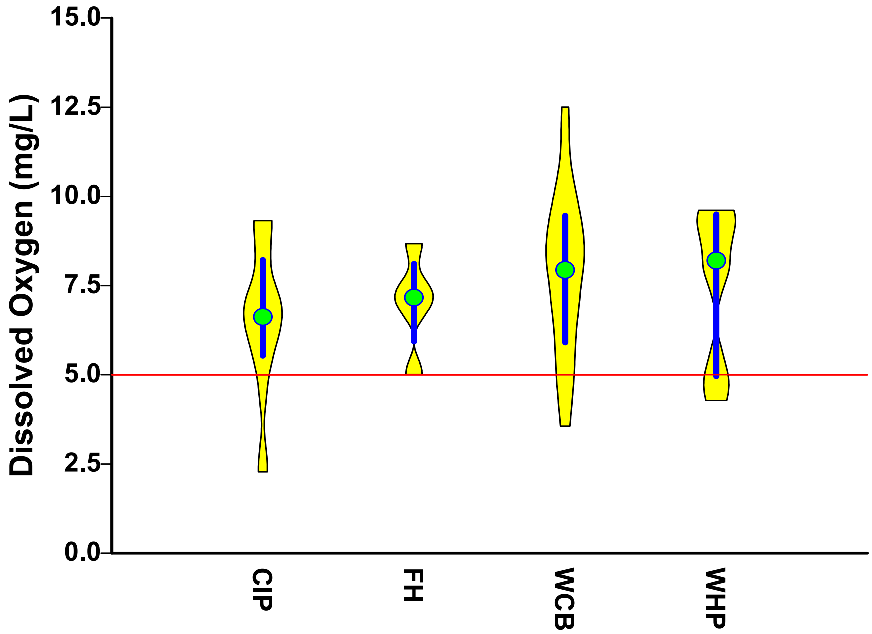

Figure 23. Dissolved oxygen (mg/L), water, *in situ*, by ecoregion. Dashed red line indicates biological criterion of 5 ug/L.

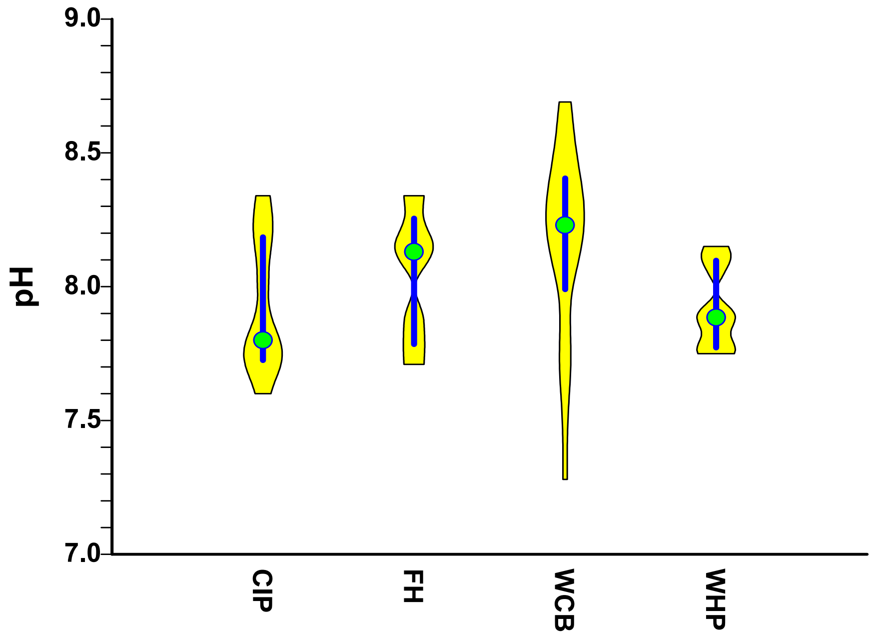

Figure 24. pH (standard units), water, *in situ*, by ecoregion.

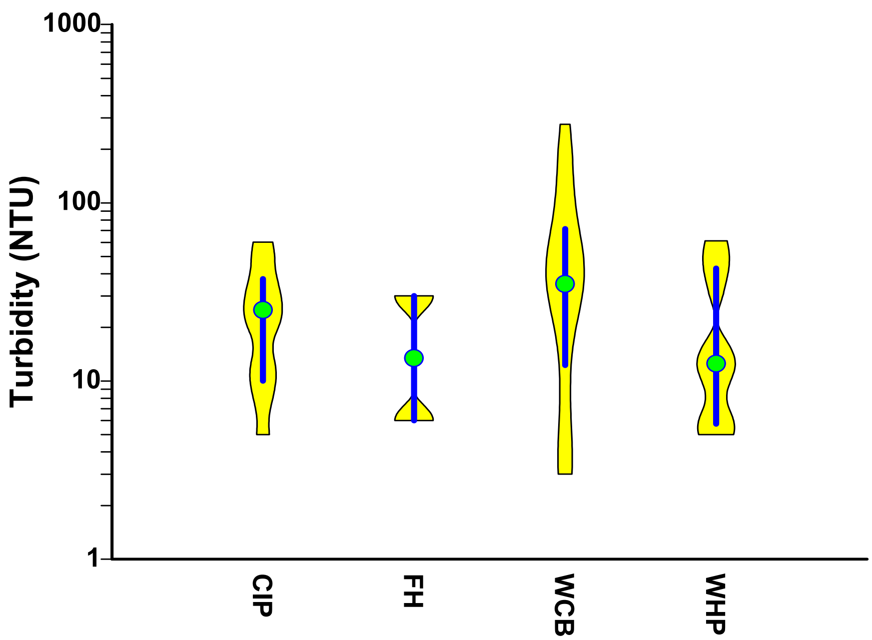

Figure 25. Turbidity (NTU), water, *in situ*, by ecoregion.

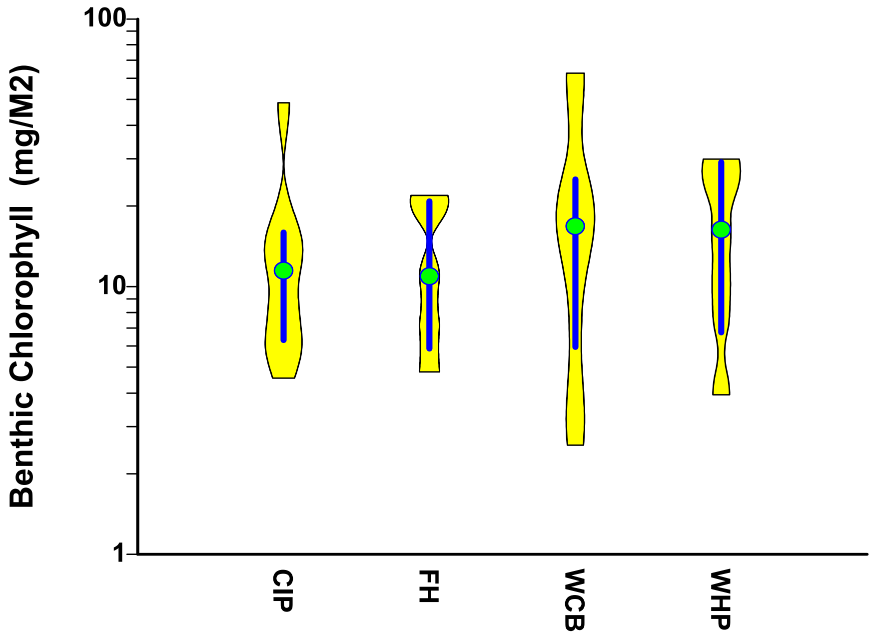

Figure 26. Benthic chlorophyll a (mg/m2), averaged from samples taken at 5 transects, by ecoregion.

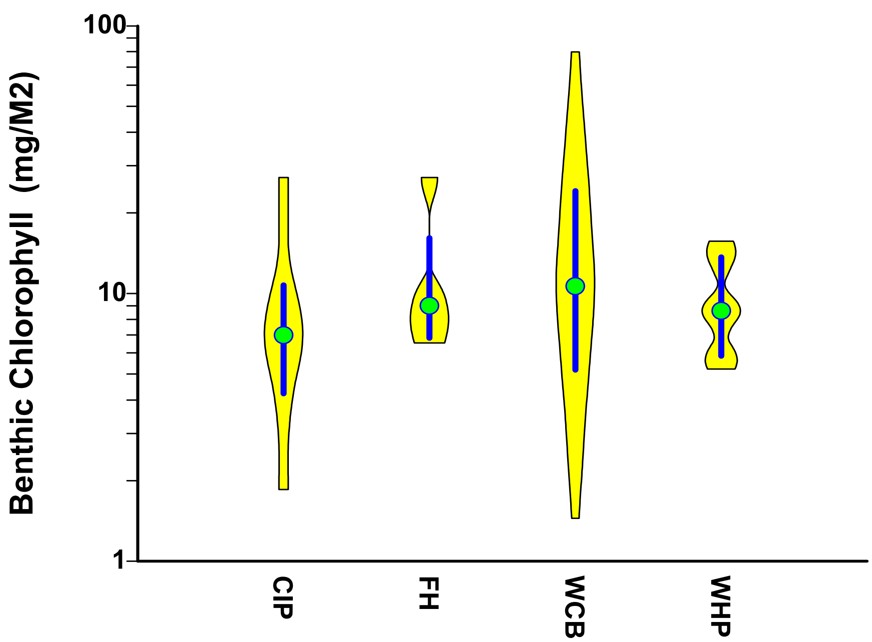

Figure 27. Benthic chlorophyll a (mg/m2), from an 11- transect composited sample collected at each stream site, by ecoregion.

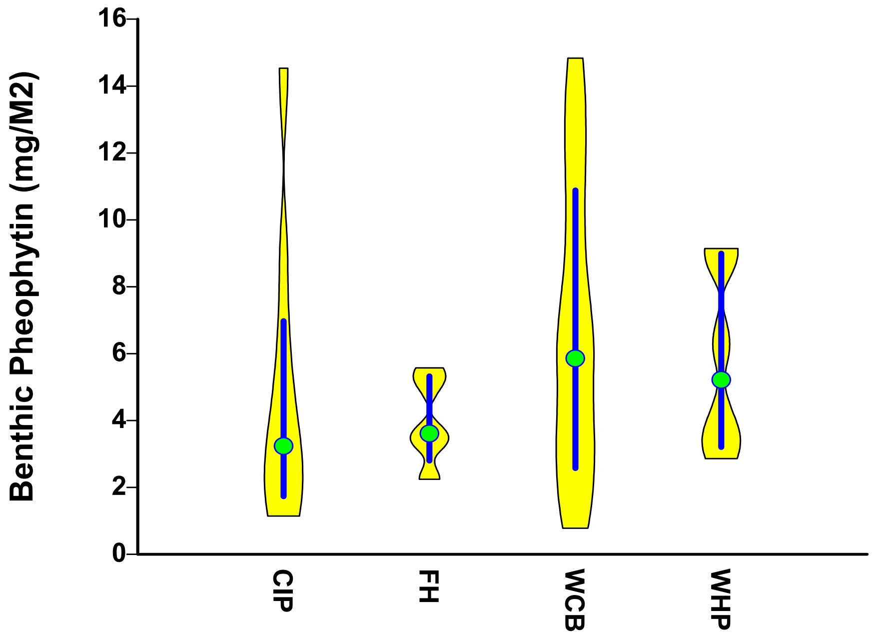

Figure 28. Benthic pheophytin a (mg/m2), averaged from samples taken at 5 transects, by ecoregion.

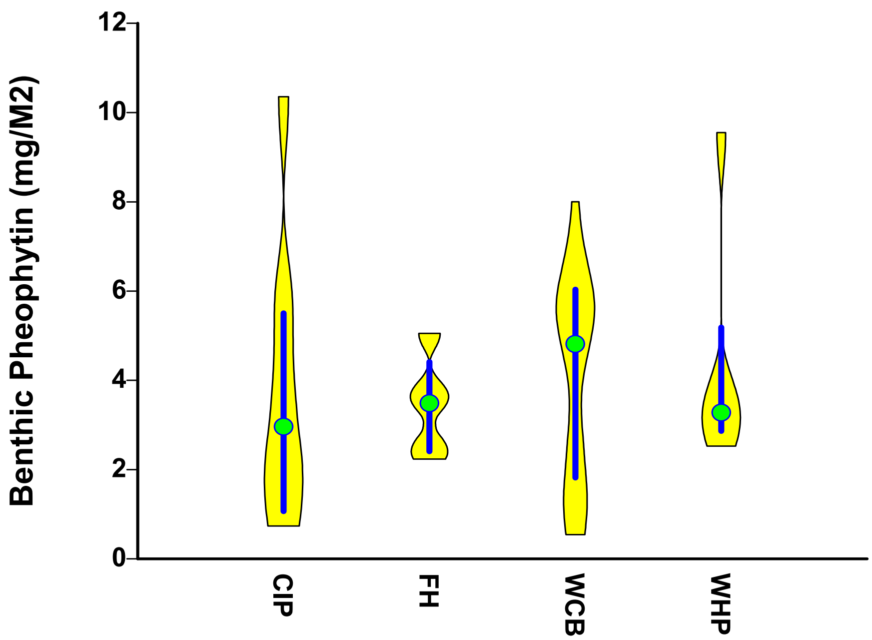

Figure 29. Benthic pheophytin a (mg/m2), from an 11- transect composited sample collected at each stream site, by ecoregion.

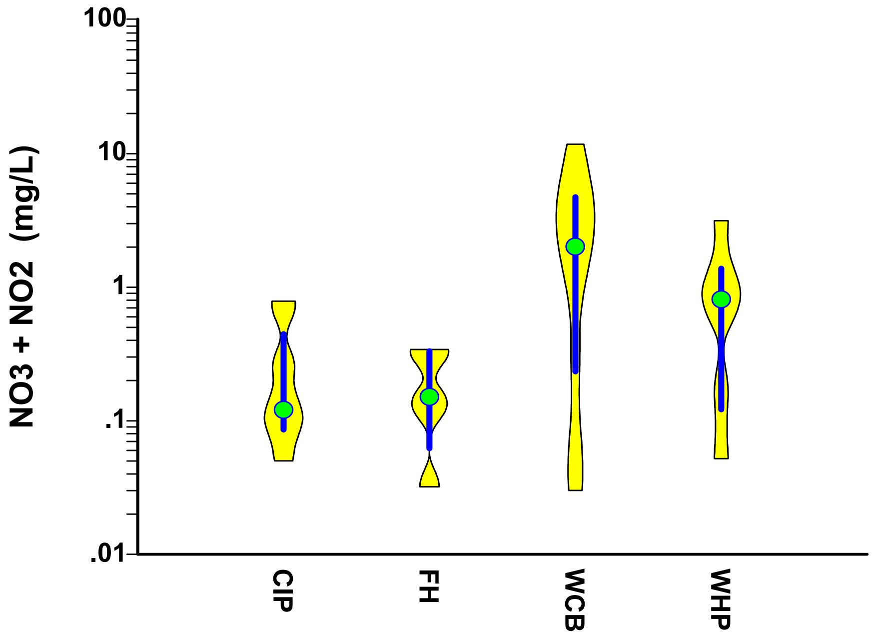

Figure 30. Water NO3+NO2 (mg/L), by ecoregion.

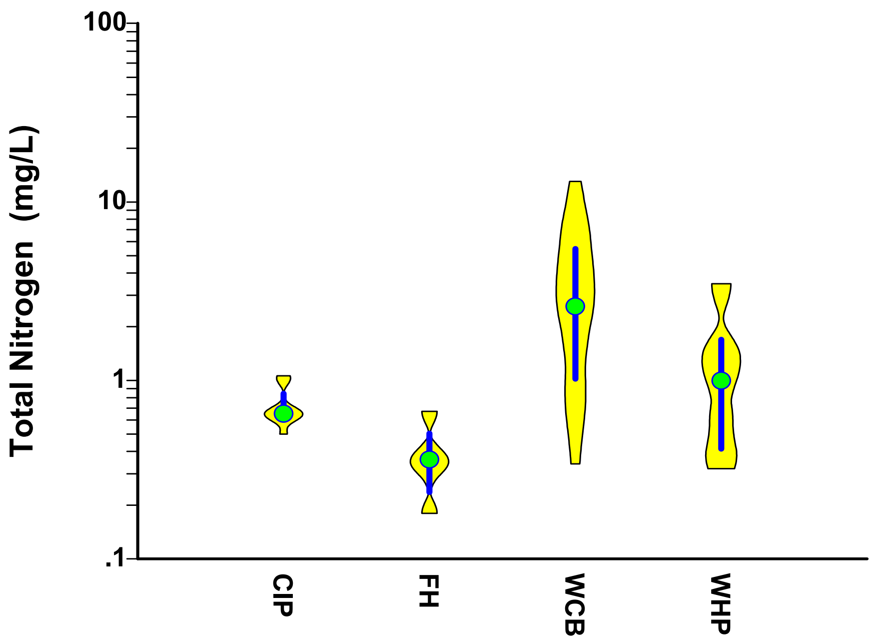

Figure 31. Water total nitrogen (mg/L), by ecoregion.

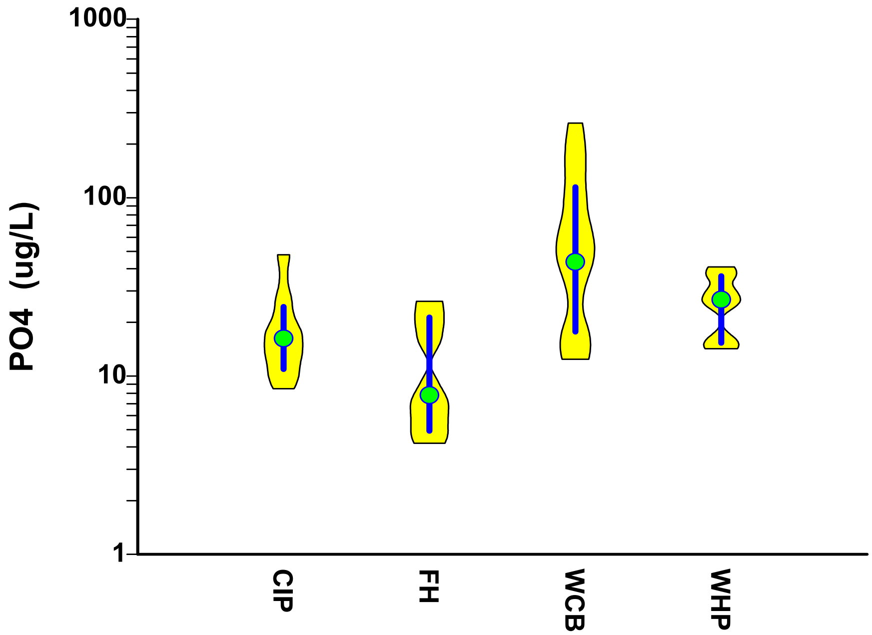

Figure 32. Water PO4 (ug/L), by ecoregion.

