Calibration of the Biological Condition Gradient (BCG) in Cold and Cool Waters of the Upper Midwest for Fish and Benthic Macroinvertebrate Assemblages

FINAL REPORT

Prepared for

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November 30, 2012

ACKNOWLEDGEMENTS

The participants in this effort invested significant time and commitment in the process. We are grateful for their hard work and enthusiasm.

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ACRONYMS

BCG	Biological Condition Gradient
EPA	EPA United States Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera and Trichoptera
FDL	Fond du Lac Band of Lake Superior Chippewa
IBI	Index of Biological Integrity
MI	Michigan
MN	Minnesota
MPCA	Minnesota Pollution Control Agency
LRBOI	Little River Band of Ottawa Indians
MBI	Midwest Biodiversity Institute
MDEQ	Michigan Department Environmental Quality (formerly MDNRE)
NMDS	Nonmetric Multidimensional Scaling
OTU	Operational Taxonomic Unit
RLDNR	Red Lake Band of Chippewa, Department of Natural Resources
SOP	SOP Standard Operating Procedure
TALU	Tiered Aquatic Life Use
WI	Wisconsin
WDNR	Wisconsin Department of Natural Resources

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EXECUTIVE SUMMARY

The objective of the Clean Water Act is to "restore and maintain physical, chemical and biological integrity of the Nation's waters." To meet this goal, we need a uniform interpretation of biological condition and operational definitions that are independent of different assessment methodologies. These definitions must be specific, well-defined, and allow for waters of different natural quality and different desired uses. The USEPA has outlined a tiered system of aquatic life use designation, along a gradient (the Biological Condition Gradient, or BCG) that describes how ecological attributes change in response to increasing levels of human disturbance. The Biological Condition Gradient is a conceptual model that describes changes in aquatic communities. It is consistent with ecological theory and has been verified by aquatic biologists throughout the US.

Specifically, the BCG describes how ten biological attributes of natural aquatic systems change in response to increasing pollution and disturbance. The ten attributes are in principle measurable, although several are not commonly measured in monitoring programs. The gradient represented by the BCG has been divided into 6 BCG levels of condition that biologists think can be readily discerned in most areas of North America, ranging from "natural or native condition" (Level 1) to "Severe changes in structure and major loss of ecosystem function" (Level 6).

This report summarizes the findings of a panel of aquatic biologists from 3 states and 4 tribal water quality agencies, who applied and calibrated the general BCG model to coldwater and coolwater streams of the northern portions of Minnesota, Wisconsin, Michigan, and the tribal lands. The panel was challenged to 1) assign Biological Condition Gradient attributes to fish and invertebrate species found in the regional dataset and 2) to achieve consensus in assigning stream reaches into BCG levels using the fish and invertebrate community data. The rules used by the panelists were compiled, tested, and refined, and vetted with the panel through a series of meetings and conference calls. The end products were 4 quantitative BCG models to predict the BCG level of a stream based on the rules developed by the panel. The panel assessed 170 calibration samples and 84 confirmation sites that were not used in the calibration step. The BCG model correctly assessed 90% to 97% of calibration samples, and 68% to 84% of confirmation samples. The coolwater fish model was 68% correct on confirmation samples, indicating that the coolwater fish model may be overfitted. A primary use of these models will be to augment traditional macroinvertebrate community data analysis used for water quality assessments. Assessments using multiple communities reflect conditions from several stressors.

1 INTRODUCTION

The objective of the 1972 Clean Water Act (CWA) is to "restore and maintain the chemical, physical and biological integrity of the Nation's waters". Why did the framers of the CWA include biological integrity? Why do people care about biology in waters? Clearly, we care about our own health – but after our own health is assured, we care first for the biological "health" or integrity of the environment. In North America, we also desire to maintain a connection with the natural continent inhabited by our Native American ancestors, and encountered and colonized by our immigrant ancestors.

The management goals of the CWA are human health and ecological sustainability of our waters, which we measure with various human health Water Quality (WQ) criteria (which have safety factors built in), aquatic life WQ criteria, and the actual measurement of biological condition. Biological condition is the best measure we have of the quality and sustainability of most ecological goods and services. There is abundant historical information on how ecological goods and services disappear and collapse, as biological condition is degraded. These two endpoints, human health criteria and biological condition, are the primary indicators that we have on achieving the goals of the CWA.

With respect to water, we care only about stressors if they harm ourselves or other biota – something that is inert and harmless would excite no attention. Thus, biological condition is the ultimate indicator and arbiter of overall integrity: a water body without physical and chemical integrity cannot have biological integrity.

Since passage of the CWA, the emphasis of water quality management in the US has been on point source discharges: cleaning up known sources of pollutants and toxic substances. This chemical focus has had great success in cleaning up the most egregiously polluted waters throughout the nation. In water quality management, this has led to various programs, each of which deals with one aspect of mostly chemical pollutants, and a general belief that maximizing all program elements leads to good water quality.

In spite of demonstrated achievements in improving water quality, many programs have reached a limit of diminishing returns because they are not integrated, and because they are focused on maximizing internal program elements (e.g., removing waters from the 303(d) list by whatever means necessary), instead of meeting the goals of the Clean Water Act. One of these goals, biological integrity, now merits increased attention.

State and local water quality monitoring programs in general, and bioassessment in particular, have been criticized in the past for lack of common program design, lack of standardized methods, and lack of common assessment endpoints, so that assessments in one jurisdiction are not compatible with assessments in neighboring jurisdictions (e.g., U.S. GAO 2000). Targeted monitoring efforts, different monitoring and analytical methods and index periods, and varying frequencies of sampling efforts among agencies were key factors as to why data could not be aggregated for consistent state, regional, or national reporting on resource condition. Current programs also demonstrated limitations for determining the geographic extent of problems and identifying those high quality resource waters potentially needing further protection.