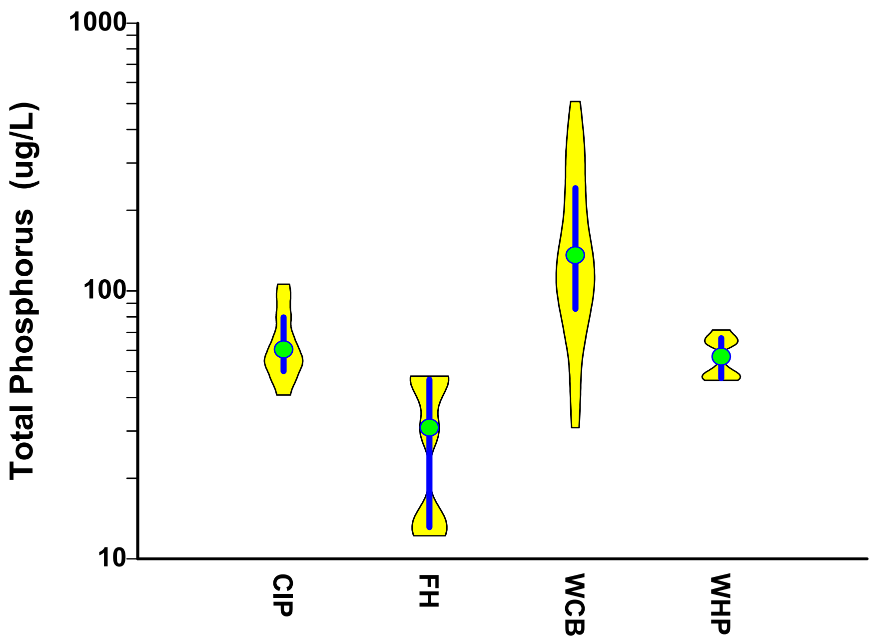

Figure 33. Water total phosphorus (ug/L), by ecoregion.

<u>Fish and Macroinvertebrate Indices</u>
A number of indicators of biotic community condition were also examined, both for *macroinvertebrates* (taxa richness, Ephemeroptera/Plecoptera/Tricoptera richness, sensitive taxa richness, Brillouin's Index, Gleason's Index, Margalef's Index, Shannon's Index, and Simpson's Index, Figure 34 - Figure 38) and for *fish* (taxa richness, sensitive taxa richness, Brillouin's Index, Gleason's Index, Margalef's Index, Shannon's Index, and Simpson's Index, Figure 39 - Figure 45).

No significant differences among ecoregions were observed for any of the macroinvertebrate indicators. Examination of the violin plots for many of the macroinvertebrate variables show that there is a wide spread in values around the median which might indicate that some of the reference streams may be under differing levels of stress for anthropogenic or nature sources. However, all but one of the fish indicators showed significantly ($p<0.002$) richer and more diverse fish communities in CIP and WCB than in CGP and WHP. No statistical difference was observed among ecoregions in sensitive taxa richness.

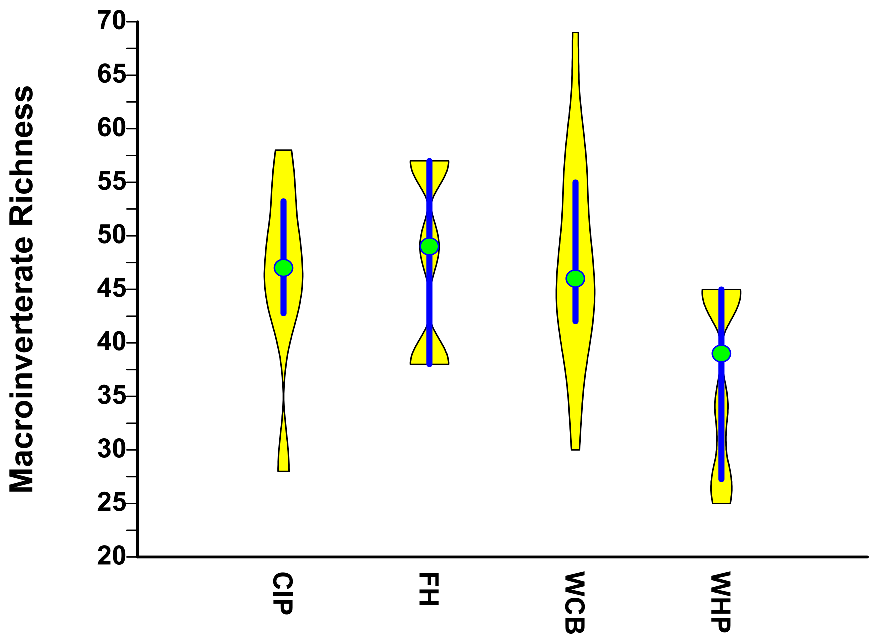

Figure 34. Macroinvertebrate taxa richness, by ecoregion.

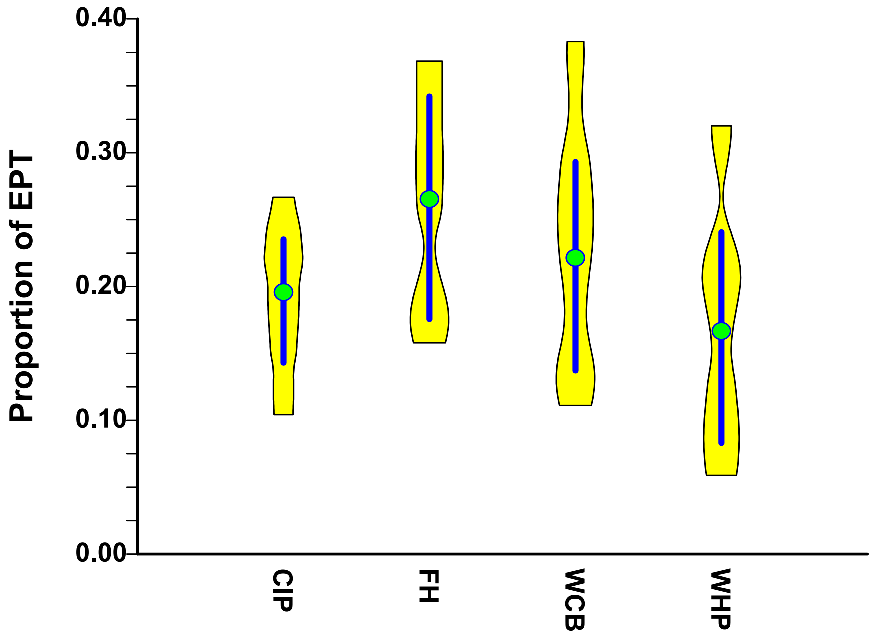

Figure 35. Proportion of macroinvertebrate taxa richness comprised of Ephemeroptera (E), Plecoptera (P), and Trichoptera (T), by ecoregion.

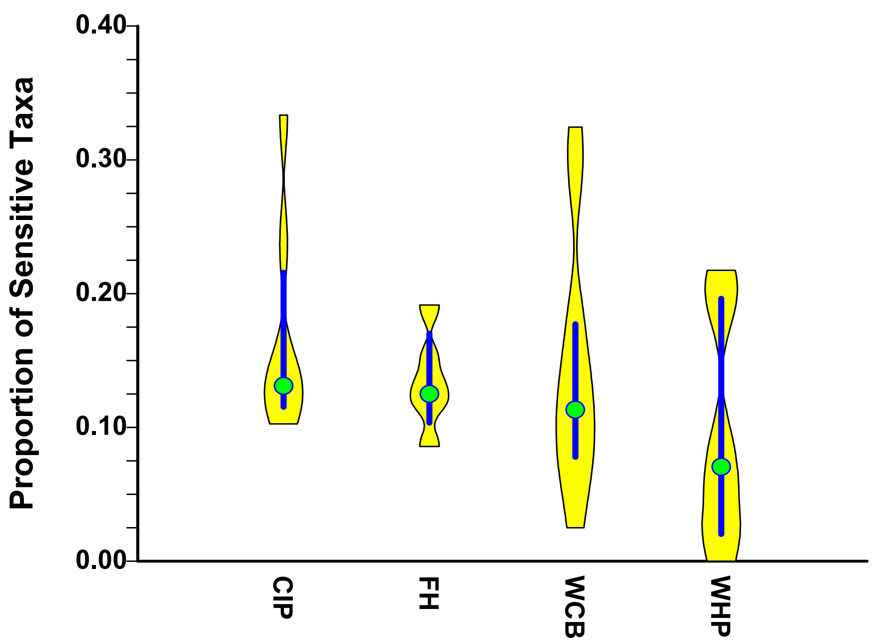

Figure 36. Proportion of macroinvertebrate taxa richness comprised of sensitive taxa, by ecoregion.

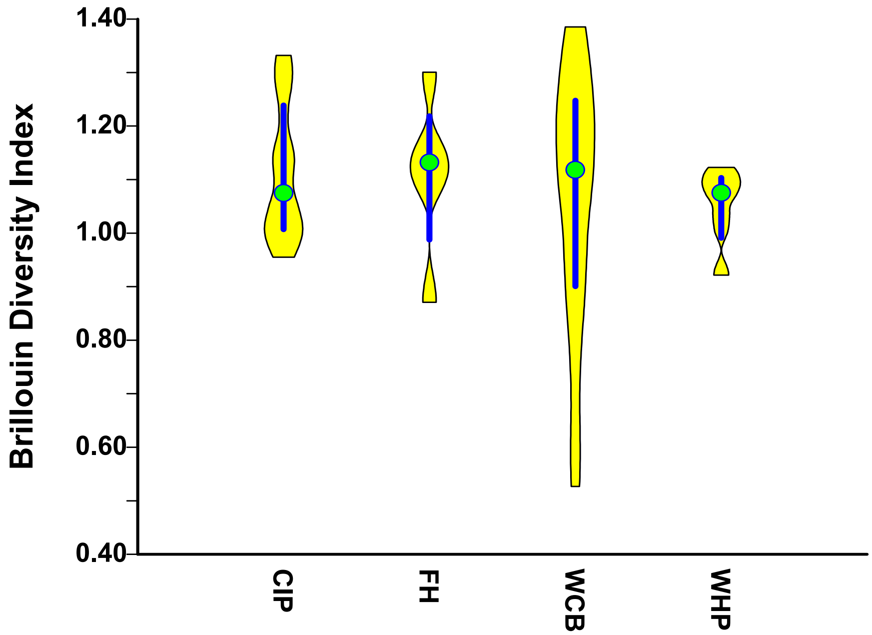

Figure 37. Macroinvertebrate Brillouin's Diversity Index, by ecoregion.

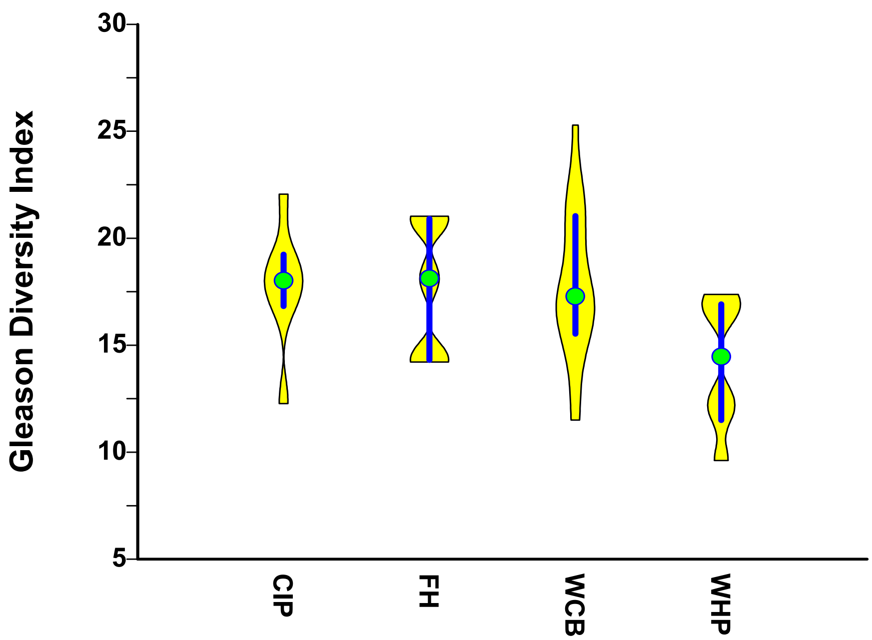

Figure 38. Macroinvertebrate Gleason Diversity Index, by ecoregion.

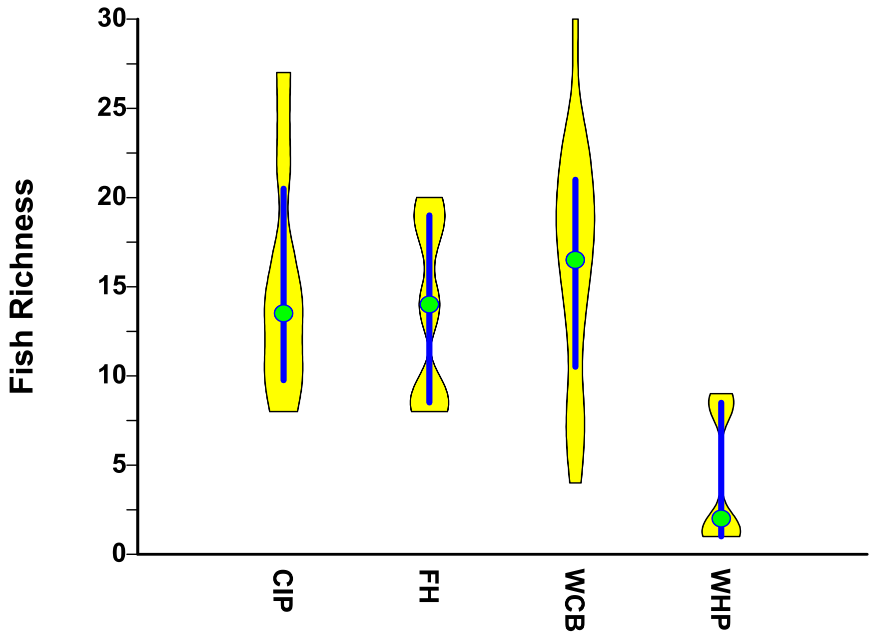

Figure 39. Fish taxa richness, by ecoregion.

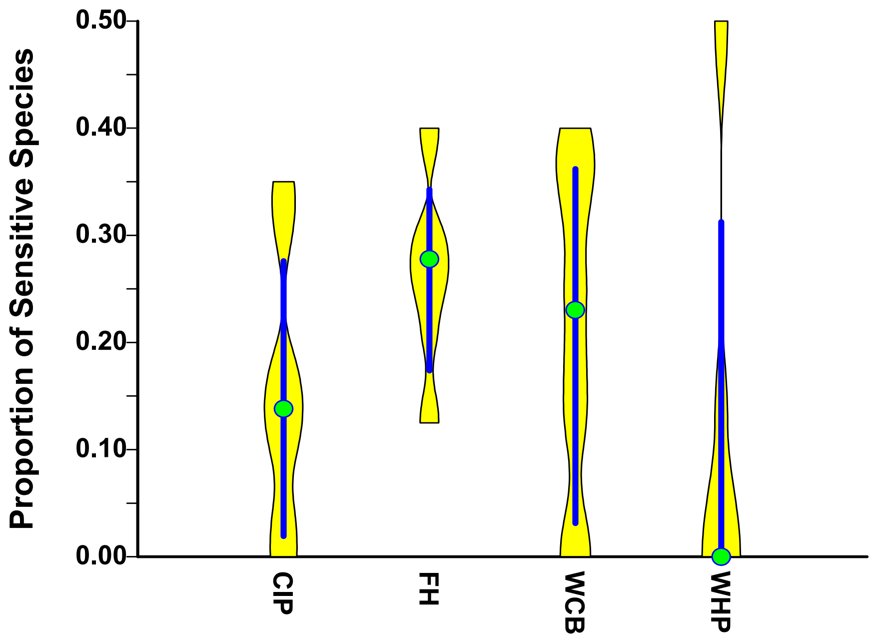

Figure 40. Proportion of fish taxa richness comprised of sensitive taxa, by ecoregion.

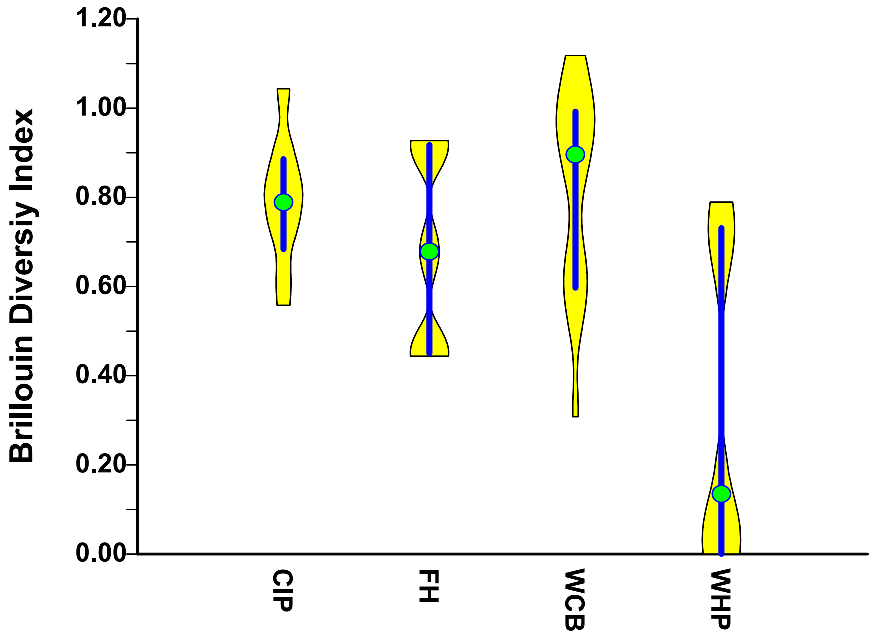

Figure 41. Fish Brillouin's Diversity Index, by ecoregion.