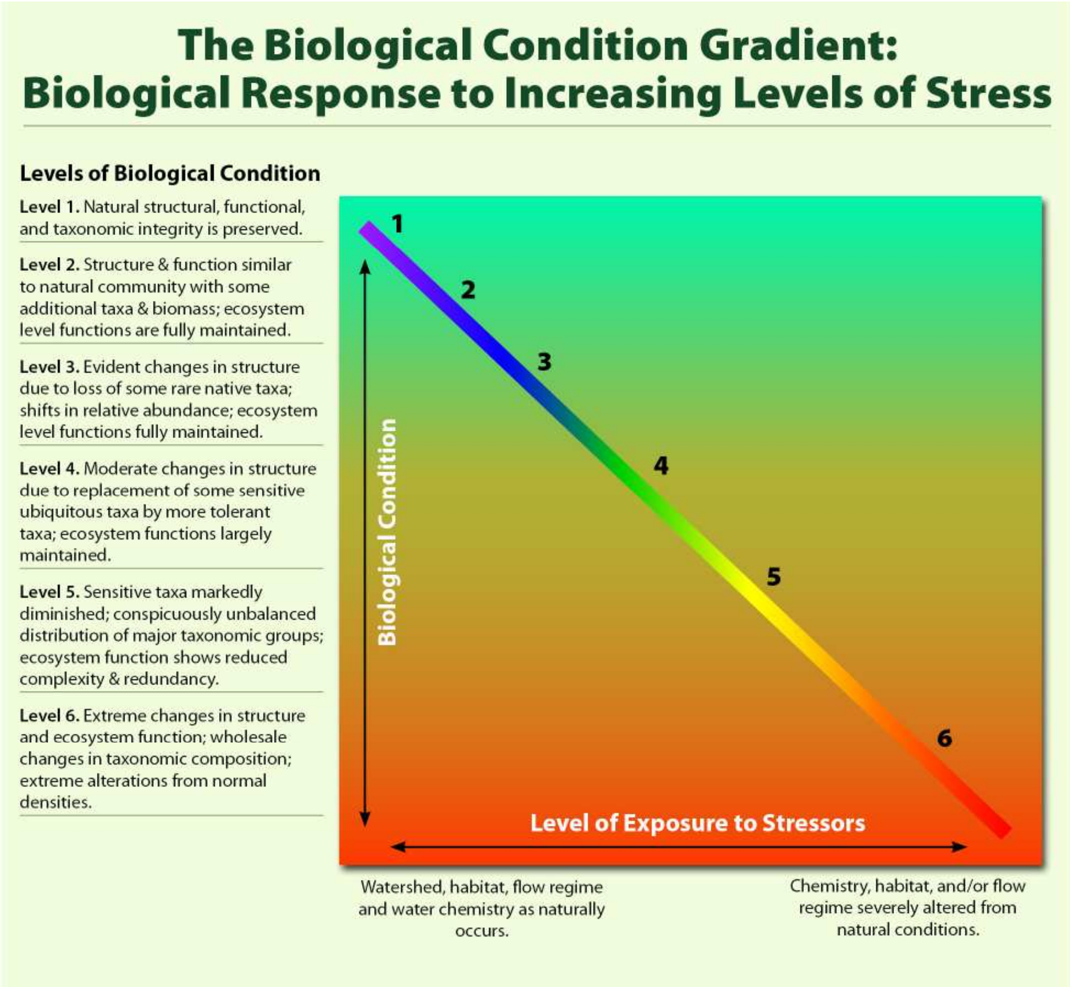
In response, several states and the US EPA have developed a framework to support improved biological assessment. The framework, called the Biological Condition gradient (BCG), supports development of biological criteria in a state's water quality standards that can protect the best quality waters, that can be used as a tool to prevent or remediate cumulative, incremental degradation, and that can help to establish realistic management goals for impaired waters. The basis of the framework is recognition that biological condition of water bodies responds to human-caused disturbance and stress, and that the biological condition can be measured reliably.

The BCG, as a conceptual model, is a universal framework that defines biologically recognizable categories of condition, and the framework is applicable for all states and regions. The BCG is not a management system, nor does it describe management goals. However, the reverse is true: management goals can be described in terms of the BCG, and biological information as measured by the BCG can tell us if criteria are being met.

This report takes the next step of translating the conceptual BCG framework into BCG-based assessment, for use by state, tribal and regional agencies. The BCG is calibrated for assessment of cold and cold-cool transitional wadeable streams of the Upper Midwest (Indian Reservations and the states of Michigan, Wisconsin, and Minnesota), and it was developed with data provided by these states and tribes. The BCG is robust to minor differences in sampling effort (area or number of organisms sampled) and taxonomic level of identification (family or genus for macroinvertebrates), but it does require that the gear used and habitats sampled among entities are comparable. These tools are calibrated for macroinvertebrate and fish assemblages.

1.1 What Is the BCG?

Over the past 40 years, states have independently developed technical approaches to assess biological condition and set designated aquatic life uses for their waters. The Biological Condition Gradient (BCG) was designed to provide a means to map different indicators on a common scale of biological condition to facilitate comparisons between programs and across jurisdictional boundaries in context of the CWA. The BCG is a conceptual, narrative model that describes how biological attributes of aquatic ecosystems change along a gradient of increasing anthropogenic stress. It provides a framework for understanding current conditions relative to natural, undisturbed conditions (Figure 1-1).