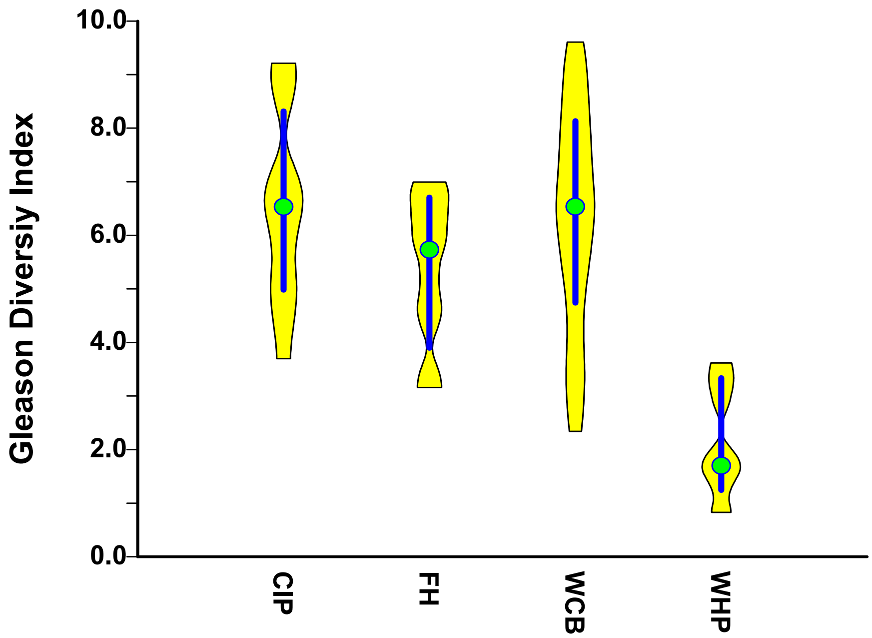

Figure 42. Fish Gleason Diversity Index, by ecoregion.

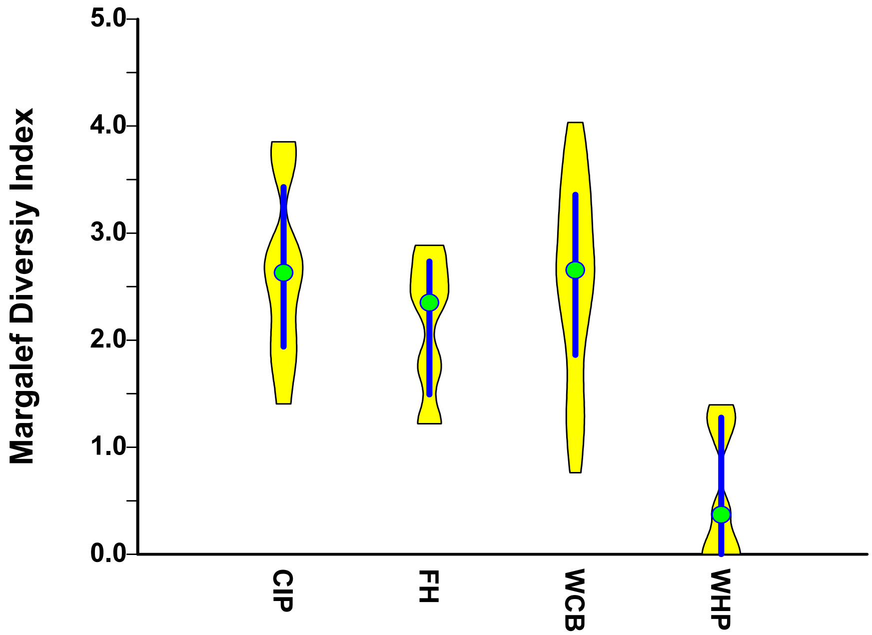

Figure 43. Fish Margalef Diversity Index, by ecoregion.

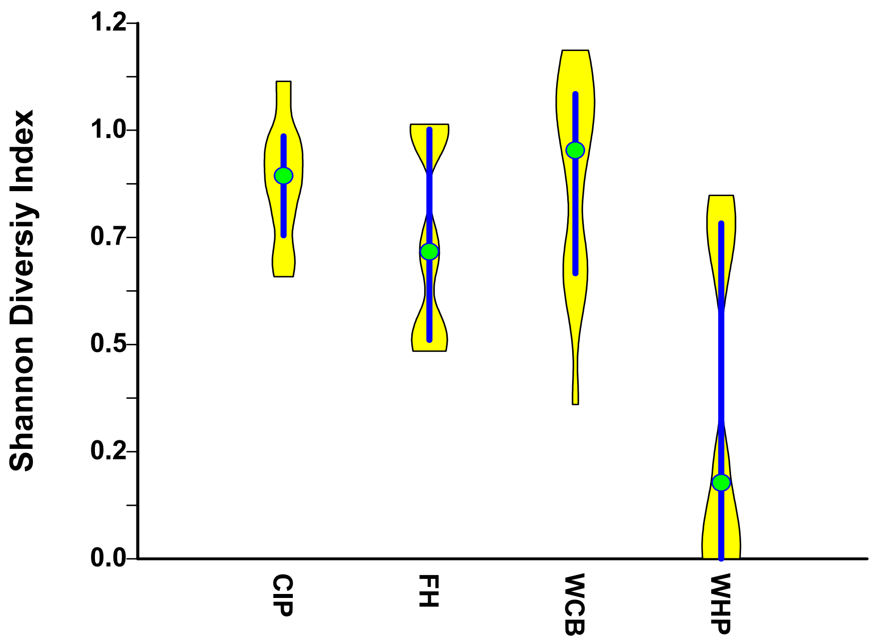

Figure 44. Fish Shannon Diversity Index, by ecoregion.

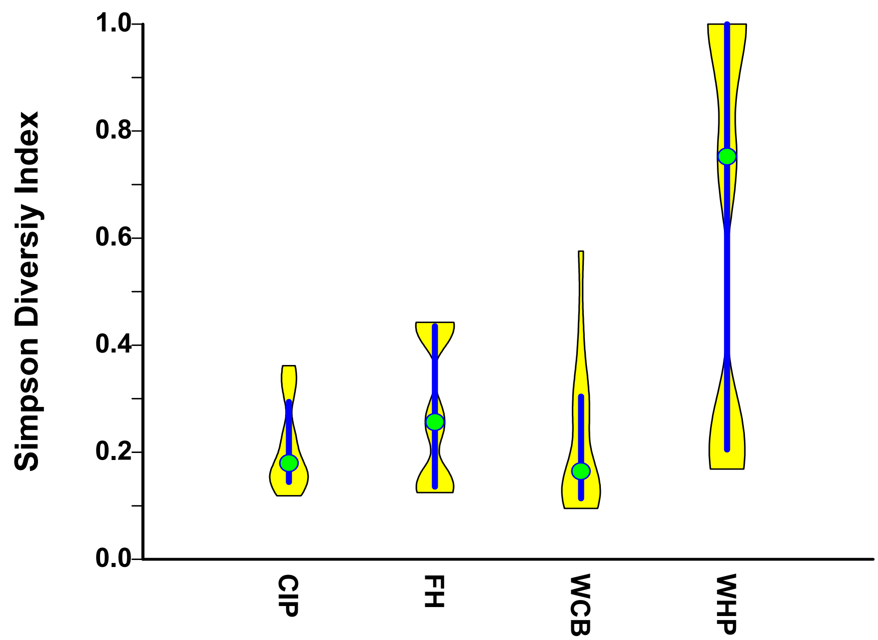

Figure 45. Fish Simpson Diversity Index, by ecoregion.

ACKNOWLEDGEMENTS

Many thanks go to project officer Dave Peck (USEPA National Health and Environmental Effects Research Laboratory, Western Ecology Division, Freshwater Ecology Branch) for support, suggestions, and patience during this project. Field crews included Karl Anderson, Debbie Baker, Alex Bartlett, Irene Beeman, Adam Blackwood, Cosmo Canacari, Jennifer Delisle, Andy Dzialowski, Bob Everhart, James Kriz, Anne Leaser, Bryant Merriman, Austin Oberzan, Sarah Schmidt, and Geoff Warlick. CPCB chemistry staff included Niang Choo Lim and Jason Beury. CPCB macroinvertebrate lab included many of the field crew and LeeAnn Bennett and Mary Anne Blackwood. Thanks to Jason Koontz for assistance in analyzing data. We thank the USEPA Region 7 in providing laboratory services, and the USEPA Corvallis office for scanning field sheets. Thanks to all the landowners for permission to access their land.

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Appendix 1. Core factors that were developed for considered in the selection of reference site for USEPA Region 7.

The Biocriteria workgroup members developed 11 core factors for reference site designation at the April 2000 workgroup meeting. Meeting proceedings are available at http://www.cpcb.ku.edu/workshops/html/2000_12.htm. These core factors were provided to state contacts to use as guidance in selection of sites to sample for this proposed project. Data for all 11-core factors may not be available for each site, in which case the available data will be used to select sites. It should be noted that biological data (Factors 9 and 10) should not be used to select reference sites, but instead to validate selected reference sites.

1. Wastewater treatment plants and other point sources
►Prefer no point source
►Acceptable if discharge effects are minimal
–Minimize number, density, and size of facilities
–Site not in close proximity to point source (below effective mixing zone)
–Effluent to stream flow ratio low
–No impairment of aquatic life beneficial use due to point source discharge
–Existing point sources have record of compliance

2. Animal feeding/grazing operations
►Prefer none
►Prefer no cattle access upstream
►Acceptable if influence AND potential of degradation is minimal
–Number of facilities low
–Number of animal units low
–Site not in close proximity to cattle access or feeding operations
–Site not in close proximity to land application of livestock waste
–No impairment of aquatic life beneficial use due to livestock impacts

3. Instream habitat
Under reference conditions, instream habitat is characterized by the highest quality and diversity of instream habitat relative to stream type, considering:
►No excessive sedimentation or embeddedness
►No riprap
►No unnatural (manufactured) substrates

4. Riparian habitat
Under reference conditions, riparian habitat would provide an effective buffer that maximizes instream habitat potential:
►No row crops
►No removal of riparian vegetation
►Preference to natural riparian conditions
►Width, length of riparian area considered

5. Land use and land cover – broad scale
This consideration involves a two-step process:
►Step one: Characterize ecoregions or sub-ecoregions using following LU/LC categories:
–Row crop

–Timber
–Grass/herbaceous vegetation
–Artificial (e.g. buildings, impervious cover)
–Water
–Barren (e.g. quarries, mines)
–Land treatment
►Step two: Summarize the LU/LC percentages by 12-digit HUCs (10-40 thousand acres) to develop summary statistics for the range of each LU/LC category

6. Land use and land cover – site-specific
►For a candidate reference site and its watershed, determine the LU/LC percentages.
►Site-specific LU/LC should not be anomalous compared to the broad-scale LU/LC.
►Percent of land cover that is natural and/or land use is treated (e.g. application of BMPs and appropriate land management) exceeds that of broad-scale ecoregion

7. Physical and chemical parameters
►Prefer sites meet or exceed aquatic life standards over the long term
►Sites should reflect best attainable physical or chemical conditions within ecoregion and flow conditions

8. Altered hydrologic regime
►Minimal channelization effects (no influence is preferred)
►Prefer sites not under influence of dams
►Sites located away from bridges and crossings influences
►Sites located away from outfall structures (e.g. storm sewers, tiles) influences
►No influence from anthropogenic dewatering
►Little or no influence of impervious surfaces or urban runoff

9. Biological metrics
►This is not a stand-alone factor
►Index of metric scores should be among the highest for a defined population in region
Caveats: This is data-driven to determine if site will be a valid reference site; not a good choice to select your site, but a good check on the validity of the site being considered for reference level

10. Biotic assemblages
►Biotic diversity is consistent with both historical assemblages (where available) and current distributions.
–Presence of rare/unique communities
–Limited number of exotics
–Temporal variations considered
–Few native species lost
–Presence of threatened or endangered species
►Take into account stream classification and size
►Migration possibilities should be taken into consideration: dams, reservoirs, drainage divides, etc. can prevent recolonization of reaches

11. Representativeness

►Reference sites should represent the range of biological, physical, and chemical conditions of the ecoregion

►These sites should be minimally disturbed by anthropogenic activities

►A sufficient number of sites should be selected to adequately represent different stream classes (e. g. cold water, saline, large, small) and capture the natural variability within specific classes).

Appendix 2. Correspondence with agencies in USEPA Region 7 regarding selection of reference sites to sample for this study.

Our inquiry emailed to the agencies in USEPA 7 is as follows:

```
 -----Original Message-----
From:    Debbie Baker [mailto:dbaker@ku.edu]
Sent:    Tuesday, February 15, 2005 11:11 AM
To:      xxxxxxxxxxxxxxx
Cc:      HugginsDon (E-mail)
Subject: reference site update request
```

Hi xxxxxxxxx,

Could you help us with some reference site information?

CPCB is submitting a proposal to EPA to sample reference streams using EMAP methods and so we're writing to you to make sure that our information about your state's reference streams is current and accurate.

1. Do you have documentation (publications, etc.) of your reference site selection process, or publications that review/refer to comparability studies using reference sites? We have your state biocriteria plan but wanted to know if there are additional documents regarding reference sites.

2. We need to document which reference sites have already been sampled using EMAP methods. Please confirm that in the attached is an Excel sheet I've correctly indicated which of your reference sites have been sampled using EMAP methods.

3. Also in the attached Excel sheet, please indicate the best reference sites in the larger ecoregions of your state. Please mark the best of approximately a third of these sites within each of the large ecoregions as being best. These we will target for sampling using EMAP.

4. Below are three definitions of reference condition. Please indicate which definition best fits your reference concept and the conditions you have used to define or identify reference sites in your state.

Thanks!
Debbie

There are many different definitions/interpretations of "reference condition". From the EMAP perspective(for inland surface waters, anyway), the following definitions are used:
Minimally Disturbed Condition - this is the condition of streams before the time of significant influence from non_native human populations. Other, roughly equivalent terms that describe this condition include "natural," "pristine" or "undisturbed." One important aspect of Minimally Disturbed Condition is the recognition that some natural disturbance has always occurred, and needs to be included in the assessment of the variability present in reference condition (hence, the term "minimally" rather than "un_" disturbed). Once established, minimally disturbed condition is an invariant definition of reference

condition. It may serve as a benchmark against which all other definitions of reference condition can be compared.

Least Disturbed Condition - this condition is equivalent to the best available conditions given today's state of the landscape. It is ideally defined by a set of strict criteria to which all reference sites must adhere. Typical criteria might include a minimal (e.g., <1%, or <5%) amount of agricultural landuse in the watershed, a fully_functional riparian forest, and/or water quality unaffected (or least affected) by human use of the watershed. The specifics of these criteria will vary across the West, as ecological characteristics of the landscape, and human use of the landscape, vary. Because the condition of the environment changes over time, as either degradation or restoration of the landscape proceeds, Least Disturbed Condition is not an invariant measure of reference condition. As the ecological condition of the very best available sites changes through time, so will our measure of Least Disturbed Condition.

Best Achievable Condition - this condition is equivalent to the ecological condition of Least Disturbed sites where the best possible management practices are in use, minimizing the impact of inevitable landuse; it is a somewhat theoretical condition predicted by the convergence of management goals, best available technology, prevailing use of the landscape, and public commitment to achieving environmental goals. The upper and lower limits on Best Achievable Condition are set by the previous two definitions of reference condition. It is very unlikely that it will ever be "better" than Minimally Disturbed Condition, nor "worse" than Least Disturbed Condition, but may be equivalent to either, depending on the prevailing level of disturbance in a region. As is the case with Least Disturbed Condition, Best Achievable Condition is not invariant, as all of the factors influencing it (e.g., available technology, public commitment) will vary over time.

Iowa

Iowa Department of Natural Resources (Tom Wilton) provided the most complete response to our inquiry of reference site selection.

Question 1 response:

Beyond the comparison of reference and test sites in the document "Biological Assessment of Iowa's Wadeable Streams," I am not aware of any other reference comparability studies from Iowa. A description of our wadeable stream reference site selection process and a listing of the sites can be found in the document titled "Biological Assessment of Iowa's Wadeable Streams," which I believe is what you are referring to as the 'state biocriteria plan.' There are three other older documents that are relevant: 1. IDNR 1992. Iowa ecoregional subdivision project: stream reference site selection guidelines. Iowa Department of Natural Resources, Environmental Protection Division, Water Quality Section. Des Moines, Iowa. 18p. 2. U.S. EPA 1993. Ecoregions and Western Corn Belt Plains Subregions of Iowa. U.S. Environmental Protection Agency, Office of Research and Development. Environmental Research Laboratory, Corvallis, Oregon. 29p. 3. Griffith, G.E., J.M. Omernik, T.F. Wilton, and S. M. Pierson 1994. Ecoregions and subecoregions of Iowa: a framework for water quality assessment and management. Journal of the Iowa Academy of Science. 10(1):5-13. I can provide copies of these documents, if you are interested in having any of them.

Question 2 response confirmed our understanding of which sites had been sampled using REMAP methods.

Question 3 response and table of sites:

I started thinking about picking the best one-third of our reference sites as requested; however, I quickly ran into some significant issues, which I'll attempt to explain.

1. Any list of the best reference sites I generate at this point in time will be totally based on 'seat of the pants' BPJ. The reason is that we have never attempted to rank our reference sites based on watershed or wq attributes or level of human disturbance. I think it would be very informative and useful to do this; however, I think you'll agree this is not a trivial task and it would require significant time and effort. Much as I'd like to launch into it, I simply don't have the time right now to embark on this type of analysis. The best I can offer are selections that are based on my general feel for the condition of the reference site watersheds using the biological indices as a response indicator of reference stream quality.

2. Iowa reference sites were selected at the Level IV scale not the Level III scale used by the WSA. Water quality and watershed attributes vary significantly across Level IVs within the Western Corn Belt Plains.

So, the question becomes, how does one apportion sites representing different Level IVs within the same Level III ecoregion? If it is done relatively evenly, the group of sites will vary substantially with respect to watershed characteristics, human disturbance and stream biological condition. For example, reference site biological condition generally declines as you move from Northeast to Southwest Iowa. Human disturbance patterns are not uniform across Level IV ecoregions. Stream size is another variable. Would you prefer a range of wadeable stream sizes or not? Our reference sites span Strahler Order 2-5. Generally, larger reference stream watersheds have more cumulative impacts than smaller ones.

If you are willing to accept a limited knowledge BPJ approach to identifying the 'best of the best', and you can answer how you want to handle the Level IV and stream size issues, I will continue generating a list of what I consider the best reference sites matching your objectives. Most likely, I can finish the list in the next few weeks. What do you think?

Question 4 response:

Of the options presented, Iowa's wadeable stream reference sites probably most closely match the description of "Least Disturbed" or "Best Available" sites selected at the scale of Level IV ecoregions. My recommendations are based on my overall familiarity with the site watersheds and consideration of the 11 core factors that we agreed were important for selecting reference sites. The attached excel file contains my recommendations for the best 20% (22 sites) of the reference or candidate reference sites listed for Iowa. The site selections are marked with an 'X' in the "bestref" column of the spreadsheet. My recommendations are based on my overall familiarity with the site watersheds and consideration of the 11 core factors that we agreed were important for selecting reference sites.