Source: Modified from Davies and Jackson 2006.

Figure 1-1. The Biological Condition Gradient (BCG). The BCG was developed to serve as a scientific framework to synthesize expert knowledge with empirical observations and develop testable hypotheses on the response of aquatic biota to increasing levels of stress. It is intended to help support more consistent interpretations of the response of aquatic biota to stressors and to clearly communicate this information to the public, and it is being evaluated and piloted in several regions and states.

Biologists from across the United States developed the BCG model, agreeing that a similar sequence of biological alterations occurs in streams and rivers in response to increasing stress, even in different geographic and climatological areas (Davies and Jackson 2006). The model shows an ecologically based relationship between the stressors affecting a waterbody (e.g., physical, chemical, biological impacts) and the response of the aquatic community (i.e., biological condition). The model is consistent with ecological theory and can be adapted or calibrated to reflect specific geographic regions and waterbody type (e.g., streams, rivers, wetlands, estuaries, lakes).

In practice, the BCG is used to first identify the critical attributes of an aquatic community (see Table 1-1) and then to describe how each attribute changes in response to stress. Practitioners can use the BCG to interpret biological condition along a standardized gradient, regardless of assessment method, and apply that information to different state or tribal programs.

The BCG model provides a framework to help water quality managers do the following:

- Decide what environmental conditions are desired (goal-setting)—The BCG can provide a framework for organizing data and information and for setting achievable goals for waterbodies relative to "natural" conditions (e.g., condition comparable or close to undisturbed or minimally disturbed condition).
- Interpret the environmental conditions that exist (monitoring and assessment)—Practitioners can get a more accurate picture of current waterbody conditions.
- Plan for how to achieve the desired conditions and measure effectiveness of restoration—The BCG framework offers water program managers a way to help evaluate the effects of stressors on a waterbody, select management measures by which to alleviate those stresses, and measure the effectiveness of management actions.
- Communicate with stakeholders—When biological and stress information is presented in this framework, it is easier for the public to understand the status of the aquatic resources relative to what high-quality places exist and what might have been lost.

1.2 How Is the BCG Constructed?

The BCG is divided into six levels of biological conditions along the stressor-response curve, ranging from observable biological conditions found at no or low levels of stress (level 1) to those found at high levels of stress (level 6) (Figure 1-1). The technical document provides a detailed description of how 10 attributes of aquatic ecosystems change in response to increasing levels of stressors along the gradient, from level 1 to 6 (see Table 1-1). The attributes include several aspects of community structure, organism condition, ecosystem function, spatial and temporal attributes of stream size, and connectivity.

Table 1-1. Biological and other ecological attributes used to characterize the BCG.

Attribute	**Description**
I. Historically documented, sensitive, long-lived, or regionally endemic taxa	Taxa known to have been supported according to historical, museum, or archeological records, or taxa with restricted distribution (occurring only in a locale as opposed to a region), often due to unique life history requirements (e.g., sturgeon, American eel, pupfish, unionid mussel species).
II. Highly sensitive (typically uncommon) taxa	Taxa that are highly sensitive to pollution or anthropogenic disturbance. Tend to occur in low numbers, and many taxa are specialists for habitats and food type. These are the first to disappear with disturbance or pollution (e.g., most stoneflies, brook trout [in the east], brook lamprey).
III. Intermediate sensitive and common taxa	Common taxa that are ubiquitous and abundant in relatively undisturbed conditions but are sensitive to anthropogenic disturbance/pollution. They have a broader range of tolerance than attribute II taxa and can be found at reduced density and richness in moderately disturbed sites (e.g., many mayflies, many darter fish species).
IV. Taxa of intermediate tolerance	Ubiquitous and common taxa that can be found under almost any conditions, from undisturbed to highly stressed sites. They are broadly tolerant but often decline under extreme conditions (e.g., filter-feeding caddisflies, many midges, many minnow species).
V. Highly tolerant taxa	Taxa that typically are uncommon and of low abundance in undisturbed conditions but that increase in abundance in disturbed sites. Opportunistic species able to exploit resources in disturbed sites. These are the last survivors (e.g., tubificid worms, black bullhead).
VI. Nonnative or intentionally introduced species	Any species not native to the ecosystem (e.g., Asiatic clam, zebra mussel, carp, European brown trout). Additionally, there are many fish native to one part of North America that have been introduced elsewhere.
VII. Organism condition	Anomalies of the organisms; indicators of individual health (e.g., deformities, lesions, tumors).
VIII. Ecosystem function	Processes performed by ecosystems, including primary and secondary production; respiration; nutrient cycling; decomposition; their proportion/dominance; and what components of the system carry the dominant functions. For example, shift of lakes and estuaries to phytoplankton production and microbial decomposition under disturbance and eutrophication.
IX. Spatial and temporal extent of detrimental effects	The spatial and temporal extent of cumulative adverse effects of stressors; for example, groundwater pumping in Kansas resulting in change in fish composition from fluvial dependent to sunfish.
X. Ecosystem connectance	Access or linkage (in space/time) to materials, locations, and conditions required for maintenance of interacting populations of aquatic life; the opposite of fragmentation. For example, levees restrict connections between flowing water and floodplain nutrient sinks (disrupt function); dams impede fish migration, spawning.

Source: Modified from Davies and Jackson 2006.