Subsequent email regarding ecoregions:

As we discussed some time ago. I have included reference sites from several different Level IV Ecoregions within the large Level III Western Corn Belt Plains (WCBP) Ecoregion. For our bioassessment purposes, we do site comparisons at Level IV; however, my understanding of what you want is a fairly broad representation of stream types from across the entire WCBP, so I did not limit my selections to any specific Level IV ecoregion within the WCBP. Originally, I think you asked for roughly the best 33% of reference sites. Below, you indicate 10 to 15 is sufficient. I have identified 22 sites (3 from the Driftless Area, 3 from the Central Irregular Plains, and 16 from the WCBP) that I'm fairly comfortable represent good quality reference sites spanning the state. The level of disturbance and the weight of consideration given to individual core factors does vary somewhat depending on the Level IV ecoregion. If you have questions about how that varies from region to region or other aspects of reference sites selection in Iowa, I'd be happy to try to answer them.

Iowa reference sites suggested for sampling, of which 15 were sampled for this study. ER3 = Omernik Level III ecoregion code.

State	ER3	IDCPCB	StreamName	County	LAT	LONG
IA	CIP	1530	Chequest Creek	Van Buren	40.761	-92.017067
IA	CIP	1265	Lick Creek	Lee	40.607156	-91.682556
IA	CIP	1263	Long Creek	Decatur	40.835563	-93.856974
IA	DA	1411	Canoe Creek	Winneshiek	43.36706	-91.618182
IA	DA	1551	French Creek	Allamakee	43.377213	-91.397228
IA	DA	1585	Middle Bear Creek	Winneshiek	43.475952	-91.64483
IA	WCB	1357	Bailey Creek	Franklin	42.902773	-93.262418
IA	WCB	1355	Bear Creek	Buchanan	42.302242	-91.958343
IA	WCB	1379	Big Creek	Crawford	42.080808	-95.369434
IA	WCB	1359	Buffalo Creek	Linn	42.205677	-91.445829
IA	WCB	1516b	Buffington Creek	Louisa	41.204983	-91.398899
IA	WCB	1352	Deer Creek	Mitchell	43.424245	-93.022224
IA	WCB	1564	Lime Creek	Buchanan	42.329157	-91.981954
IA	WCB	1353	Little Cedar River	Floyd	43.152362	-92.643717
IA	WCB	1364	Little Turkey River	Fayette	43.009116	-91.95867
IA	WCB	1331	Lizard Creek	Webster	42.541337	-94.344799
IA	WCB	1324	Maynes Creek	Franklin	42.662704	-93.230529
IA	WCB	1382	Rock Creek	Cedar	41.731573	-91.150807
IA	WCB	1351	Volga River	Fayette	42.819235	-91.884667
IA	WCB	1350	Wapsipinicon River*	Chickasaw	43.01256	-92.390104
IA	WCB	1308	Waterman Creek	O'Brien	42.97929	-95.427686
IA	WCB	1323	Willow Creek	Worth	43.276736	-93.353791

*Instead of sampling site 1350, CPCB sampled site 1360 Wapsipinicon River, Mitchell County.

Nebraska

Nebraska reference sites suggested for sampling, of which xxx were sampled for this study. ER3 = Omernik Level III ecoregion code.

State	ER3	IDCPCB	StreamName	County	LAT	LONG
NE	CGP	8033	Center Creek	Franklin	40.12594	-98.99197
NE	CGP	8034	Cottonwood Creek	Franklin	40.10464	-99.06969
NE	CGP	8024	Frenchman Creek (A)	Hitchcock	40.32297	-101.0433

State	ER3	IDCPCB	StreamName	County	LAT	LONG
NE	NSH	339	Big Creek	Cherry	42.31783	-100.8441
NE	NSH	8123	Goose Creek	Brown	42.11702	-100.1357
NE	NSH	340	N. Fork Dismal River (A)	Hooker	41.86031	-101.1378
NE	NSH	8047	Niobrara River (B)	Sheridan	42.56239	-102.4673
NE	NSH	350	Niobrara River (C)	Cherry	42.77201	-101.8167
NE	WCB	8136	Battle Creek	Madison	41.98146	-97.61391
NE	WCB	1557	Howe Creek	Knox	42.67111	-97.84782
NE	WCB	1284	Omaha Creek	Dakota	42.28846	-96.49129
NE	WCB	347	Rattlesnake Creek	Richardson	40.06581	-95.8597
NE	WHP	8007	Middle Fork Soldier Creek	Sioux	42.69819	-103.568
NE	WHP	1590	Monroe Creek	Sioux	42.76723	-103.9275
NE	WHP	1596	Ninemile Creek	Scottsbluff	41.88677	-103.4382
NE	WHP	8041	Rush Creek	Garden	41.32129	-102.5944

Kansas
Kansas sites (34) to target for sampling were chosen by Don Huggins at CPCB.

Kansas reference sites suggested for sampling, of which 19 were sampled for this study. IDCPCB site code "new" indicates the site has no data in the USEPA Region 7 database. ER3 = Omernik Level III ecoregion code.

State	ER3	IDCPCB	StreamName	County	LAT	LONG
KS	CGP	1233	North Fork Ninnescah River	Reno	37.90889	-98.18167
KS	CGP	1656	Chikaskia River	Sumner	37.12889	-97.60112
KS	CGP	1597b	North Fork Ninnescah River	Reno	37.9375	-98.2167
KS	CGP	1623	Salt Creek	Russell	38.9485	-98.9207
KS	CIP	1657	Big Creek	Allen	37.7477	-95.2694
KS	CIP	151	Big Creek	Neosho	37.64523	-95.34185
KS	CIP	187	Buck Creek	Jefferson	39.05334	-95.29112
KS	CIP	6031	Marmaton River	Bourbon	37.81459	-94.78086
KS	CIP	1651	Middle Creek	Miami	38.40639	-94.85584
KS	CIP	1652	upper Elm Creek	Miami	38.4331	-94.6847
KS	CIP	33	Verdigris River	Montgomery	37.32572	-95.68717
KS	COT	750	Caney River	Chautauqua	37.00266	-96.3133
KS	COT	1655	Sandy Creek	Woodson	37.7559	-95.8537
KS	COT	new	Upper N. Caney River	Chautauqua	37.1168	-96.0641
KS	FH	1529	Cedar Creek	Chase	38.24536	-96.80683
KS	FH	6018	Illinois Creek	Wabaunsee	38.96889	-96.34028
KS	FH	1563	Cedar Creek	Chautauqua	37.0998	-96.5075
KS	FH	new	Clear Creek	Marshall	39.6098	-96.434
KS	FH	157	Four Mile Creek	Morris	38.6127	-96.47189
KS	FH	1555	Grouse Creek 2	Cowley	37.3306	-96.6744
KS	FH	900a	Kings Creek	Riley	39.1074	-96.6074
KS	FH	900b	McDowell Creek	Geary and Riley	39.11995	-96.61389
KS	FH	1462a	Otter Creek	Greenwood	37.71088	-96.22332
KS	FH	6025	Palmer Creek	Chase	38.49167	-96.58222
KS	ST	1638b	Thompson Creek	Kiowa	37.4551	-99.1173
KS	ST	1595	Nescatunga Creek	Comanche	37.1332	-99.1719
KS	ST	1595	Nescatunga Creek	Comanche	37.12032	-99.1686

State	ER3	IDCPCB	StreamName	County	LAT	LONG
KS	WCB	8	French Creek	Nemaha	39.56652	-96.21751
KS	WCB	905	North Elm Creek	Marshall	39.9917	-96.5572
KS	WCB	1637	Straight Creek	Jackson	39.54472	-95.72964
KS	WHP	new	Rose Creek	Wallace	38.88084	-101.63945
KS	WHP	1618	South Fork Republican River	Cheyenne	39.7669	-101.8247
KS	WHP	1617b	South Fork Republican River	Cheyenne	39.7378	-101.8769
KS	WHP	865	Willow Creek	Wallace	38.92917	-101.91695

Appendix 3. Cover letter and water quality explanation sent to land owners of 13 sites upon completion of this project. Only data analyzed by CPCB labs were sent to the landowners.

The University of Kansas

Kansas Biological Survey

31 July 2008

Dear Landowner,

Thank you for the opportunity to sample a stream on your property for the Central Plains Center for BioAssessment's 2005/2006 reference stream project. Enclosed are the results from the samples that we processed, as well as some general descriptions of each parameter. This table presents the average of the parameters from 48 samples collected for the entire study.

State	# sites	NO3+NO2 ug/L	NO2 ug/L	NH3 ug/L	organic N ug/L	TN ug/L	PO4 ug/L	organic P ug/L	TP ug/L	susp. chla ug/L	susp. pheo ug/L	benthic chla ug/m2	benthic pheo ug/m2
IA	15	3,409	17	38	845	4,292	41	68	108	22	9	37,877	8,281
KS	22	302	12	100	389	790	28	52	83	10	6	15,489	5,181
NE	11	1,364	21	39	247	1,650	109	84	193	3	3	15,110	6,364

State	# sites	Air temp (C)	Water temp (C)	pH	Conductivity (mS/cm)	Turbidity (NTU)	DO (mg/l)	Salinity (%)
IA	15	22.4	22.8	8.28	0.557	25.80	8.53	0.020
KS	22	23.5	22.5	7.95	2.430	48.74	6.47	0.009
NE	11	18.2	15.3	7.96	0.409	61.55	8.69	0.014

Let us know if you have any questions. Again, we thank you for granting permission to work on your property.

Sincerely,

Debbie Baker
Assistant Director
Central Plains Center for BioAssessment
phone: 785-864-1551
fax: 785-864-1537
dbaker@ku.edu
www.cpcb.ku.edu

Higuchi Hall • 2101 Constant Ave., Room 108 • Lawrence, KS 66047-3759
(785) 864-1500 • Fax: (785) 864-1534 • www.kbs.ku.edu

INFORMATION ABOUT WATER QUALITY PARAMETERS

Average values of reference streams by state.

State	# of sites	TN (ug/L)	TP (µg/L)	Chl-*a* susp. (µg/L)	Chl-*a* benthic (µg/m^2)
IA	94	5,220	137	6.0	35,200
KS	53	1,050	95	6.4	25,700
MO	60	930	181	3.0	20,100
NE	47	17,100	214	4.7	57,100

From CPCB's U.S. EPA Region 7 Stream Median Database,
www.cpcb.ku.edu/progwg/html/nutrientwg.htm

The **pH** of a liquid is a measure of the concentration of hydrogen ions, which determines the solubility (amount that can be dissolved in the water) and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.). A pH of 7 is neutral, pH < 7 is acidic (lemon juice = 4), pH > 7 is basic (or alkaline, soap = 10). Rainwater has a pH of 5.6, while the pH of most natural waters is 6.5 to 8.5. Central plains streams tend to be alkaline.

Conductivity measures the presence of charged ions in water, usually metals, but also salts. High conductivities are detected in groundwater and surface waters fed by groundwater.

Turbidity measures the clarity of the water, which in turn is affected by algae, suspended soil particles, and other materials suspended in the water. In agricultural regions suspended soil particles, or sediment, is an extremely important parameter to monitor. Silt, clay, and other organic materials settle to the bottom where they can suffocate newly hatched larvae and fill in spaces between rocks which otherwise would have served as habitat for aquatic organisms.

Dissolved oxygen (DO) is the amount of oxygen gas (O_2) dissolved in water. Sources of DO in streams and rivers include riffle areas and water falls where water comes into contact with oxygen in the atmosphere. In addition, oxygen is released into the water by plants and algae through photosynthesis. Alternatively, bacterial digestion of organic material (dead leaves, decaying organisms, etc.) requires oxygen, thus decreasing DO concentrations if oxygen is used faster than it can be replenished. When DO is low or near zero, a condition known as anoxia, aquatic organisms such as fish and macroinvertebrates suffocate.

Nutrients such as nitrogen and phosphorus influence the productivity of aquatic ecosystems. Total phosphorous (TP) and total nitrogen (TN) indicate the combined dissolved and organic nutrient concentration. Eutrophication, or excessive nutrient enrichment, can produce harmful algal blooms. When these blooms die, they become decaying organic material that is consumed by bacteria along with dissolved oxygen, and may create anoxic conditions. On a large scale, this is what causes dead zones in the Gulf of Mexico and off the coast of Oregon.

Chlorophyll *a* (chl-*a*) is a light-sensitive pigment responsible for photosynthesis in plants and most algae. **Pheophytin *a*** (pheo-*a*) is a breakdown product of chlorophyll *a*. Suspended (susp.) refers to these pigments found in algae floating in the water column. Benthic refers to these pigments found in algae attached to the stream bottom, and is reported in a standard-sized area such as square meters.

Poor water quality can be caused by insufficient containment/mitigation of wastewater run-off from animal feeding operations and other agricultural/urban land-use practices.

Borrowed from various sources including Water on the Web: http://waterontheweb.org 2008 CPCB

Appendix 4. Variables names in the flatfile exported to NCSS for analyses. The flatfile was created from many data tables in the project database. Not all database variables were analyzed.

Variable	Type	Data table	Description
IDCPCB	Char	tbl_sites	CPCB site code
visit	Num	tbl_sites	visit number
ER3	Char	tbl_sites	Omernik Level III Ecoregion code.
StreamName	Char	tbl_sites	Stream Name
State	Char	tbl_sites	State
Date	Date	tbl_horiba	Date sampled
Air temp (C)	Num	tbl_horiba	Taken in situ by thermometer or Horiba U-10 Water Quality Checker. MDL = 0.1 C.
pH	Num	tbl_horiba	Taken in situ by Horiba U-10 Water Quality Checker. MDL = 0.1.
Conductivity (mS/cm)	Num	tbl_horiba	millisiemins per centimeter. Taken in situ by Horiba U-10 Water Quality Checker. MDL = 0.001 mV.
Turbidity (NTU)	Num	tbl_horiba	Nephelometric Turbidity Units. Taken in situ by Horiba U-10 Water Quality Checker. MDL = 1 NTU.
DO (mg/l)	Num	tbl_horiba	Dissolved oxygen. Taken in situ by Horiba U-10 Water Quality Checker. MDL = 0.1 mg/l.
Water temp (C)	Num	tbl_horiba	Taken in situ by Horiba U-10 Water Quality Checker. MDL = 0.1 C.
Salinity (ppt)	Num	tbl_horiba	Taken in situ by Horiba U-10 Water Quality Checker.
horiba_com	Char	tbl_horiba	horiba comments
#vials	Num	tbl_peri5vialavg	# vials collected for periphyton, 4 or 5
AvgChla_ug/m2	Num	tbl_peri5vialavg	average of the chlorophyll a (ug/m2) from 4 or 5 vials of periphtyon
AvgPheo_ug/m2	Num	tbl_peri5vialavg	average of the pheophytin a (ug/m2) from 4 or 5 vials of periphtyon
comp_trans	Num	tbl_pericomposite	# transects comprising composite periphyton sample
comp_chla_ug_m2	Num	tbl_pericomposite	Chlorophyll a (ug/m2) from composite periphyton sample.
comp_pheo_ug_m2	Num	tbl_pericomposite	Pheophytin a (ug/m2) from composite periphyton sample.
comp_com	Num	tbl_pericomposite	composite periphyton sample - comments
NO3+NO2_mg/L	Num	tbl_cpcb chem	NO3+NO2 mg N/L or ppm, signif figure - 2 decimal places (3.09 = 3.09ppm), MDL = 0.01 ppm
NO2_mg/L	Num	tbl_cpcb chem	NO2 mg N/L or ppm, signif figure - 2 decimal places (3.09 = 3.09ppm), MDL = 0.01 ppm
NH3_ug/L	Num	tbl_cpcb chem	NH3 ug N/L or ppb, signif figure - no decimal place (3.09 = 3ppb) MDL = 1 ppb
TN_ mg/L	Num	tbl_cpcb chem	TOTAL nitrogen mg/L or ppm, signif figure - 2 decimal places (3.09 = 3.09ppm) MDL = 0.01 ppm
orgN_mg/L	Num	tbl_cpcb chem	ORGANIC nitrogen mg N/L or ppm, signif figure - 2 decimal places (3.09 = 3.09ppm) MDL = 0.01 ppm
PO4_ug/L	Num	tbl_cpcb chem	PO4 ug P/L or ppb, PO4 ug-P/L, signif figure - no decimal place (3.09 = 3ppb) MDL = 1 ppb
TP_ug/L	Num	tbl_cpcb chem	TOTAL phosphorus ug P/L or ppb, signif figure - no decimal place (3.09 = 3ppb) MDL = 5 ppb
orgP_ug/L	Num	tbl_cpcb chem	ORGANIC phosphorus ug P/L or ppb, signif figure - no decimal place (3.09 = 3ppb) MDL = 5 ppb
chla_ug/L	Num	tbl_cpcb chem	Chlorophyll a ug/L or ppb, water column, signif figure - no decimal place (3.09 = 3ppb) MDL = 1 ppb
chla_remark	Char	tbl_cpcb chem	remark for the water column chlorophyll a
pheo_ug/L	Num	tbl_cpcb chem	Pheophytin a ug/L or ppb water column, signif figure - no decimal place (3.09 = 3ppb) MDL = 1 ppb
pheo_remark	Char	tbl_cpcb chem	remark for the water column phaeophytin a

Variable	Type	Data table	Description
chem_com	Char	tbl_cpcb chem	comments about the water chemistry
IDbuglab	Char	tbl_bugs_metrics	Bug lab database site ID
bugBI	Num	tbl_bugs_metrics	Brillouin's Index
bugFN	Num	tbl_bugs_metrics	Fager's Number of Moves
bugGN	Num	tbl_bugs_metrics	Gleason's Index
bugMI	Num	tbl_bugs_metrics	Margalef's Index
bugMcI	Num	tbl_bugs_metrics	McIntosh's Index
bugMenI	Num	tbl_bugs_metrics	Menhinick's Index
bugRichAbun	Num	tbl_bugs_metrics	Richness / Abundance
bugShan	Num	tbl_bugs_metrics	Shannon's Index (H')
bugSimpCompl	Num	tbl_bugs_metrics	Simpson's Compliment
bugSimpI	Num	tbl_bugs_metrics	Simpson's Index
bugSimpRec	Num	tbl_bugs_metrics	Simpson's Reciprocal
bugStdDev	Num	tbl_bugs_metrics	Standard Deviation
bugRich	Num	tbl_bugs_metrics	Taxa Richness
bugAbun	Num	tbl_bugs_metrics	Total Abundance
bugsens	Num	tbl_bugs_EPTCsens	proportion of all taxa with sensitivity scores that are sensitive (<3.67) from RBP manual
bugEPT	Num	tbl_bugs_EPTCsens	proportion of all taxa that are Ephemeroptera, Plecoptera, or Tricoptera
bugE	Num	tbl_bugs_EPTCsens	proportion of all taxa that are Ephemeroptera
bugP	Num	tbl_bugs_EPTCsens	proportion of all taxa that are Plecoptera
bugT	Num	tbl_bugs_EPTCsens	proportion of all taxa that are Tricoptera
bugC	Num	tbl_bugs_EPTCsens	proportion of all taxa that are Chironomidae
bugdom	Num	tbl_bugs_EPTCsens	proportion of individuals in top 1 taxa, take the number of individuals in the most numerous taxa (tbl event1domfam) and divide by total individuals in the sample (tbl eventsum)
fishBI	Num	tbl_fish_metrics	Brillouin's Index
fishFN	Num	tbl_fish_metrics	Fager's Number of Moves
fishGI	Num	tbl_fish_metrics	Gleason's Index
fishMI	Num	tbl_fish_metrics	Margalef's Index
fishMcI	Num	tbl_fish_metrics	McIntosh's Index
fishMenI	Num	tbl_fish_metrics	Menhinick's Index
fishRichAbun	Num	tbl_fish_metrics	Richness / Abundance
fishShan	Num	tbl_fish_metrics	Shannon's Index (H')
fishSimpCompl	Num	tbl_fish_metrics	Simpson's Compliment
fishSimpInd	Num	tbl_fish_metrics	Simpson's Index
fishSimpRec	Num	tbl_fish_metrics	Simpson's Reciprocal
fishStdDev	Num	tbl_fish_metrics	Standard Deviation
fishRich	Num	tbl_fish_metrics	Taxa Richness
fishAbun	Num	tbl_fish_metrics	Total Abundance
fishsen	Num	tbl_fish_sens	proportion of taxa that were sensitive in this sample of those that had a sensitivity value (CPCBtol in tbl_fish) or NumSensitive/ScoredSensitive
BFWD_RAT	Num	EPA habitat metrics	Mean bankfull width/depth ratio (m/m)
BKA_Q1	Num	EPA habitat metrics	Bank Angle-Lower Quartile (degrees)
BKA_Q3	Num	EPA habitat metrics	Bank Angle-Upper Quartile (degrees)
BKUN_Q1	Num	EPA habitat metrics	Undercut Distance-Lower Quartile (m)
BKUN_Q3	Num	EPA habitat metrics	Undercut Distance-Upper Quartile (m)
BXPBLDG	Num	EPA habitat metrics	building metric
BXPCROP	Num	EPA habitat metrics	crop metric

Variable	Type	Data table	Description
BXPLDFL	Num	EPA habitat metrics	landfill metric
BXPLOG	Num	EPA habitat metrics	logging metric
BXPMINE	Num	EPA habitat metrics	mine metric
BXPPARK	Num	EPA habitat metrics	park metric
BXPPIPE	Num	EPA habitat metrics	pipe metric
BXPPSTR	Num	EPA habitat metrics	pasture metric
BXPPVMT	Num	EPA habitat metrics	pavement metric
BXPROAD	Num	EPA habitat metrics	road metric
BXPWALL	Num	EPA habitat metrics	channel revetment metric
CROWS_D	Num	EPA habitat metrics	Straight line valley length of reach (m)
CXPBLDG	Num	EPA habitat metrics	building metric
CXPCROP	Num	EPA habitat metrics	crop metric
CXPLDFL	Num	EPA habitat metrics	landfill metric
CXPLOG	Num	EPA habitat metrics	logging metric
CXPMINE	Num	EPA habitat metrics	mine metric
CXPPARK	Num	EPA habitat metrics	park metric
CXPPIPE	Num	EPA habitat metrics	pipe metric
CXPPSTR	Num	EPA habitat metrics	pasture metric
CXPPVMT	Num	EPA habitat metrics	pavement metric
CXPROAD	Num	EPA habitat metrics	road metric
CXPWALL	Num	EPA habitat metrics	wall/bank Revet. metric
dfc_ohv	Num	EPA habitat metrics	
dfc_ucb	Num	EPA habitat metrics	
epa_HabitatClass_sidecnt	Num	EPA habitat metrics	
epa_HabitatClass_sidecnt2	Num	EPA habitat metrics	
epa_ThalwegAndChannel_sidecnt	Num	EPA habitat metrics	
epa_ThalwegAndChannel_sidecnt2	Num	EPA habitat metrics	
f_ARCMIN	Num	EPA habitat metrics	
f_ARUDON	Num	EPA habitat metrics	
f_BROTEC	Num	EPA habitat metrics	
f_CARNUT	Num	EPA habitat metrics	
f_CIRARV	Num	EPA habitat metrics	
f_DIPFUL	Num	EPA habitat metrics	
f_ELAANG	Num	EPA habitat metrics	
f_EUPESU	Num	EPA habitat metrics	
f_HEDHEL	Num	EPA habitat metrics	
f_PHAARU	Num	EPA habitat metrics	
f_RUBDIS	Num	EPA habitat metrics	
f_TAMSPP	Num	EPA habitat metrics	
f_XMISSX	Num	EPA habitat metrics	
f_xnontx	Num	EPA habitat metrics	
FISH_D	Num	EPA habitat metrics	Reach Length (m) -- as the fish swims
FXPBLDG	Num	EPA habitat metrics	building metric
FXPCROP	Num	EPA habitat metrics	crop metric
FXPLDFL	Num	EPA habitat metrics	landfill metric
FXPLOG	Num	EPA habitat metrics	logging metric
FXPMINE	Num	EPA habitat metrics	mine metric

Variable	Type	Data table	Description
FXPPARK	Num	EPA habitat metrics	park metric
FXPPIPE	Num	EPA habitat metrics	pipe metric
FXPPSTR	Num	EPA habitat metrics	pasture metric
FXPPVMT	Num	EPA habitat metrics	pavement metric
FXPROAD	Num	EPA habitat metrics	road metric
FXPWALL	Num	EPA habitat metrics	wall/bank revet. metric
idrohv	Num	EPA habitat metrics	
idrucb	Num	EPA habitat metrics	
INTQBKA	Num	EPA habitat metrics	Bank Angle-interquartile range (degrees)
INTQBKUN	Num	EPA habitat metrics	Undercut Distance- interquart range, (m)
ip_score	Num	EPA habitat metrics	
iqrucb	Num	EPA habitat metrics	
LOCMETHOD	Char	EPA habitat metrics	Channel location method (GPS/ANALOG)
ltfracl	Num	EPA habitat metrics	
ltfracm	Num	EPA habitat metrics	
ltfracs	Num	EPA habitat metrics	
ltfracx	Num	EPA habitat metrics	
ltmddist	Num	EPA habitat metrics	
ltmddom	Num	EPA habitat metrics	
ltmddomn	Num	EPA habitat metrics	
ltmdsub	Num	EPA habitat metrics	
ltmdsubn	Num	EPA habitat metrics	
ltmxcnt	Num	EPA habitat metrics	
ltmxdbh	Num	EPA habitat metrics	
ltmxdist	Num	EPA habitat metrics	
ltmxht	Num	EPA habitat metrics	
ltmxsize	Num	EPA habitat metrics	
ltmxspp	Num	EPA habitat metrics	
ltsplist	Num	EPA habitat metrics	
MEDBK_A	Num	EPA habitat metrics	Bank Angle--Median (degrees)
MEDBKUN	Num	EPA habitat metrics	Undercut Distance--Median (m)
N_BA	Num	EPA habitat metrics	Number of observations--Bank Angle
N_BFRAT	Num	EPA habitat metrics	number of nonmissing values, bf_rat
N_BH	Num	EPA habitat metrics	no observations-Bankfull Height
N_BW	Num	EPA habitat metrics	no observations--Bankfull Width
N_D	Num	EPA habitat metrics	Number of obs -- Thalweg Depth
N_INCIS	Num	EPA habitat metrics	no of observations-Chan Incision Ht.(m)
N_UN	Num	EPA habitat metrics	Number of observations--Undercut dist.
N_W	Num	EPA habitat metrics	Number of obs -- Wetted Width
N_WD	Num	EPA habitat metrics	Number of obs -- W*D Product
N_WDR	Num	EPA habitat metrics	Number of obs -- W/D Ratio
N_XTOT	Num	EPA habitat metrics	Number of X/east dists for sinuosity
N_YTOT	Num	EPA habitat metrics	Number of Y/north dists for sinuosity
N33	Num	EPA habitat metrics	number of observations in XEMBED
N55	Num	EPA habitat metrics	number of observations in XCEMBED
NBNK	Num	EPA habitat metrics	Number of Bank Obs-Densiometer
NMID	Num	EPA habitat metrics	Number of Mid-channel Obs-Densiometer
NSLP	Num	EPA habitat metrics	# of values used to calc mean slope
PCT_CA	Num	EPA habitat metrics	Cascade (% of reach)
PCT_DR	Num	EPA habitat metrics	Dry channel (% of reach)

Variable	Type	Data table	Description
PCT_DRS	Num	EPA habitat metrics	Dry Channel or Subsurf Flow (%)
PCT_FA	Num	EPA habitat metrics	Falls (% of reach)
PCT_FAST	Num	EPA habitat metrics	Fast Wtr Hab (% riffle & faster)
PCT_GL	Num	EPA habitat metrics	Glide (% of reach)
PCT_P	Num	EPA habitat metrics	Pool--Type not noted (% of reach)
PCT_PB	Num	EPA habitat metrics	Backwater Pool (% of reach length)
PCT_PD	Num	EPA habitat metrics	Impoundment Pool (% of reach)
PCT_PL	Num	EPA habitat metrics	Lateral Scour Pool (% of reach)
PCT_POOL	Num	EPA habitat metrics	Pools -- All Types (% of reach)
PCT_PP	Num	EPA habitat metrics	Plunge Pool (% of reach)
PCT_PT	Num	EPA habitat metrics	Trench Pool (% of reach)
PCT_RA	Num	EPA habitat metrics	Rapids (% of reach)
PCT_RI	Num	EPA habitat metrics	Riffle (% of reach)
PCT_SIDE	Num	EPA habitat metrics	Side channel presence (% of reach)
PCT_SLOW	Num	EPA habitat metrics	Slow Wtr Hab (% Glide & Pool)
PCT_SUB	Num	EPA habitat metrics	Subsurface Flow (% of reach)
PFC_ALG	Num	EPA habitat metrics	Filamentous Algae Presence (% Rch)
PFC_ALL	Num	EPA habitat metrics	Any Types Fsh Cvr Present (% Rch)
PFC_AQM	Num	EPA habitat metrics	Aq. Macrophytes Presence (% Rch)
PFC_BIG	Num	EPA habitat metrics	LWD,RCK,OHB or HUM Fsh Cvr Pres (% Rch)
PFC_BRS	Num	EPA habitat metrics	Brush & Small Debris Prsnce (% Rch)
PFC_HUM	Num	EPA habitat metrics	Artif. Structs. Presence (% Rch)
PFC_LWD	Num	EPA habitat metrics	LWD Presence (% Rch)
PFC_NAT	Num	EPA habitat metrics	Any Natural Fish Cover Present (% Rch)
PFC_OHV	Num	EPA habitat metrics	Overhang. Veg. Presence (% Rch)
PFC_RCK	Num	EPA habitat metrics	Boulders Presence (% Rch)
PFC_UCB	Num	EPA habitat metrics	Undercut Bank Presence (% Rch)
sdb_hall	Num	EPA habitat metrics	
SDBK_A	Num	EPA habitat metrics	Bank Angle--Std. Dev. (degrees)
SDBKF_H	Num	EPA habitat metrics	Bankfull Height-Std. Dev. (m)
SDBKF_W	Num	EPA habitat metrics	Bankfull Width--Std. Dev. (m)
sdc_hall	Num	EPA habitat metrics	
sdcb_hall	Num	EPA habitat metrics	
SDDEPTH	Num	EPA habitat metrics	Std Dev of Thalweg Depth (cm)
SDINC_H	Num	EPA habitat metrics	Channel Incision Ht.-Std. Dev. (m)
SDUN	Num	EPA habitat metrics	Undercut Distance--Std. Dev. (m)
sdwcb_hall	Num	EPA habitat metrics	
SDWD_RAT	Num	EPA habitat metrics	Std Dev of Width/Depth Ratio (m/m)
SDWIDTH	Num	EPA habitat metrics	Std Dev of Wetted Width (m)
SDWXD	Num	EPA habitat metrics	Std Dev of Width*Depth Product (m2)
sidecnt3	Num	EPA habitat metrics	
SINU	Num	EPA habitat metrics	Channel Sinuosity (m/m)
siqrohv	Num	EPA habitat metrics	
sxfc_alg	Num	EPA habitat metrics	aerial cover algae metric
sxfc_aqm	Num	EPA habitat metrics	aerial cover aquatic macrophyte metric
TOTEAST	Num	EPA habitat metrics	net east-west travel of reach
TOTNORTH	Num	EPA habitat metrics	net north-south travel of reach
TRANSPC	Num	EPA habitat metrics	Mean dist. betw. Transects (m)
VCDENBK	Num	EPA habitat metrics	Std. Dev. Bank Canopy Density (%)
VCDENMID	Num	EPA habitat metrics	Std. Dev. Mid-channel Canopy Density (%)

Variable	Type	Data table	Description
VCEMBED	Num	EPA habitat metrics	SD Embeddedness--Channel only (%)
VEMBED	Num	EPA habitat metrics	SD Embeddedness--Channel+Margin (%)
VSLOPE	Num	EPA habitat metrics	Std Dev of Channel % Slope
W1_HAG	Num	EPA habitat metrics	Rip Dist--Sum Agric Types (ProxWt Pres)
W1_HALL	Num	EPA habitat metrics	Rip Dist--Sum All Types (ProxWt Pres)
W1_HNOAG	Num	EPA habitat metrics	Rip Dist--Sum NonAg Types (ProxWt Pres)
W1H_BLDG	Num	EPA habitat metrics	Rip Dist--Buildings (ProxWt Pres)
W1H_CROP	Num	EPA habitat metrics	Rip Dist--Row Crop (ProxWt Pres)
W1H_LDFL	Num	EPA habitat metrics	Rip Dist--Trash/Landfill (ProxWt Pres)
W1H_LOG	Num	EPA habitat metrics	Rip Dist--Logging Activity (ProxWt Pres)
W1H_MINE	Num	EPA habitat metrics	Rip Dist--Mining Activity (ProxWt Pres)
W1H_PARK	Num	EPA habitat metrics	Rip Dist--Lawn/Park (ProxWt Pres)
W1H_PIPE	Num	EPA habitat metrics	Rip Dist--Pipes infl/effl (ProxWt Pres)
W1H_PSTR	Num	EPA habitat metrics	Rip Dist--Pasture/Hayfield (ProxWt Pres)
W1H_PVMT	Num	EPA habitat metrics	Rip Dist--Pavement (ProxWt Pres)
W1H_ROAD	Num	EPA habitat metrics	Rip Dist--Road/Railroad (ProxWt Pres)
W1H_WALL	Num	EPA habitat metrics	Rip Dist--Wall/Bank Revet. (ProxWt Pres)
X_HAG	Num	EPA habitat metrics	Rip Dist Sum-Ag Types rip Plt & Beyond
X_HALL	Num	EPA habitat metrics	Rip Dist--Sum All Types str plt & beyond
X_HNOAG	Num	EPA habitat metrics	Rip Dist Sum-Non Ag rip Plt & Beyond
XBEARING	Num	EPA habitat metrics	Mean Flow Direction of reach (degrees)
XBKA	Num	EPA habitat metrics	Bank Angle--mean (degrees)
XBKF_H	Num	EPA habitat metrics	Bankfull Height-Mean (m)
XBKF_W	Num	EPA habitat metrics	Bankfull Width--Mean (m)
XC_HAG	Num	EPA habitat metrics	Rip Dist-Sum of Ag Types in Ripar Plot
XC_HALL	Num	EPA habitat metrics	Rip Dist--Sum All Types in Ripar Plots
XC_HNOAG	Num	EPA habitat metrics	Rip Dist Sum-Non Ag Types in Ripar Plot
XCB_HAG	Num	EPA habitat metrics	Rip Dist Sum-Ag Types instrm & on Bank
XCB_HALL	Num	EPA habitat metrics	Rip Dist--Sum All Types instrm & in plot
XCB_HNAG	Num	EPA habitat metrics	Rip Dist Sum-Non Ag Types instrm & Bank
XCDENBK	Num	EPA habitat metrics	Mean Bank Canopy Density (%)
XCDENMID	Num	EPA habitat metrics	Mean Mid-channel Canopy Density (%)
XCEMBED	Num	EPA habitat metrics	Mean Embeddedness--Channel only (%)
XDEPTH	Num	EPA habitat metrics	Thalweg Mean Depth (cm)
XEMBED	Num	EPA habitat metrics	Mean Embeddedness--Channel+Margin (%)
XF_HAG	Num	EPA habitat metrics	Rip Dist Sum-Ag Types Beyond Ripar Plot
XF_HALL	Num	EPA habitat metrics	Rip Dist--Sum All Types beyond Rip Plots
XF_HNOAG	Num	EPA habitat metrics	Rip Dist Sum-Non Ag Types Beyond Rip Plt
XFC_ALL	Num	EPA habitat metrics	Fish Cvr-All Types (Sum Areal Prop)
XFC_BIG	Num	EPA habitat metrics	Fish Cvr-LWD,RCK,UCBorHUM(Sum Area Prop)
XFC_BRS	Num	EPA habitat metrics	Fish Cvr-Brush&Small Debris (Areal Prop)
XFC_HUM	Num	EPA habitat metrics	Fish Cvr-Artif. Structs. (Areal Prop)
XFC_LWD	Num	EPA habitat metrics	Fish Cvr-Large Woody Debris (Areal Prop)
XFC_NAT	Num	EPA habitat metrics	Fish Cvr-Natural Types (Sum Areal Prop)
XFC_OHV	Num	EPA habitat metrics	Fish Cvr-Overhang Veg (Areal Prop)
XFC_RCK	Num	EPA habitat metrics	Fish Cvr-Boulders (Areal Prop)
XFC_UCB	Num	EPA habitat metrics	Fish Cvr-Undercut Banks (Areal Prop)
XINC_H	Num	EPA habitat metrics	Channel Incision Ht.-Mean (m)
XSLOPE	Num	EPA habitat metrics	Channel Slope -- reach mean (%)
XUN	Num	EPA habitat metrics	Undercut Distance--Mean (m)

Variable	Type	Data table	Description
XWD_RAT	Num	EPA habitat metrics	Mean Width/Depth Ratio (m/m)
XWIDTH	Num	EPA habitat metrics	Wetted Width -- Mean (m)
XWXD	Num	EPA habitat metrics	Mean Width*Depth Product (m2)
PCT_BDRK	Num	EPA habitat metrics	Substrate Bedrock (%)
PCT_BIGR	Num	EPA habitat metrics	Substrate >= Coarse Gravel (>16 mm) (%)
PCT_BL	Num	EPA habitat metrics	Substrate Boulders -- 250-4000 mm (%)
PCT_CB	Num	EPA habitat metrics	Substrate Cobbles -- 64-250 mm (%)
PCT_FN	Num	EPA habitat metrics	Substrate Fines -- Silt/Clay/Muck (%)
PCT_GC	Num	EPA habitat metrics	Substrate Coarse Gravel -- 16-64 mm (%)
PCT_GF	Num	EPA habitat metrics	Substrate Fine Gravel -- 39129 mm (%)
PCT_HP	Num	EPA habitat metrics	Substrate Hardpan -- (%)
PCT_OM	Num	EPA habitat metrics	Substrate Organic Detritus -- (%)
PCT_ORG	Num	EPA habitat metrics	Substrate Wood or Detritus -- (%)
PCT_OT	Num	EPA habitat metrics	Substrate Miscellaneous -- (%)
PCT_RC	Num	EPA habitat metrics	Substrate Concrete (%)
PCT_RR	Num	EPA habitat metrics	Substrate Rough Bedrock (%)
PCT_RS	Num	EPA habitat metrics	Substrate Smooth Bedrock (%)
PCT_SA	Num	EPA habitat metrics	Substrate Sand -- .06-2 mm (%)
PCT_SAFN	Num	EPA habitat metrics	Substrate Sand & Fines -- <2 mm (%)
PCT_SB	Num	EPA habitat metrics	Substrate Boulders -- 250-1000 mm (%)
PCT_SFGF	Num	EPA habitat metrics	Substrate <= Fine Gravel (<=16 mm) (%)
PCT_WD	Num	EPA habitat metrics	Substrate Woody -- (%)
PCT_XB	Num	EPA habitat metrics	Substrate Boulders -- 1000-4000 mm (%)

Appendix 5. Descriptive statistics by ecoregion for select instream condition metrics. See Appendix 4 for variable names.