2 METHODS AND DATA

2.1 Developing and Calibrating the BCG

The BCG can serve as a starting point for defining the response of aquatic biota to increasing levels of stress in a specific region. Although the BCG was developed primarily using forested stream ecosystems, the model can be applied to any region or waterbody by calibrating it to local conditions using specific expertise and local data. To date, many states and tribes are calibrating the BCG using the first seven attributes that characterize the biotic community primarily on the basis of tolerance to stressors, presence/absence of native and nonnative species, and organism condition. Although the conceptual model has been developed for six levels of condition, six levels might not be necessary or feasible depending on limitations in data or level of technical rigor or naturally occurring conditions.

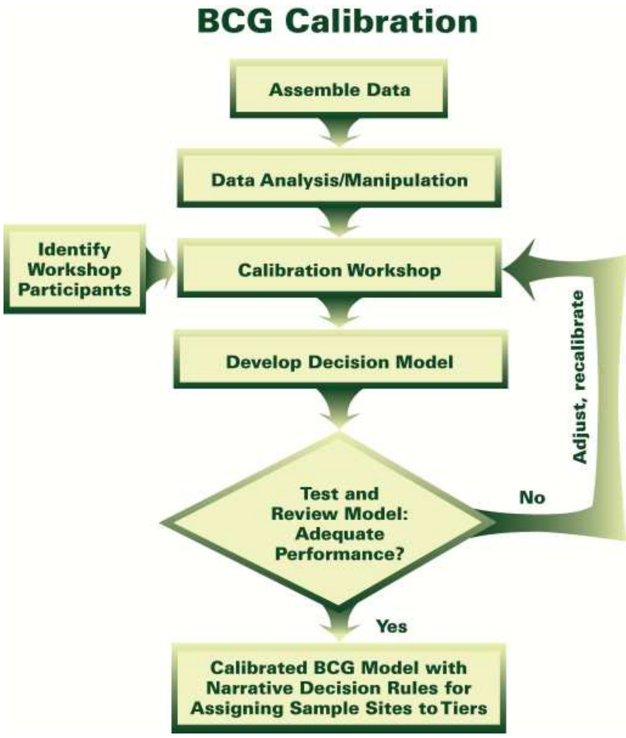


Figure 2-1. Steps in a BCG calibration.

Calibrating a BCG to local conditions (Figure 2-1) is a multistep process. The process is followed to describe the native aquatic assemblages under natural conditions; identify the predominant regional stressors; and describe the BCG, including the theoretical foundation and observed assemblage response to stressors. Calibration begins with the assembly and analysis of biological monitoring data. A calibration workshop is held in which experts familiar with local conditions use the data to define the ecological attributes and set narrative statements. For example, the experts determine narrative decision rules for assigning sites to a BCG level on the basis of the biological information collected at sites. Documentation of expert opinion in assigning sites to tiers is a critical part of the process. A decision model is then developed that encompasses those rules and is tested with independent data sets. A decision model based on the tested decision rules is a transparent, formal, and testable method for documenting and validating expert knowledge. A quantitative data analysis program can then be developed using those rules.

2.1.1 Assign Sites to Levels

The conceptual model of the BCG is universal (Davies and Jackson 2006; USEPA 2005), but descriptions of communities, species, and their responses to the stressor gradient are specific to the conditions and communities found in the sample region. The expert panel described the biological condition levels that can be discerned within their region. The description of natural conditions requires biological knowledge of the region, a natural classification of the assemblages, and, if available, historical descriptions of the habitats and assemblages. Working from the description of undisturbed communities and species composition data from example sites, the panel then assigned sites to the levels of the BCG. These site assignments were used to describe changes in the aquatic communities for lower levels of biological condition, leading to a complete descriptive model of the BCG for the region. Throughout this process, the panel made use of the prepared data, examining species composition and abundance data from sites with different levels of cumulative stress, from least stressed to severely stressed. Samples were selected by data analysts; the panel was initially unaware of the stressor status of individual sites. The panel worked with data tables showing the species and attributes for each site. In developing assessments, the panel worked "blind", that is, no stressor information was included in the data table. Only non-anthropogenic classification variables were shown. Panel members discussed the species composition and what they expected to see for each level of the BCG, for example, "I expect to see more stonefly taxa in a BCG Level 2 site."

2.1.2 Quantitative Description

Level descriptions in the conceptual model tend to be rather general (e.g., "reduced richness"). To allow for consistent assignments of sites to levels, it is necessary to formalize the expert knowledge by codifying level descriptions into a set of rules (e.g., Droesen 1996). If formalized properly, any person (with data) can follow the rules to obtain the same level assignments as the group of experts. This makes the actual decision criteria transparent to stakeholders.

Rules are logic statements that experts use to make their decisions; for example, "If taxon richness is high, then biological condition is high." Rules on attributes can be combined, for example: "If the number of highly sensitive taxa (Attribute II) is high, <u>and</u> the number of tolerant individuals (Attribute V) is low, then assignment is Level 2." In questioning individuals on how decisions are made in assigning sites to levels, people generally do not use inflexible, "crisp" rules, for example, the following rule is unlikely to be adopted:

"Level 2 always has 10 or more Attribute II taxa; 9 Attribute II taxa is always Level 3."

Rather, people use strength of evidence in allowing some deviation from their ideal for any individual attributes, as long as most attributes are in or near the desired range. Clearly, the definitions of "high," "moderate," "low," etc., are fuzzy. These rules preserve the collective professional judgment of the expert group and set the stage for the development of models that reliably assign sites to levels without having to reconvene the same group. In essence, the rules and the models capture the panel's collective decision criteria.