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
XBKF_W	CGP	4	15.89	18.06	9.03	2.96	42.61	--	4.17	34.51
XBKF_W	CIP	9	18.01	10.75	3.58	9.09	44.58	15.02	11.30	20.21
XBKF_W	COT	1	15.93	--	--	15.93	--	--	--	--
XBKF_W	DA	2	7.45	4.95	3.50	3.95	10.95	--	--	--
XBKF_W	FH	5	15.49	5.94	2.66	9.37	21.86	15.82	9.49	21.33
XBKF_W	NSH	3	9.20	6.12	3.54	3.78	15.85	--	--	--
XBKF_W	ST	1	4.65	--	--	4.65	--	--	--	--
XBKF_W	WCB	15	13.84	7.57	1.95	6.84	27.27	11.73	7.41	21.74
XBKF_W	WHP	6	5.37	2.09	0.85	2.69	9.03	5.14	3.97	6.61
xdepth	CGP	4	45.03	30.41	15.21	18.96	88.17	--	21.68	76.91
xdepth	CIP	9	66.13	29.71	9.90	33.76	104.04	48.91	38.81	99.07
xdepth	COT	1	66.08	--	--	66.08	--	--	--	--
xdepth	DA	2	42.19	17.03	12.04	30.15	54.23	--	--	--
xdepth	FH	5	51.25	17.43	7.79	32.49	71.96	52.90	33.68	67.99
xdepth	NSH	3	46.91	3.55	2.05	44.56	50.99	--	--	--
xdepth	ST	1	6.89	--	--	6.89	--	--	--	--
xdepth	WCB	15	44.61	14.40	3.72	17.69	68.75	43.81	31.94	60.15
xdepth	WHP	6	39.55	15.73	6.42	11.85	55.36	43.45	27.23	51.97
xwidth	CGP	4	15.26	18.19	9.09	2.22	42.13	--	3.35	34.07
xwidth	CIP	9	14.89	9.92	3.31	5.60	39.23	12.19	9.21	17.28
xwidth	COT	1	12.48	--	--	12.48	--	--	--	--
xwidth	DA	2	6.01	3.93	2.78	3.24	8.79	--	--	--
xwidth	FH	5	9.65	4.49	2.01	4.66	14.80	10.60	5.01	13.81
xwidth	NSH	3	7.48	4.43	2.56	3.33	12.15	6.97	3.33	12.15
xwidth	ST	1	3.25	--	--	3.25	--	--	--	--
xwidth	WCB	15	11.24	7.66	1.98	2.50	24.23	7.03	5.10	18.89
xwidth	WHP	6	3.71	1.53	0.62	1.42	5.55	3.87	2.32	5.10
sinu	CGP	4	1.39	0.66	0.33	1.02	2.38	--	1.03	2.05
sinu	CIP	9	1.21	0.14	0.05	1.04	1.41	1.20	1.09	1.37
sinu	COT	1	1.09	--	--	1.09	--	--	--	--
sinu	DA	2	1.26	0.08	0.05	1.21	1.31	--	--	--
sinu	FH	5	1.30	0.28	0.13	1.06	1.71	1.13	1.08	1.59
sinu	NSH	3	1.43	0.39	0.22	1.04	1.81	1.43	1.04	1.81
sinu	ST	1	1.07	--	--	1.07	--	--	--	--
sinu	WCB	15	1.33	0.18	0.05	1.05	1.66	1.34	1.19	1.45

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
sinu	WHP	6	1.28	0.43	0.17	1.03	2.12	1.09	1.03	1.55
xslope	CGP	4	0.14	0.06	0.03	0.10	0.24	--	0.10	0.20
xslope	CIP	9	0.73	0.61	0.20	0.10	1.72	0.49	0.18	1.36
xslope	COT	1	2.07	--	--	2.07	--	--	--	--
xslope	DA	2	1.11	0.04	0.03	1.08	1.13	--	--	--
xslope	FH	5	0.26	0.22	0.10	0.11	0.63	0.14	0.11	0.46
xslope	NSH	3	0.16	0.10	0.06	0.10	0.27	0.10	0.10	0.27
xslope	ST	1	0.10	--	--	0.10	--	--	--	--
xslope	WCB	15	0.58	0.42	0.11	0.09	1.60	0.51	0.24	0.66
xslope	WHP	6	0.36	0.37	0.15	0.10	1.05	0.22	0.10	0.60
xembed	CGP	4	93.39	6.16	3.08	85.82	100.00	--	87.20	99.09
xembed	CIP	9	56.60	22.96	7.65	32.91	100.00	50.95	33.64	72.18
xembed	COT	1	59.82	--	--	59.82	--	--	--	--
xembed	DA	2	47.82	5.66	4.00	43.82	51.82	--	--	--
xembed	FH	5	39.40	9.75	4.36	31.80	56.25	36.64	32.85	47.34
xembed	NSH	3	100.00	0.00	0.00	100.00	100.00	--	--	--
xembed	ST	1	100.00	--	--	100.00	--	--	--	--
xembed	WCB	15	80.21	11.04	2.85	60.50	100.00	80.39	72.73	85.64
xembed	WHP	6	85.05	20.24	8.26	52.59	100.00	95.00	63.94	100.00
bfwd_rat	CGP	4	21.26	25.26	12.63	4.98	58.55	--	5.33	47.69
bfwd_rat	CIP	9	16.01	6.20	2.07	7.98	29.20	14.92	11.68	18.82
bfwd_rat	COT	1	15.21	--	--	15.21	--	--	--	--
bfwd_rat	DA	2	10.60	4.99	3.53	7.07	14.13	--	--	--
bfwd_rat	FH	5	13.09	2.59	1.16	8.87	15.35	13.95	10.70	15.05
bfwd_rat	NSH	3	10.56	6.19	3.57	4.96	17.20	--	--	--
bfwd_rat	ST	1	12.12	--	--	12.12	--	--	--	--
bfwd_rat	WCB	15	14.63	8.42	2.17	4.67	31.53	10.79	7.99	21.50
bfwd_rat	WHP	6	6.93	2.25	0.92	5.45	11.43	6.21	5.62	7.80
pfc_lwd	CGP	4	0.23	0.16	0.08	0.00	0.36	--	0.07	0.34
pfc_lwd	CIP	9	0.31	0.18	0.06	0.00	0.55	0.33	0.18	0.45
pfc_lwd	COT	1	0.64	--	--	0.64	--	--	--	--
pfc_lwd	DA	2	0.23	0.06	0.05	0.18	0.27	--	--	--
pfc_lwd	FH	5	0.41	0.26	0.12	0.00	0.69	0.45	0.18	0.62
pfc_lwd	NSH	3	0.06	0.05	0.03	0.00	0.09	--	--	--
pfc_lwd	ST	1	0.00	--	--	0.00	--	--	--	--
pfc_lwd	WCB	15	0.17	0.16	0.04	0.00	0.45	0.09	0.00	0.27

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
pfc_lwd	WHP	6	0.21	0.24	0.10	0.00	0.64	0.18	0.00	0.36
pfc_all	CGP	4	0.98	0.05	0.02	0.91	1.00	--	0.93	1.00
pfc_all	CIP	9	0.97	0.06	0.02	0.82	1.00	1.00	0.95	1.00
pfc_all	COT	1	1.00	--	--	1.00	--	--	--	--
pfc_all	DA	2	1.00	0.00	0.00	1.00	1.00	--	--	--
pfc_all	FH	5	0.98	0.04	0.02	0.91	1.00	1.00	0.95	1.00
pfc_all	NSH	3	1.00	0.00	0.00	1.00	1.00	--	--	--
pfc_all	ST	1	1.00	--	--	1.00	--	--	--	--
pfc_all	WCB	15	0.98	0.07	0.02	0.73	1.00	1.00	1.00	1.00
pfc_all	WHP	6	0.98	0.04	0.02	0.91	1.00	1.00	0.98	1.00
PCT_CB	CGP	4	0.00	0.00	0.00	0.00	0.00	--	0.00	0.00
PCT_CB	CIP	9	23.31	14.78	4.93	0.00	44.76	28.57	10.95	35.24
PCT_CB	COT	1	29.52	--	--	29.52	--	--	--	--
PCT_CB	DA	2	22.38	8.75	6.19	16.19	28.57	--	--	--
PCT_CB	FH	5	25.36	19.19	8.58	3.81	51.92	30.39	6.74	41.46
PCT_CB	NSH	3	0.00	0.00	0.00	0.00	0.00	--	--	--
PCT_CB	ST	1	0.00	--	--	0.00	--	--	--	--
PCT_CB	WCB	15	16.98	14.18	3.66	0.00	39.05	14.55	0.00	31.43
PCT_CB	WHP	6	10.24	23.22	9.48	0.00	57.58	0.50	0.00	16.54
PCT_SA	CGP	4	11.19	22.38	11.19	0.00	44.76	--	0.00	33.57
PCT_SA	CIP	9	5.50	11.08	3.69	0.00	32.38	0.95	0.00	7.62
PCT_SA	COT	1	0.95	--	--	0.95	--	--	--	--
PCT_SA	DA	2	0.00	0.00	0.00	0.00	0.00	--	--	--
PCT_SA	FH	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PCT_SA	NSH	3	100.00	0.00	0.00	100.00	100.00	--	--	--
PCT_SA	ST	1	100.00	--	--	100.00	--	--	--	--
PCT_SA	WCB	15	17.82	17.97	4.64	0.00	51.20	11.00	2.86	37.14
PCT_SA	WHP	6	9.61	18.88	7.71	0.00	47.62	1.01	0.00	17.90
pct_RI	CGP	4	1.08	0.83	0.42	0.00	2.00	--	0.25	1.83
pct_RI	CIP	9	7.11	5.40	1.80	0.00	13.00	10.00	0.50	11.50
pct_RI	COT	1	8.00	--	--	8.00	--	--	--	--
pct_RI	DA	2	24.00	14.14	10.00	14.00	34.00	--	--	--
pct_RI	FH	5	11.13	12.95	5.79	0.00	33.00	6.00	2.33	22.50
pct_RI	NSH	3	0.00	0.00	0.00	0.00	0.00	--	--	--
pct_RI	ST	1	0.00	--	--	0.00	--	--	--	--
pct_RI	WCB	15	8.52	9.22	2.38	0.00	36.00	7.00	1.33	11.00

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
pct_RI	WHP	6	14.01	21.44	8.75	0.00	53.00	2.86	0.00	32.25
pct_P	CGP	4	0.00	0.00	0.00	0.00	0.00	--	0.00	0.00
pct_P	CIP	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
pct_P	COT	1	0.00	--	--	0.00	--	--	--	--
pct_P	DA	2	0.00	0.00	0.00	0.00	0.00	--	--	--
pct_P	FH	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
pct_P	NSH	3	0.00	0.00	0.00	0.00	0.00	--	--	--
pct_P	ST	1	0.00	--	--	0.00	--	--	--	--
pct_P	WCB	15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
pct_P	WHP	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
pct_pool	CGP	4	0.00	0.00	0.00	0.00	0.00	--	0.00	0.00
pct_pool	CIP	9	1.33	4.00	1.33	0.00	12.00	0.00	0.00	0.00
pct_pool	COT	1	0.00	--	--	0.00	--	--	--	--
pct_pool	DA	2	7.50	7.78	5.50	2.00	--	--	--	13.00
pct_pool	FH	5	1.07	2.39	1.07	0.00	5.33	0.00	0.00	2.67
pct_pool	NSH	3	0.00	0.00	0.00	0.00	0.00	--	--	--
pct_pool	ST	1	0.00	--	--	0.00	--	--	--	--
pct_pool	WCB	15	7.13	15.19	3.92	0.00	56.00	0.00	0.00	10.00
pct_pool	WHP	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
XINC_H	CGP	4	1.43	0.65	0.32	0.83	2.28	--	0.88	2.10
XINC_H	CIP	9	2.56	0.91	0.30	0.97	3.93	2.82	1.83	3.17
XINC_H	COT	1	2.32	--	--	2.32	--	--	--	--
XINC_H	DA	2	1.10	0.61	0.43	0.67	--	--	--	1.54
XINC_H	FH	5	2.60	0.78	0.35	1.59	3.63	2.42	1.93	3.35
XINC_H	NSH	3	0.77	0.19	0.11	0.57	0.95	--	--	--
XINC_H	ST	1	0.94	--	--	0.94	--	--	--	--
XINC_H	WCB	15	2.54	2.11	0.55	0.75	8.00	1.91	1.21	2.85
XINC_H	WHP	6	1.00	0.26	0.11	0.58	1.34	1.06	0.78	1.19

Appendix 6. Descriptive statistics by ecoregion for select *in situ*, nutrient, and chlorophyll water quality parameters. See Appendix 4 for variable names.

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
pH	CGP	4	7.95	1.13	0.57	6.26	8.72	--	6.79	8.65
pH	CIP	9	7.92	0.26	0.09	7.60	8.34	7.80	7.73	8.18
pH	COT	1	8.15	--	--	8.15	--	--	--	--
pH	DA	2	8.26	0.03	0.02	8.24	8.28	--	--	--
pH	FH	5	8.04	0.25	0.11	7.71	8.34	8.13	7.79	8.26
pH	NSH	3	8.04	0.64	0.37	7.39	8.66	--	--	--
pH	ST	1	8.10	--	--	8.10	--	--	--	--
pH	WCB	17	8.17	0.36	0.09	7.28	8.69	8.23	7.99	8.41
pH	WHP	6	7.92	0.16	0.07	7.75	8.15	7.89	7.77	8.10
Conductivity__mS_cm_	CGP	4	10.95	20.50	10.25	0.44	41.70	--	0.45	31.57
Conductivity__mS_cm_	CIP	9	0.47	0.09	0.03	0.29	0.55	0.51	0.38	0.54
Conductivity__mS_cm_	COT	1	0.23	--	--	0.23	--	--	--	--
Conductivity__mS_cm_	DA	2	0.54	0.05	0.03	0.51	0.58	--	--	--
Conductivity__mS_cm_	FH	5	0.60	0.15	0.07	0.43	0.83	0.55	0.48	0.75
Conductivity__mS_cm_	NSH	3	0.17	0.13	0.07	0.08	0.31	--	0.08	0.31
Conductivity__mS_cm_	ST	1	0.89	--	--	0.89	--	--	--	--
Conductivity__mS_cm_	WCB	17	0.58	0.11	0.03	0.42	0.73	0.53	0.48	0.71
Conductivity__mS_cm_	WHP	6	0.46	0.22	0.09	0.26	0.74	0.38	0.28	0.74
Turbidity__NTU_	CGP	4	118.00	71.64	35.82	23.00	197.00	--	48.50	179.50
Turbidity__NTU_	CIP	9	25.33	17.94	5.98	5.00	60.00	25.00	10.00	38.00
Turbidity__NTU_	COT	1	26.00	--	--	26.00	--	--	--	--
Turbidity__NTU_	DA	2	4.50	3.54	2.50	2.00	7.00	--	--	--
Turbidity__NTU_	FH	2	18.00	16.97	12.00	6.00	30.00	--	--	--
Turbidity__NTU_	NSH	3	14.00	9.85	5.69	3.00	22.00	--	--	--
Turbidity__NTU_	ST	1	19.00	--	--	19.00	--	--	--	--
Turbidity__NTU_	WCB	17	60.18	70.87	17.19	3.00	275.00	35.00	12.50	73.00
Turbidity__NTU_	WHP	6	22.50	22.37	9.13	5.00	61.00	12.50	5.75	43.75
DO__mg_l_	CGP	3	7.43	3.26	1.88	3.79	10.08	--	--	--
DO__mg_l_	CIP	9	6.58	2.13	0.71	2.28	9.32	6.62	5.53	8.22
DO__mg_l_	COT	1	5.01	--	--	5.01	--	--	--	--
DO__mg_l_	DA	2	11.16	2.13	1.51	9.65	12.66	--	--	--
DO__mg_l_	FH	5	7.05	1.33	0.60	5.01	8.67	7.16	5.93	8.11
DO__mg_l_	NSH	1	8.71	--	--	8.71	--	--	--	--
DO__mg_l_	ST	1	7.63	--	--	7.63	--	--	--	--