As the panel assigned example sites to BCG levels, the members were polled on the critical information and criteria they used to make their decisions. These formed preliminary, narrative rules that explained how panel members made decisions. For example, "For BCG Level 2, sensitive taxa must make up half or more of all taxa in a sample." The decision rule for a single level of the BCG does not always rest on a single attribute (e.g., highly sensitive taxa) but may include other attributes as well (intermediate sensitive taxa, tolerant taxa, indicator species), so these are termed "Multiple Attribute Decision Rules." With data from the sites, the rules can be checked and quantified. Quantification of rules allows users to consistently assess sites according to the same rules used by the expert panel, and allows a computer algorithm, or other persons, to obtain the same level assignments as the panel.

Rule development requires discussion and documentation of BCG level assignment decisions and the reasoning behind the decisions. During this discussion, we recorded:

- Each participant's decision ("vote") for the site
- The critical or most important information for the decision—for example, the number of taxa of a certain attribute, the abundance of an attribute, the presence of indicator taxa, etc.
- Any confounding or conflicting information and how this was resolved for the eventual decision

Following the initial site assignment and rule development, we developed descriptive statistics of the attributes and other biological indicators for each BCG level determined by the panel. These descriptions assisted in review of the rules and their iteration for testing and refinement.

Rule development is iterative, and may require 2 or more panel sessions. Following the initial development phase, the draft rules were tested by the panel with new data to ensure that new sites are assessed in the same way. The new test sites were not used in the initial rule development and also should span the range of anthropogenic stress. Any remaining ambiguities and inconsistencies from the first iterations were also resolved.

2.1.3 Decision Criteria Models

Consensus professional judgment used to describe the BCG levels can take into account nonlinear responses, uncommon stressors, masking of responses, and unequal weighting of attributes. This is in contrast to the commonly used biological indexes, which are typically unweighted sums of attributes (e.g., multimetric indexes; Barbour et al. 1999; Karr and Chu 1999), or a single attribute, such as observed to expected taxa (e.g., Simpson and Norris 2000; Wright 2000). Consensus assessments built from the professional judgment of many experts result in a high degree of confidence in the assessments, but the assessments are labor-intensive (several experts must rate each site). It is also not practical to reconvene the same group of experts for every site that is monitored in the long term. Since experts may be replaced on a panel over time, assessments may in turn "drift" due to individual differences of new panelists. Management and regulation, however, require clear and consistent methods and rules for assessment, which do not change unless deliberately reset.

Use of the BCG in routine monitoring and assessment thus requires a way to automate the consensus expert judgment so that the assessments are consistent. We codified the decision criteria into a decision model, which has the advantage that the criteria are visible and transparent.

Codification of Decision Criteria

The expert rules can be automated in Multiple Attribute Decision Models. These models replicate the decision criteria of the expert panel by assembling the decision rules using logic and set theory, in the same way the experts used the rules. Instead of a statistical prediction of expert judgment, this approach directly and transparently converts the expert consensus to automated site assessment. The method uses modern mathematical set theory and logic (called “fuzzy set theory”) applied to rules developed by the group of experts. Fuzzy set theory is directly applicable to environmental assessment, and has been used extensively in engineering applications worldwide (e.g., Demicco and Klir 2004) and environmental applications have been explored in Europe and Asia (e.g., Castella and Speight 1996; Ibelings et al. 2003).

Mathematical fuzzy set theory allows degrees of membership in sets, and degrees of truth in logic, compared to all-or-nothing in classical set theory and logic. Membership of an object in a set is defined by its membership function, a function that varies between 0 and 1. To illustrate, we compare how classical set theory and fuzzy set theory treat the common classification of sediment, where sand is defined as particles less than or equal to 2.0 mm diameter, and gravel is greater than 2.0 mm (Demicco and Klir 2004). In classical “crisp” set theory, a particle with diameter of 1.999 mm is classified as “sand”, and one with 2.001 mm diameter is classified as “gravel.” In fuzzy set theory, both particles have nearly equal membership (approximately 0.5) in both classes (Demicco 2004). Very small measurement error in particle diameter greatly increases the uncertainty of classification in classical set theory, but not in fuzzy set theory (Demicco and Klir 2004). Demicco and Klir (2004) proposed four reasons why fuzzy sets and fuzzy logic enhance scientific methodology:

- Fuzzy set theory has greater capability to deal with “irreducible measurement uncertainty,” as in the sand/gravel example above.
- Fuzzy set theory captures vagueness of linguistic terms, such as “many,” “large” or “few.”
- Fuzzy set theory and logic can be used to manage complexity and computational costs of control and decision systems.
- Fuzzy set theory enhances the ability to model human reasoning and decision-making, which is critically important for defining thresholds and decision levels for environmental management.

Development of the BCG

In order to develop the fuzzy inference model, each linguistic variable (e.g., “high taxon richness”) must be defined quantitatively as a fuzzy set (e.g., Klir 2004). A fuzzy set has a membership function; example membership functions of different classes of taxon richness are shown in Figure 2-2. In this example (Figure 2-2), piecewise linear functions (functions consisting of line segments) are used to assign membership of a sample to the fuzzy sets. Numbers below a lower threshold have membership of 0, and numbers above an upper threshold have membership of 1, and membership is a straight line between the lower and upper thresholds. For example, in Figure 2-2, a sample with 20 taxa would have a membership of approximately 0.5 in the set “low to moderate Taxa” and a membership of 0.5 in the set “Moderate Taxa.”