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
DO__mg_l_	WCB	16	7.86	2.33	0.58	3.56	12.50	7.94	5.90	9.46
DO__mg_l_	WHP	6	7.49	2.25	0.92	4.28	9.61	8.20	4.96	9.50
AvgChla_ug_m2	CGP	4	11506.26	5367.46	2683.73	5133.65	17686.12	--	6263.25	16652.89
AvgChla_ug_m2	CIP	9	14314.44	13554.32	4518.11	4554.37	48659.79	11473.80	6308.20	15969.57
AvgChla_ug_m2	COT	1	4258.73	--	--	4258.73	--	--	--	--
AvgChla_ug_m2	DA	2	81312.72	60076.88	42480.77	38831.95	123793.50	--	--	--
AvgChla_ug_m2	FH	5	12935.46	7611.46	3403.95	4802.06	21919.54	10938.47	5988.59	20880.83
AvgChla_ug_m2	NSH	3	29804.90	23575.27	13611.19	11511.09	56410.20	--	--	--
AvgChla_ug_m2	ST	1	19655.68	--	--	19655.68	--	--	--	--
AvgChla_ug_m2	WCB	17	26778.63	27963.14	6782.06	2556.84	103631.80	17232.01	6646.44	41260.95
AvgChla_ug_m2	WHP	6	17401.36	10849.78	4429.41	3944.45	29957.60	16752.61	7031.63	29194.54
AvgPheo_ug_m2	CGP	4	4032.64	651.64	325.82	3460.04	4913.00	--	3502.56	4716.60
AvgPheo_ug_m2	CIP	9	4829.62	4311.75	1437.25	1144.26	14528.69	3234.53	1730.97	6974.65
AvgPheo_ug_m2	COT	1	4274.63	--	--	4274.63	--	--	--	--
AvgPheo_ug_m2	DA	2	14276.87	290.59	205.48	14071.39	14482.35	--	--	--
AvgPheo_ug_m2	FH	5	3971.05	1349.37	603.46	2243.62	5572.31	3609.69	2798.27	5324.52
AvgPheo_ug_m2	NSH	3	12081.93	8966.31	5176.70	5567.30	22308.06	--	--	--
AvgPheo_ug_m2	ST	1	8983.28	--	--	8983.28	--	--	--	--
AvgPheo_ug_m2	WCB	17	6822.49	4422.68	1072.66	779.52	14832.05	5856.42	2572.00	10881.61
AvgPheo_ug_m2	WHP	6	5781.52	2785.25	1137.07	2860.46	9137.60	5213.95	3206.60	8990.30
comp_chla_ug_m2	CGP	4	7517.97	2273.52	1136.76	5665.72	10750.33	--	5810.99	9915.01
comp_chla_ug_m2	CIP	9	9064.37	7580.69	2526.90	1853.71	27117.96	6991.35	4285.61	11113.52
comp_chla_ug_m2	COT	1	1888.57	--	--	1888.57	--	--	--	--
comp_chla_ug_m2	DA	2	67794.91	58210.71	41161.19	26633.71	108956.10	--	--	--
comp_chla_ug_m2	FH	5	11873.79	8615.65	3853.04	6537.37	27117.96	9007.04	6827.92	18353.05
comp_chla_ug_m2	NSH	3	21984.92	19719.59	11385.11	4939.34	43582.44	--	--	--
comp_chla_ug_m2	ST	1	5520.44	--	--	5520.44	--	--	--	--
comp_chla_ug_m2	WCB	17	17761.57	19551.27	4741.88	1445.83	79901.13	10653.48	5302.53	24212.46
comp_chla_ug_m2	WHP	6	9551.01	4065.11	1659.58	5229.89	15689.68	8619.64	5861.84	13728.47
comp_pheo_ug_m2	CGP	4	2238.69	405.93	202.97	1706.98	2665.79	--	1825.74	2599.33
comp_pheo_ug_m2	CIP	9	3636.12	3090.90	1030.30	737.09	10353.25	2960.70	1067.23	5503.01
comp_pheo_ug_m2	COT	1	3520.01	--	--	3520.01	--	--	--	--
comp_pheo_ug_m2	DA	2	9445.28	2468.82	1745.72	7699.56	11191.00	--	--	--
comp_pheo_ug_m2	FH	5	3425.77	1106.28	494.74	2234.33	5050.72	3486.60	2408.66	4412.48
comp_pheo_ug_m2	NSH	3	11032.17	8035.43	4639.26	4625.55	20047.92	--	--	--
comp_pheo_ug_m2	ST	1	3281.76	--	--	3281.76	--	--	--	--

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
comp_pheo_ug_m2	WCB	17	4147.41	2342.33	568.10	542.80	7999.80	4813.44	1818.84	6033.50
comp_pheo_ug_m2	WHP	6	4221.03	2641.47	1078.38	2524.88	9549.40	3275.06	2862.64	5182.29
NO3_NO2_mg_L	CGP	4	1.09	1.46	0.73	0.01	3.19	--	0.05	2.64
NO3_NO2_mg_L	CIP	9	0.27	0.28	0.09	0.05	0.78	0.12	0.09	0.49
NO3_NO2_mg_L	COT	1	0.11	--	--	0.11	--	--	--	--
NO3_NO2_mg_L	DA	2	3.36	2.66	1.88	1.48	5.24	--	--	--
NO3_NO2_mg_L	FH	5	0.19	0.13	0.06	0.03	0.34	0.15	0.08	0.33
NO3_NO2_mg_L	NSH	3	0.36	0.26	0.15	0.09	0.60	--	--	--
NO3_NO2_mg_L	ST	1	0.04	--	--	0.04	--	--	--	--
NO3_NO2_mg_L	WCB	17	3.00	3.21	0.78	0.03	11.60	1.99	0.26	4.79
NO3_NO2_mg_L	WHP	6	1.00	1.11	0.45	0.05	3.11	0.81	0.13	1.56
NO2_mg_L	CGP	4	0.02	0.02	0.01	0.00	0.04	--	0.00	0.04
NO2_mg_L	CIP	9	0.01	0.01	0.00	0.00	0.02	0.01	0.01	0.01
NO2_mg_L	COT	1	0.00	--	--	0.00	--	--	--	--
NO2_mg_L	DA	2	0.02	0.01	0.01	0.01	0.03	--	--	--
NO2_mg_L	FH	5	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01
NO2_mg_L	NSH	3	0.01	0.01	0.00	0.00	0.01	--	--	--
NO2_mg_L	ST	1	0.01	--	--	0.01	--	--	--	--
NO2_mg_L	WCB	17	0.03	0.04	0.01	0.00	0.13	0.01	0.00	0.04
NO2_mg_L	WHP	6	0.01	0.01	0.00	0.00	0.02	0.01	0.01	0.01
NH3_ug_L	CGP	4	153.15	189.84	94.92	28.60	436.00	--	38.50	346.95
NH3_ug_L	CIP	9	72.24	48.97	16.32	6.71	168.00	53.90	35.77	104.00
NH3_ug_L	COT	1	54.70	--	--	54.70	--	--	--	--
NH3_ug_L	DA	2	50.00	50.91	36.00	14.00	86.00	--	--	--
NH3_ug_L	FH	5	64.03	53.20	23.79	5.73	136.00	71.70	12.02	112.20
NH3_ug_L	NSH	3	16.10	2.86	1.65	12.80	17.90	--	--	--
NH3_ug_L	ST	1	7.07	--	--	7.07	--	--	--	--
NH3_ug_L	WCB	17	70.73	100.33	24.33	14.00	437.00	43.25	30.43	59.95
NH3_ug_L	WHP	6	32.53	26.66	10.88	11.30	83.30	25.50	13.25	47.60
TN__mg_L	CGP	4	2.04	1.18	0.59	0.45	3.30	--	0.89	3.03
TN__mg_L	CIP	9	0.72	0.19	0.06	0.50	1.06	0.65	0.62	0.86
TN__mg_L	COT	1	0.58	--	--	0.58	--	--	--	--
TN__mg_L	DA	2	4.87	4.23	2.99	1.88	7.87	--	--	--
TN__mg_L	FH	5	0.38	0.18	0.08	0.18	0.67	0.36	0.25	0.53
TN__mg_L	NSH	3	0.52	0.21	0.12	0.30	0.71	--	--	--
TN__mg_L	ST	1	0.24	--	--	0.24	--	--	--	--

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
TN__mg_L	WCB	17	3.74	3.34	0.81	0.34	13.00	2.59	1.03	5.55
TN__mg_L	WHP	6	1.27	1.16	0.47	0.32	3.47	1.04	0.42	1.87
PO4_ug_L	CGP	3	36.56	28.75	16.60	6.09	63.20	--	--	--
PO4_ug_L	CIP	9	19.35	12.20	4.07	8.48	47.70	16.20	10.90	24.65
PO4_ug_L	COT	1	10.80	--	--	10.80	--	--	--	--
PO4_ug_L	DA	2	63.30	58.97	41.70	21.60	105.00	--	--	--
PO4_ug_L	FH	5	12.25	9.31	4.17	4.19	26.20	7.80	4.98	21.75
PO4_ug_L	NSH	3	145.87	130.61	75.41	43.60	293.00	--	--	--
PO4_ug_L	ST	1	7.31	--	--	7.31	--	--	--	--
PO4_ug_L	WCB	17	76.92	73.49	17.82	12.40	261.00	43.50	17.70	115.00
PO4_ug_L	WHP	6	26.52	10.42	4.25	14.20	40.80	26.75	15.33	36.38
TP_ug_L	CGP	4	156.25	79.55	39.78	87.00	268.00	--	94.00	239.75
TP_ug_L	CIP	9	64.70	20.77	6.92	40.90	106.00	60.50	50.20	80.20
TP_ug_L	COT	1	47.60	--	--	47.60	--	--	--	--
TP_ug_L	DA	2	125.50	113.84	80.50	45.00	206.00	--	--	--
TP_ug_L	FH	5	30.14	16.85	7.53	12.20	48.10	30.90	13.15	46.75
TP_ug_L	NSH	3	223.33	140.16	80.92	76.00	355.00	--	--	--
TP_ug_L	ST	1	22.10	--	--	22.10	--	--	--	--
TP_ug_L	WCB	17	169.52	127.82	31.00	30.90	510.00	136.00	85.70	244.00
TP_ug_L	WHP	6	57.55	10.70	4.37	46.40	71.50	57.30	47.23	66.85
chla_ug_L	CGP	4	30.72	40.89	20.44	1.12	88.40	--	1.40	74.09
chla_ug_L	CIP	9	9.00	7.29	2.43	2.80	21.67	4.61	3.11	15.88
chla_ug_L	COT	1	4.98	--	--	4.98	--	--	--	--
chla_ug_L	DA	2	7.53	3.61	2.55	4.98	10.09	--	--	--
chla_ug_L	FH	4	5.63	5.87	2.93	1.37	14.19	--	1.62	11.80
chla_ug_L	NSH	3	2.66	1.12	0.65	1.49	3.74	--	--	--
chla_ug_L	ST	1	1.99	--	--	1.99	--	--	--	--
chla_ug_L	WCB	16	17.31	25.77	6.44	1.12	76.58	4.17	2.21	23.39
chla_ug_L	WHP	4	2.09	1.25	0.63	1.00	3.86	--	1.12	3.39
pheo_ug_L	CGP	4	15.38	15.05	7.53	1.61	28.86	--	1.99	28.63
pheo_ug_L	CIP	8	4.27	1.78	0.63	1.70	7.19	4.12	2.96	5.71
pheo_ug_L	COT	1	4.56	--	--	4.56	--	--	--	--
pheo_ug_L	DA	2	16.83	20.17	14.26	2.56	31.09	--	--	--
pheo_ug_L	FH	4	2.22	1.39	0.69	1.13	4.08	--	1.14	3.68
pheo_ug_L	NSH	3	2.80	0.72	0.42	2.32	3.63	--	--	--
pheo_ug_L	ST	1	1.92	--	--	1.92	--	--	--	--

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
pheo_ug_L	WCB	14	7.09	9.76	2.61	1.21	39.82	4.89	2.50	6.76
pheo_ug_L	WHP	5	2.18	1.42	0.64	0.98	4.59	1.91	1.15	3.35

Appendix 7. Descriptive statistics by ecoregion for select metal and herbicide water quality parameters. See Appendix 4 for variable names.

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
Mercury_Dissolved_ugPerL	CGP	4	0.20	0.00	0.00	0.20	0.20	--	0.20	0.20
Mercury_Dissolved_ugPerL	CIP	9	5.23	15.10	5.03	0.20	45.50	0.20	0.20	0.20
Mercury_Dissolved_ugPerL	COT	1	0.20	--	--	0.20	--	--	--	--
Mercury_Dissolved_ugPerL	DA	2	0.20	0.00	0.00	0.20	0.20	--	--	--
Mercury_Dissolved_ugPerL	FH	5	0.20	0.00	0.00	0.20	0.20	0.20	0.20	0.20
Mercury_Dissolved_ugPerL	NSH	3	0.20	0.00	0.00	0.20	0.20	--	--	--
Mercury_Dissolved_ugPerL	ST	1	0.20	--	--	0.20	--	--	--	--
Mercury_Dissolved_ugPerL	WCB	17	2.31	8.68	2.11	0.20	36.00	0.20	0.20	0.20
Mercury_Dissolved_ugPerL	WHP	6	0.20	0.00	0.00	0.20	0.20	0.20	0.20	0.20
Mercury_mgPerKg	CGP	4	0.01	0.00	0.00	0.01	0.01	--	0.01	0.01
Mercury_mgPerKg	CIP	9	0.04	0.04	0.01	0.00	0.10	0.02	0.01	0.07
Mercury_mgPerKg	COT	1	0.02	--	--	0.02	--	--	--	--
Mercury_mgPerKg	DA	2	0.01	0.00	0.00	0.01	0.02	--	--	--
Mercury_mgPerKg	FH	5	0.03	0.02	0.01	0.01	0.05	0.02	0.01	0.04
Mercury_mgPerKg	NSH	3	0.01	0.00	0.00	0.01	0.01	--	--	--
Mercury_mgPerKg	ST	1	0.01	--	--	0.01	--	--	--	--
Mercury_mgPerKg	WCB	17	0.01	0.01	0.00	0.00	0.04	0.01	0.01	0.02
Mercury_mgPerKg	WHP	6	0.01	0.01	0.00	0.01	0.03	0.01	0.01	0.01
Mercury_Total_ugPerL	CGP	4	0.20	0.00	0.00	0.20	0.20	--	0.20	0.20
Mercury_Total_ugPerL	CIP	9	3.16	8.87	2.96	0.20	26.80	0.20	0.20	0.20
Mercury_Total_ugPerL	COT	1	0.20	--	--	0.20	--	--	--	--
Mercury_Total_ugPerL	DA	2	0.20	0.00	0.00	0.20	0.20	--	--	--
Mercury_Total_ugPerL	FH	5	0.20	0.00	0.00	0.20	0.20	0.20	0.20	0.20
Mercury_Total_ugPerL	NSH	3	0.20	0.00	0.00	0.20	0.20	--	--	--
Mercury_Total_ugPerL	ST	1	0.20	--	--	0.20	--	--	--	--
Mercury_Total_ugPerL	WCB	17	1.92	7.08	1.72	0.20	29.40	0.20	0.20	0.20
Mercury_Total_ugPerL	WHP	6	0.20	0.00	0.00	0.20	0.20	0.20	0.20	0.20
Atrazine_ugPerKg	CGP	4	738.00	1188.04	594.02	132.00	2520.00	--	135.00	1929.00
Atrazine_ugPerKg	CIP	8	195.25	94.37	33.36	94.00	336.00	156.00	114.00	303.00
Atrazine_ugPerKg	COT	1	144.00	--	--	144.00	--	--	--	--
Atrazine_ugPerKg	DA	2	120.00	14.14	10.00	110.00	130.00	--	--	--
Atrazine_ugPerKg	FH	5	177.60	17.80	7.96	156.00	204.00	180.00	162.00	192.00
Atrazine_ugPerKg	NSH	3	140.00	6.93	4.00	132.00	144.00	--	--	--
Atrazine_ugPerKg	ST	1	144.00	--	--	144.00	--	--	--	--

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
Atrazine_ugPerKg	WCB	14	134.00	49.83	13.32	90.00	276.00	115.00	99.75	153.00
Atrazine_ugPerKg	WHP	6	170.00	17.66	7.21	144.00	192.00	174.00	153.00	183.00
Atrazine_ugPerL	CGP	4	3.00	0.00	0.00	3.00	3.00	--	3.00	3.00
Atrazine_ugPerL	CIP	9	3.33	0.50	0.17	3.00	4.00	3.00	3.00	4.00
Atrazine_ugPerL	COT	1	3.00	--	--	3.00	--	--	--	--
Atrazine_ugPerL	DA	2	4.00	0.00	0.00	4.00	4.00	--	--	--
Atrazine_ugPerL	FH	5	3.20	0.45	0.20	3.00	4.00	3.00	3.00	3.50
Atrazine_ugPerL	NSH	3	3.33	0.58	0.33	3.00	4.00	--	--	--
Atrazine_ugPerL	ST	1	3.00	--	--	3.00	--	--	--	--
Atrazine_ugPerL	WCB	17	5.41	6.08	1.48	3.00	29.00	4.00	4.00	4.00
Atrazine_ugPerL	WHP	6	3.33	0.52	0.21	3.00	4.00	3.00	3.00	4.00
Alachlor_ugPerKg	CGP	4	36.90	59.40	29.70	6.60	126.00	--	6.75	96.45
Alachlor_ugPerKg	CIP	9	8.81	5.15	1.72	3.50	16.80	7.80	3.70	14.10
Alachlor_ugPerKg	COT	1	7.20	--	--	7.20	--	--	--	--
Alachlor_ugPerKg	DA	2	4.60	0.57	0.40	4.20	5.00	--	--	--
Alachlor_ugPerKg	FH	5	8.88	0.89	0.40	7.80	10.20	9.00	8.10	9.60
Alachlor_ugPerKg	NSH	3	7.00	0.35	0.20	6.60	7.20	--	--	--
Alachlor_ugPerKg	ST	1	7.20	--	--	7.20	--	--	--	--
Alachlor_ugPerKg	WCB	17	5.44	2.84	0.69	3.40	13.80	4.10	3.70	6.90
Alachlor_ugPerKg	WHP	6	8.50	0.88	0.36	7.20	9.60	8.70	7.65	9.15
Alachlor_ugPerL	CGP	4	0.20	0.00	0.00	0.20	0.20	--	0.20	0.20
Alachlor_ugPerL	CIP	9	0.20	0.00	0.00	0.20	0.20	0.20	0.20	0.20
Alachlor_ugPerL	COT	1	0.20	--	--	0.20	--	--	--	--
Alachlor_ugPerL	DA	2	0.20	0.00	0.00	0.20	0.20	--	--	--
Alachlor_ugPerL	FH	5	0.20	0.00	0.00	0.20	0.20	0.20	0.20	0.20
Alachlor_ugPerL	NSH	3	0.20	0.00	0.00	0.20	0.20	--	--	--
Alachlor_ugPerL	ST	1	0.20	--	--	0.20	--	--	--	--
Alachlor_ugPerL	WCB	17	0.20	0.00	0.00	0.20	0.20	0.20	0.20	0.20
Alachlor_ugPerL	WHP	6	0.20	0.00	0.00	0.20	0.20	0.20	0.20	0.20
p_p__DDE_ugPerKg	CGP	4	12.30	19.80	9.90	2.20	42.00	--	2.25	32.15
p_p__DDE_ugPerKg	CIP	9	2.93	1.72	0.57	1.20	5.60	2.60	1.20	4.70
p_p__DDE_ugPerKg	COT	1	2.40	--	--	2.40	--	--	--	--
p_p__DDE_ugPerKg	DA	2	1.55	0.21	0.15	1.40	1.70	--	--	--
p_p__DDE_ugPerKg	FH	5	2.96	0.30	0.13	2.60	3.40	3.00	2.70	3.20
p_p__DDE_ugPerKg	NSH	3	2.33	0.12	0.07	2.20	2.40	2.40	2.20	2.40
p_p__DDE_ugPerKg	ST	1	2.40	--	--	2.40	--	--	--	--

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
p_p__DDE_ugPerKg	WCB	17	1.82	0.95	0.23	1.10	4.60	1.40	1.20	2.30
p_p__DDE_ugPerKg	WHP	6	2.83	0.29	0.12	2.40	3.20	2.90	2.55	3.05
Diazinon_ugPerL	CGP	4	0.40	0.00	0.00	0.40	0.40	--	0.40	0.40
Diazinon_ugPerL	CIP	9	0.40	0.00	0.00	0.40	0.40	0.40	0.40	0.40
Diazinon_ugPerL	COT	1	0.40	--	--	0.40	--	--	--	--
Diazinon_ugPerL	DA	2	0.40	0.00	0.00	0.40	0.40	--	--	--
Diazinon_ugPerL	FH	5	0.40	0.00	0.00	0.40	0.40	0.40	0.40	0.40
Diazinon_ugPerL	NSH	3	0.40	0.00	0.00	0.40	0.40	--	--	--
Diazinon_ugPerL	ST	1	0.40	--	--	0.40	--	--	--	--
Diazinon_ugPerL	WCB	17	0.40	0.00	0.00	0.40	0.40	0.40	0.40	0.40
Diazinon_ugPerL	WHP	6	0.40	0.00	0.00	0.40	0.40	0.40	0.40	0.40
Dieldrin_ugPerKg	CGP	4	7.38	11.88	5.94	1.32	25.20	--	1.35	19.29
Dieldrin_ugPerKg	CIP	9	1.76	1.03	0.34	0.70	3.36	1.56	0.75	2.82
Dieldrin_ugPerKg	COT	1	1.44	--	--	1.44	--	--	--	--
Dieldrin_ugPerKg	DA	2	0.92	0.10	0.07	0.85	0.99	--	--	--
Dieldrin_ugPerKg	FH	5	1.68	0.32	0.14	1.20	2.04	1.80	1.38	1.92
Dieldrin_ugPerKg	NSH	3	1.40	0.07	0.04	1.32	1.44	--	--	--
Dieldrin_ugPerKg	ST	1	1.44	--	--	1.44	--	--	--	--
Dieldrin_ugPerKg	WCB	17	1.09	0.57	0.14	0.68	2.76	0.81	0.74	1.38
Dieldrin_ugPerKg	WHP	6	1.70	0.18	0.07	1.44	1.92	1.74	1.53	1.83
Zinc_Dissolved_ugPerL	CGP	4	4.00	0.00	0.00	4.00	4.00	--	4.00	4.00
Zinc_Dissolved_ugPerL	CIP	9	29.41	30.80	10.27	4.00	83.60	11.20	4.00	58.05
Zinc_Dissolved_ugPerL	COT	1	49.20	--	--	49.20	--	--	--	--
Zinc_Dissolved_ugPerL	DA	2	4.00	0.00	0.00	4.00	4.00	--	--	--
Zinc_Dissolved_ugPerL	FH	5	6.83	3.97	1.77	4.00	12.30	4.00	4.00	11.07
Zinc_Dissolved_ugPerL	NSH	3	17.75	19.77	11.41	4.00	40.40	--	--	--
Zinc_Dissolved_ugPerL	ST	1	4.00	--	--	4.00	--	--	--	--
Zinc_Dissolved_ugPerL	WCB	17	5.24	2.77	0.67	4.00	12.00	4.00	4.00	4.00
Zinc_Dissolved_ugPerL	WHP	6	20.68	23.72	9.68	4.00	66.20	9.65	6.53	36.95
Zinc_mgPerKg	CGP	4	15.66	18.65	9.33	5.00	43.60	--	5.37	34.59
Zinc_mgPerKg	CIP	9	61.46	56.28	18.76	13.70	203.00	47.00	26.70	66.35
Zinc_mgPerKg	COT	1	13.60	--	--	13.60	--	--	--	--
Zinc_mgPerKg	DA	2	42.75	10.39	7.35	35.40	50.10	--	--	--
Zinc_mgPerKg	FH	5	43.76	13.89	6.21	30.20	63.60	38.70	32.10	57.95
Zinc_mgPerKg	NSH	3	5.00	0.00	0.00	5.00	5.00	--	--	--
Zinc_mgPerKg	ST	1	5.00	--	--	5.00	--	--	--	--

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
Zinc_mgPerKg	WCB	17	26.45	14.16	3.43	9.57	52.00	26.60	14.00	39.90
Zinc_mgPerKg	WHP	6	14.80	3.92	1.60	10.10	21.00	14.20	11.68	18.08
Zinc_Total_ugPerL	CGP	4	54.00	58.00	29.00	25.00	141.00	--	25.00	112.00
Zinc_Total_ugPerL	CIP	9	33.54	19.25	6.42	25.00	81.70	25.00	25.00	35.10
Zinc_Total_ugPerL	COT	1	25.00	--	--	25.00	--	--	--	--
Zinc_Total_ugPerL	DA	2	25.00	0.00	0.00	25.00	25.00	--	--	--
Zinc_Total_ugPerL	FH	5	30.02	11.23	5.02	25.00	50.10	25.00	25.00	37.55
Zinc_Total_ugPerL	NSH	3	39.23	24.65	14.23	25.00	67.70	--	--	--
Zinc_Total_ugPerL	ST	1	25.00	--	--	25.00	--	--	--	--
Zinc_Total_ugPerL	WCB	17	25.48	1.96	0.48	25.00	33.10	25.00	25.00	25.00
Zinc_Total_ugPerL	WHP	6	52.95	46.13	18.83	25.00	134.00	25.00	25.00	96.28

Appendix 8. Descriptive statistics by ecoregion for select fish and macroinvertebrate metrics. See Appendix 4 for variable names.

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
fishsen	CGP	3	0.07	0.13	0.07	0.00	0.22	--	--	--
fishsen	CIP	8	0.15	0.13	0.05	0.00	0.35	0.14	0.02	0.28
fishsen	COT	1	0.20	--	--	0.20	--	--	--	--
fishsen	DA	2	0.14	0.19	0.14	0.00	0.27	--	--	--
fishsen	FH	5	0.26	0.10	0.04	0.13	0.40	0.28	0.17	0.34
fishsen	NSH	3	0.21	0.06	0.03	0.15	0.27	--	--	--
fishsen	ST	1	0.29	--	--	0.29	--	--	--	--
fishsen	WCB	16	0.21	0.15	0.04	0.00	0.40	0.23	0.03	0.36
fishsen	WHP	5	0.13	0.22	0.10	0.00	0.50	0.00	0.00	0.31
fishBI	CGP	3	0.23	0.18	0.10	0.08	0.42	--	--	--
fishBI	CIP	8	0.79	0.15	0.05	0.56	1.04	0.79	0.68	0.89
fishBI	COT	1	0.76	--	--	0.76	--	--	--	--
fishBI	DA	2	0.71	0.17	0.12	0.59	0.82	--	0.59	0.82
fishBI	FH	5	0.68	0.23	0.10	0.44	0.93	0.68	0.45	0.92
fishBI	NSH	3	0.58	0.13	0.08	0.49	0.73	--	--	--
fishBI	ST	1	0.45	--	--	0.45	--	--	--	--
fishBI	WCB	16	0.83	0.23	0.06	0.31	1.12	0.90	0.60	0.99
fishBI	WHP	5	0.32	0.38	0.17	0.00	0.79	0.13	0.00	0.73
fishGI	CGP	3	2.30	0.93	0.54	1.59	3.36	--	--	--
fishGI	CIP	8	6.46	1.89	0.67	3.70	9.21	6.53	4.98	8.32
fishGI	COT	1	6.60	--	--	6.60	--	--	--	--
fishGI	DA	2	5.25	3.46	2.45	2.80	7.69	--	--	--
fishGI	FH	5	5.39	1.52	0.68	3.16	7.00	5.73	3.90	6.71
fishGI	NSH	3	4.25	1.48	0.85	2.76	5.72	--	--	--
fishGI	ST	1	3.43	--	--	3.43	--	--	--	--
fishGI	WCB	16	6.32	2.12	0.53	2.34	9.61	6.53	4.74	8.13
fishGI	WHP	5	2.17	1.13	0.51	0.83	3.62	1.70	1.25	3.34
fishMI	CGP	3	0.82	0.43	0.25	0.52	1.31	--	--	--
fishMI	CIP	8	2.61	0.84	0.30	1.40	3.85	2.63	1.94	3.43
fishMI	COT	1	2.69	--	--	2.69	--	--	--	--
fishMI	DA	2	2.11	1.54	1.09	1.01	3.20	--	--	--
fishMI	FH	5	2.16	0.67	0.30	1.22	2.89	2.35	1.49	2.74
fishMI	NSH	3	1.65	0.67	0.39	0.96	2.29	--	--	--
fishMI	ST	1	1.28	--	--	1.28	--	--	--	--
fishMI	WCB	16	2.57	0.94	0.23	0.76	4.03	2.65	1.86	3.36

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
fishMI	WHP	5	0.59	0.66	0.29	0.00	1.40	0.37	0.00	1.28
fishShan	CGP	3	0.24	0.18	0.11	0.09	0.44	--	--	--
fishShan	CIP	8	0.85	0.14	0.05	0.63	1.07	0.86	0.72	0.95
fishShan	COT	1	0.80	--	--	0.80	--	--	--	--
fishShan	DA	2	0.73	0.16	0.11	0.62	0.84	--	--	--
fishShan	FH	5	0.72	0.24	0.11	0.47	0.97	0.69	0.49	0.96
fishShan	NSH	3	0.62	0.14	0.08	0.51	0.77	--	--	--
fishShan	ST	1	0.49	--	--	0.49	--	--	--	--
fishShan	WCB	16	0.86	0.23	0.06	0.35	1.14	0.92	0.64	1.04
fishShan	WHP	5	0.33	0.39	0.17	0.00	0.81	0.17	0.00	0.75
fishSimpInd	CGP	3	0.71	0.29	0.16	0.39	0.92	--	--	--
fishSimpInd	CIP	8	0.21	0.09	0.03	0.12	0.36	0.18	0.14	0.29
fishSimpInd	COT	1	0.24	--	--	0.24	--	--	--	--
fishSimpInd	DA	2	0.24	0.05	0.03	0.21	0.27	--	--	--
fishSimpInd	FH	5	0.28	0.15	0.07	0.12	0.44	0.26	0.14	0.44
fishSimpInd	NSH	3	0.36	0.14	0.08	0.25	0.51	--	--	--
fishSimpInd	ST	1	0.44	--	--	0.44	--	--	--	--
fishSimpInd	WCB	16	0.22	0.14	0.03	0.10	0.58	0.16	0.11	0.30
fishSimpInd	WHP	5	0.63	0.40	0.18	0.17	1.00	0.75	0.20	1.00
fishRich	CGP	3	6.00	3.46	2.00	4.00	10.00	--	--	--
fishRich	CIP	8	15.13	6.51	2.30	8.00	27.00	13.50	9.75	20.50
fishRich	COT	1	16.00	--	--	16.00	--	--	--	--
fishRich	DA	2	14.50	12.02	8.50	6.00	23.00	--	--	--
fishRich	FH	5	13.80	5.31	2.37	8.00	20.00	14.00	8.50	19.00
fishRich	NSH	3	9.67	4.16	2.40	5.00	13.00	11.00	--	--
fishRich	ST	1	7.00	--	--	7.00	--	--	--	--
fishRich	WCB	16	16.50	6.83	1.71	4.00	30.00	16.50	10.50	21.00
fishRich	WHP	5	4.20	3.96	1.77	1.00	9.00	2.00	1.00	8.50
bugsens	CGP	4	0.08	0.08	0.04	0.00	0.16	--	0.01	0.15
bugsens	CIP	8	0.17	0.08	0.03	0.10	0.33	0.13	0.12	0.22
bugsens	COT	1	0.20	--	--	0.20	--	--	--	--
bugsens	DA	2	0.15	0.04	0.03	0.12	0.18	--	--	--
bugsens	FH	5	0.13	0.04	0.02	0.09	0.19	0.13	0.10	0.17
bugsens	NSH	3	0.10	0.06	0.03	0.04	0.15	--	--	--
bugsens	ST	1	0.00	--	--	0.00	--	--	--	--
bugsens	WCB	16	0.14	0.09	0.02	0.03	0.32	0.11	0.08	0.18

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
bugsens	WHP	6	0.10	0.09	0.04	0.00	0.22	0.07	0.02	0.20
bugEPT	CGP	4	0.14	0.10	0.05	0.00	0.23	--	0.04	0.22
bugEPT	CIP	8	0.23	0.11	0.04	0.10	0.46	0.21	0.15	0.26
bugEPT	COT	1	0.22	--	--	0.22	--	--	--	--
bugEPT	DA	2	0.22	0.02	0.01	0.21	0.24	--	--	--
bugEPT	FH	5	0.26	0.09	0.04	0.16	0.37	0.27	0.18	0.34
bugEPT	NSH	3	0.17	0.08	0.04	0.10	0.25	--	--	--
bugEPT	ST	1	0.11	--	--	0.11	--	--	--	--
bugEPT	WCB	16	0.26	0.12	0.03	0.11	0.48	0.24	0.14	0.35
bugEPT	WHP	6	0.17	0.10	0.04	0.06	0.32	0.17	0.08	0.24
bugBI	CGP	4	0.86	0.36	0.18	0.48	1.34	--	0.55	1.23
bugBI	CIP	8	1.11	0.13	0.05	0.95	1.33	1.07	1.01	1.24
bugBI	COT	1	1.21	--	--	1.21	--	--	--	--
bugBI	DA	2	1.28	0.06	0.05	1.24	1.33	--	--	--
bugBI	FH	5	1.11	0.15	0.07	0.87	1.30	1.13	0.99	1.22
bugBI	NSH	3	0.73	0.33	0.19	0.35	0.95	--	--	--
bugBI	ST	1	0.66	--	--	0.66	--	--	--	--
bugBI	WCB	16	1.07	0.25	0.06	0.53	1.39	1.12	0.90	1.25
bugBI	WHP	6	1.05	0.07	0.03	0.92	1.12	1.08	0.99	1.10
bugGN	CGP	4	13.44	6.94	3.47	5.85	22.49	--	7.22	20.39
bugGN	CIP	8	17.81	2.77	0.98	12.28	22.06	18.02	16.82	19.24
bugGN	COT	1	17.76	--	--	17.76	--	--	--	--
bugGN	DA	2	19.65	2.94	2.08	17.57	21.73	--	--	--
bugGN	FH	5	17.71	3.32	1.48	14.21	21.03	18.13	14.30	20.92
bugGN	NSH	3	11.69	3.18	1.84	8.78	15.09	--	--	--
bugGN	ST	1	7.96	--	--	7.96	--	--	--	--
bugGN	WCB	16	17.87	3.54	0.89	11.50	25.29	17.28	15.53	21.05
bugGN	WHP	6	14.13	3.22	1.32	9.61	17.37	14.47	11.49	16.92
bugMI	CGP	4	5.67	3.02	1.51	2.37	9.60	--	2.97	8.70
bugMI	CIP	8	7.57	1.21	0.43	5.14	9.41	7.65	7.14	8.20
bugMI	COT	1	7.56	--	--	7.56	--	--	--	--
bugMI	DA	2	8.37	1.27	0.90	7.47	9.26	--	--	--
bugMI	FH	5	7.53	1.44	0.65	6.01	8.97	7.71	6.05	8.92
bugMI	NSH	3	4.91	1.36	0.79	3.65	6.36	--	--	--
bugMI	ST	1	3.27	--	--	3.27	--	--	--	--
bugMI	WCB	16	7.60	1.54	0.38	4.83	10.82	7.34	6.58	8.98

Parameter	Ecoregion	Count	ArithMean	StdDev	StErr	Min	Max	Median	25thPtile	75thPtile
bugMI	WHP	6	5.97	1.40	0.57	4.01	7.38	6.12	4.81	7.18
bugShan	CGP	4	0.91	0.39	0.19	0.50	1.43	--	0.58	1.30
bugShan	CIP	8	1.18	0.14	0.05	1.04	1.42	1.14	1.07	1.34
bugShan	COT	1	1.27	--	--	1.27	--	--	--	--
bugShan	DA	2	1.36	0.09	0.06	1.30	1.42	--	--	--
bugShan	FH	5	1.17	0.16	0.07	0.92	1.37	1.19	1.05	1.28
bugShan	NSH	3	0.78	0.36	0.21	0.38	1.06	--	--	--
bugShan	ST	1	0.72	--	--	0.72	--	--	--	--
bugShan	WCB	16	1.13	0.26	0.06	0.56	1.47	1.18	0.96	1.32
bugShan	WHP	6	1.11	0.08	0.03	0.98	1.19	1.14	1.04	1.16
bugSimpl	CGP	4	0.28	0.20	0.10	0.06	0.53	--	0.10	0.48
bugSimpl	CIP	8	0.13	0.06	0.02	0.06	0.21	0.14	0.07	0.18
bugSimpl	COT	1	0.09	--	--	0.09	--	--	--	--
bugSimpl	DA	2	0.07	0.02	0.01	0.06	0.08	--	--	--
bugSimpl	FH	5	0.14	0.08	0.04	0.07	0.28	0.11	0.09	0.22
bugSimpl	NSH	3	0.36	0.30	0.17	0.18	0.70	--	--	--
bugSimpl	ST	1	0.32	--	--	0.32	--	--	--	--
bugSimpl	WCB	16	0.18	0.15	0.04	0.06	0.55	0.11	0.08	0.29
bugSimpl	WHP	6	0.13	0.04	0.02	0.10	0.22	0.12	0.10	0.16
bugRich	CGP	4	36.00	18.81	9.41	15.00	60.00	--	18.75	54.75
bugRich	CIP	8	46.50	9.07	3.21	28.00	58.00	47.00	42.75	53.25
bugRich	COT	1	49.00	--	--	49.00	--	--	--	--
bugRich	DA	2	51.50	4.95	3.50	48.00	55.00	--	--	--
bugRich	FH	5	47.80	9.52	4.26	38.00	57.00	49.00	38.00	57.00
bugRich	NSH	3	29.67	5.13	2.96	24.00	34.00	--	--	--
bugRich	ST	1	18.00	--	--	18.00	--	--	--	--
bugRich	WCB	16	47.75	9.81	2.45	30.00	69.00	46.00	42.00	55.00
bugRich	WHP	6	36.83	9.06	3.70	25.00	45.00	39.00	27.25	45.00