How are inferences made? Suppose there are two rules for determining if a waterbody is BCG Level 3 (using definitions of Figure 2-2):

- The number of total taxa is high
- The number of sensitive taxa is low to moderate

In crisp set theory, these rules translate to:

- Total taxa > 27
- Sensitive taxa > 10

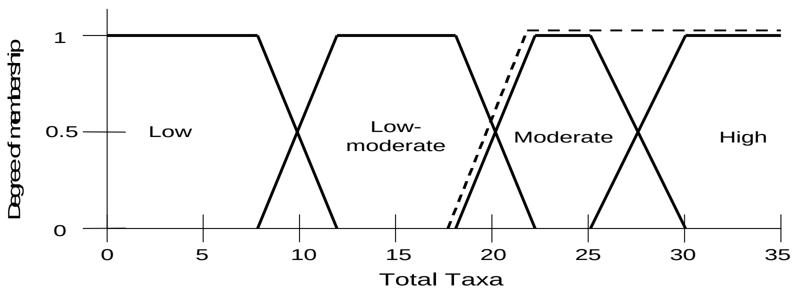


Figure 2-2. Fuzzy set membership functions assigning linguistic values of Total Taxa to defined quantitative ranges. Heavy dashed line shows membership of fuzzy set defined by "Total taxa are moderate to high."

If the two rules are combined with an "AND" operator, that is, both must be true, then under crisp set theory, if total taxa = 28 and sensitive taxa = 10, the sample would be judged not to be in the set of BCG Level 3. This is because sensitive taxa is 1 short of being greater than 10.

In fuzzy set theory, an AND statement is equivalent to the minimum membership given by each rule: Level 3 = MIN (total taxa is high, sensitive taxa is low to moderate)

Fuzzy membership in "total taxa is high" = 0.6 (Figure 2-2), and fuzzy membership in "Sensitive taxa is low to moderate" = 0.5 (Figure 2-2). Membership of Level 3 is then 0.5

If the two rules are combined with an "OR" operator, then either can be true for a site to meet BCG Level 3, and both conditions are not necessary. Crisp set theory now yields a value of "true" if total taxa = 28 and sensitive taxa = 10 (total taxa > 27, therefore it is true). Fuzzy set theory yields a membership of 0.6 (maximum of 0.5. and 0.6). Using the fuzzy set theory model, finding an additional taxon in a sample does not cause the assessment to flip to another class, unlike crisp decision criteria.

2.2 Biological Data

Coldwater stream data were requested from state and tribal biomonitoring programs in Minnesota, Michigan and Wisconsin. Data were grouped into two subclasses, cold and cold-cool transitional, based on classifications provided by the states and tribes. Temperature thresholds for these subclasses are summarized in Figure 2-3. The MPCA temperature classifications are based largely on groundwater influence; sites in the Driftless Area of southeastern Minnesota are generally colder than northern streams because they tend to be groundwater-dominated. The North-South boundary line runs roughly east to west through the center of the state and corresponds to major watershed boundaries. In Michigan and Wisconsin, MDEQ and WDNR based temperature designations on predictive models of summer temperature[1] that were developed as part of a collaborative research project on fish communities (Lyons et al. 2009) (Figure 2-3, Appendix A - Figure A-1). For this project, some of the Wisconsin sites were reclassified so that all sites in the Driftless Area ecoregion were grouped into the coldwater subclass[2]. The Driftless Area is a karst region in southwestern Wisconsin and southeast Minnesota that has groundwater-dominated streams. Samples from Fond du Lac Chippewa tribal lands in Minnesota were also analyzed in this study. Initially, some of the Fond du Lac sites were grouped into the coldwater subclass. However, after reviewing average July temperatures at these sites, participants decided that it was more appropriate to place all of the Fond du Lac samples in the cold-cool transitional subclass. Locations of the fish and macroinvertebrate sampling sites that were used in our analyses are shown in Figures 2-4 and 2-5, respectively. In addition, maps showing the locations of the biological sampling sites in relation to baseflow index and land use land cover are provided in Figures 2-6 and 2-7, respectively.

[1] For the Michigan sites, July mean water temperatures were estimated based on either maximum–minimum or continuous water temperatures measured during 1989–2005 at 830 stream sites (Lyons et al. 2009, Wehrly et al. 2009). July mean temperature was chosen because it is a useful predictor of fish assemblage structure (Wehrly et al. 2003, Steen et al., 2008) and July is the time in northern latitudes when temperature differences among streams are most pronounced (Caissie et al. 2006, Kevin E. Wehrly, unpublished data).In Wisconsin, June–August mean, July mean, and maximum daily mean water temperatures were estimated from an artificial-neural-network predictive model based on continuous water temperature measurements from 223 sites, continuous air temperature variables from weather stations and site-specific information on catchment soil permeability, slope, and land cover (Roehl et al. 2006, Stewart et al. 2006, Lyons et al. 2009).

[2] We felt comfortable revising these classifications because WDNR has noted some errors with the predictive model (Mike Miller, WDNR, pers. comm.).

SUBCLASS	MICHIGAN	WISCONSIN	MINNESOTA	FOND DU LAC
COLD	cold stream (<80 mi^2, <17.5°C)	cold mainstem (<80 mi^2, <17.5°C)	southern groundwater coldwater small (<35 mi^2, <16°C)	NA
	cold small river (80-300 mi^2, <17.5°C)	NA	NA	NA
COLD-COOL TRANSITIONAL	cold transitional stream (<80 mi^2, 17.5-19°C)	cool (cold transition) stream (<80 mi^2, 17.5-19°C)	northern surface coldwater small (<35 mi^2, < 19°C)	coldwater (<50 mi^2, ≤ 21°C)
	cold transitional small river (80-300 mi^2, 17.5-19°C)	cool (cold transition) small river (80-300 mi^2, 17.5-19°C)	southern groundwater coldwater large (35-300 mi^2, <17.7°C) northern surface coldwater large? (35-150 mi^2, ? °C)	NA
	cold transitional large river (> 300 mi^2, 17.5-19°C)	NA	NA	NA

Figure 2-3. Comparable stream types across entities, developed by fish participants at the LaCrosse BCG workshop. The Michigan thresholds in this diagram are based on unpublished MDEQ data by Paul Seelbach that takes into account work published by Lyons et al. 2009 and Brenden et al. 2008, with some modification (Lei Wang, MDEQ, pers. comm.). Because climate, topography, and land use are relatively similar between Michigan and Wisconsin (Wehrly et al. 2009), the Michigan thresholds were used for comparable stream types in Wisconsin. The Michigan and Wisconsin temperature values are average July temperatures derived from a predictive model, as described in Wehrly et al. 2009. Minnesota thresholds are based on unpublished data by Amy Phillips that was derived from analyses that utilized methods similar to those described in Wehrly et al. 2003 (John Sandberg, MPCA, pers. comm.). Temperature values for MPCA-Minnesota samples and Fond du Lac samples are average July temperatures based on actual measurements. NA = not available, meaning that these types of streams do not exist in these state or tribal lands (i.e. cold small river and cold transitional large rivers sites only exist in Michigan).

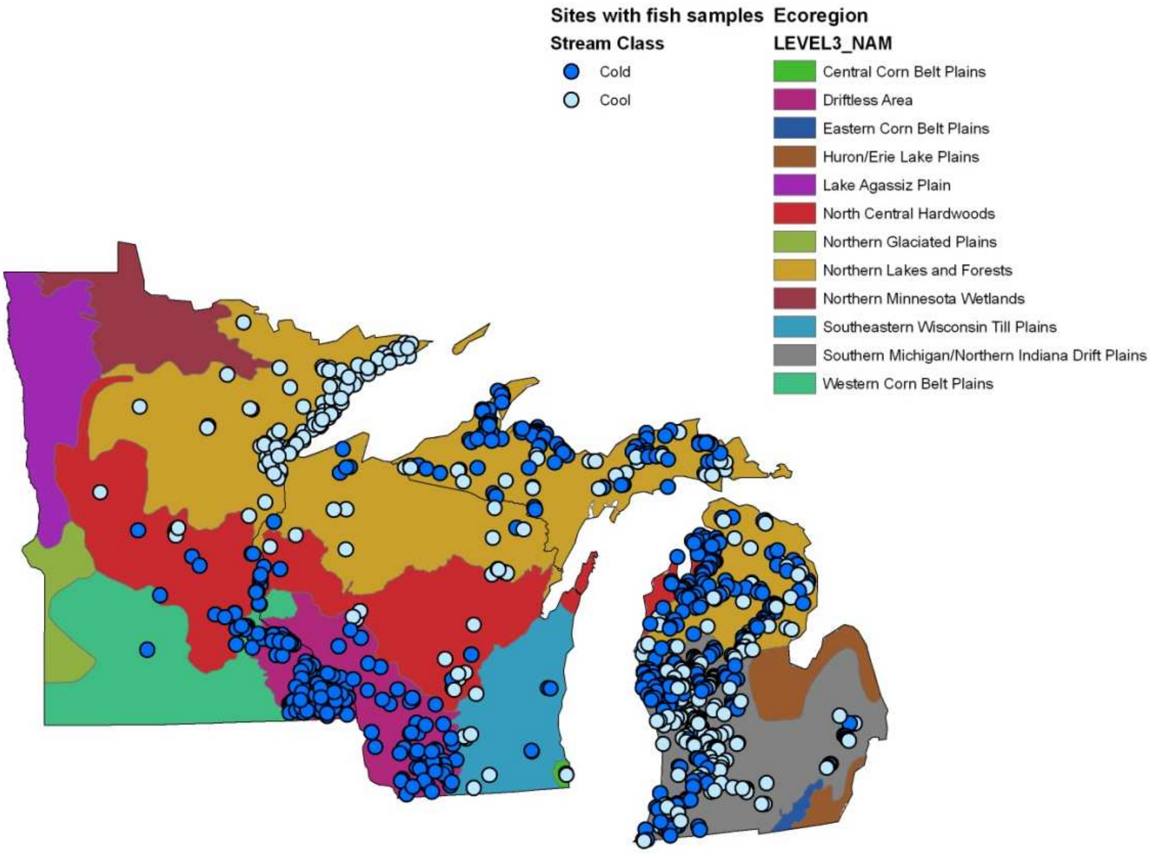


Figure 2-4. Locations of the fish sampling sites that were used in our analyses, grouped by temperature subclass. Samples from 692 sites were used to calibrate the coldwater fish BCG model and samples from 483 sites were used to calibrate the cool water (=cold/cool transitional) BCG model.

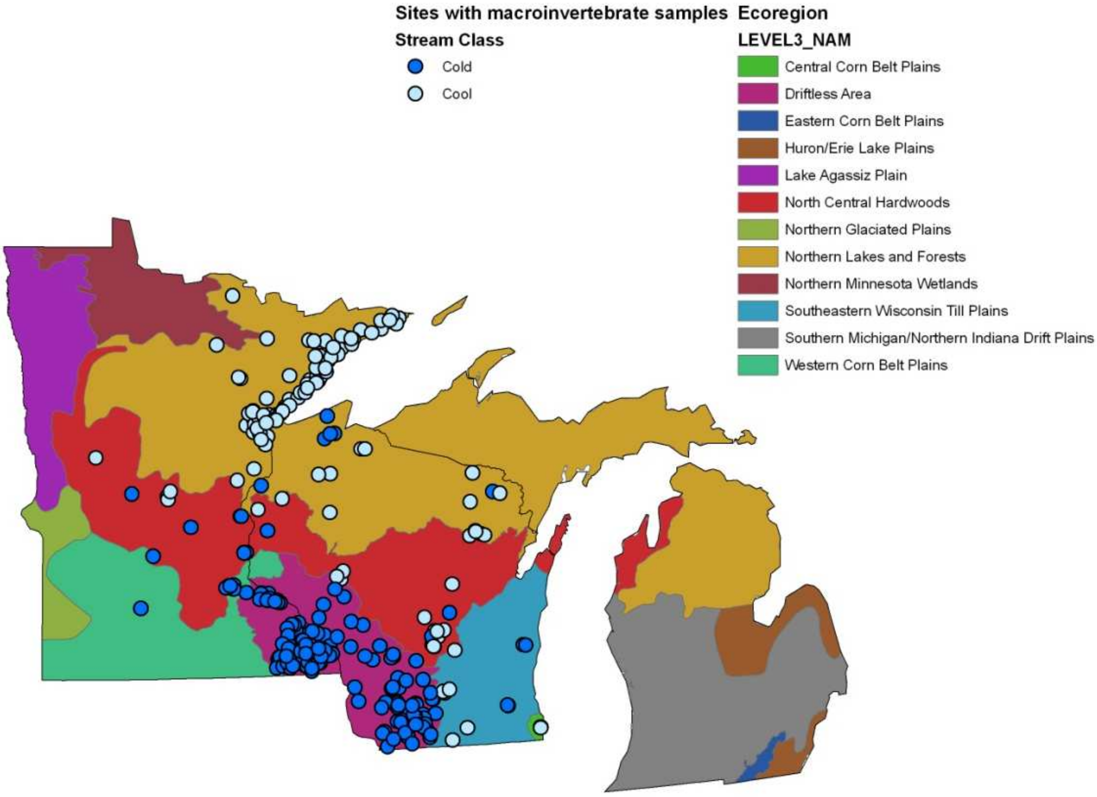


Figure 2-5. Locations of the macroinvertebrate sampling sites that were used in our analyses, grouped by temperature subclass (cool=cold/cool transitional). Samples from 217 sites were used to calibrate the coldwater macroinvertebrate BCG model and samples from 121 sites were used to calibrate the cool water (=cold/cool transitional) BCG model.

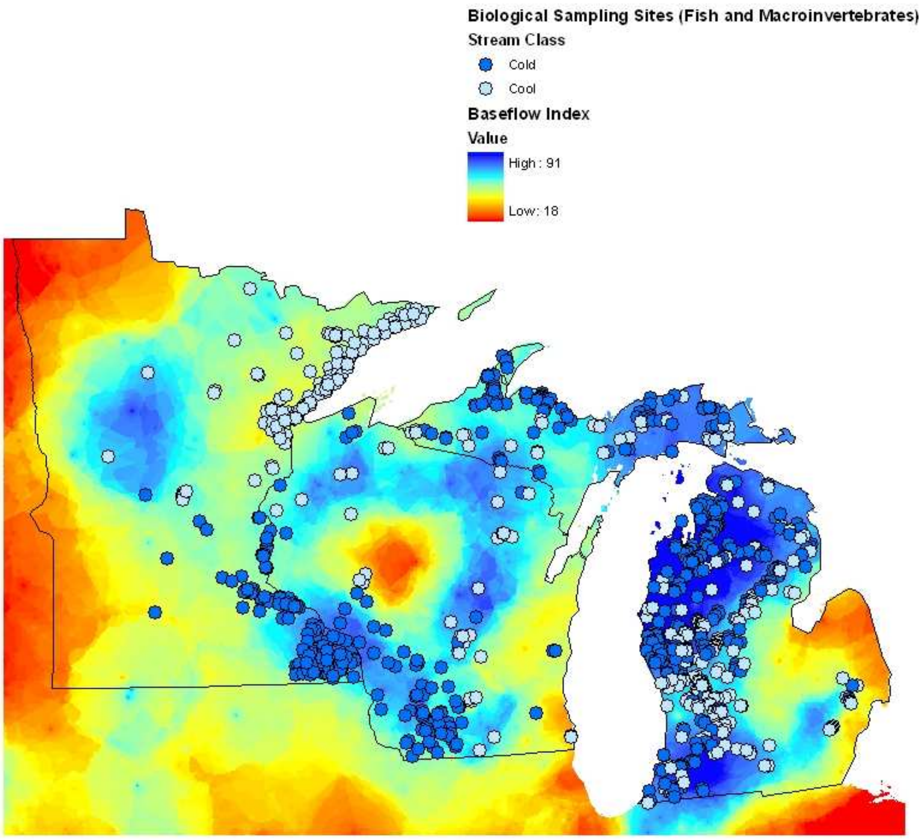


Figure 2-6. Map of baseflow index values and biological sampling sites. Baseflow values are derived from a base-flow index grid (1-km resolution, raster digital data) that was created by interpolating base-flow index values estimated at U.S. Geological Survey (USGS) stream gages (Wolock 2003).

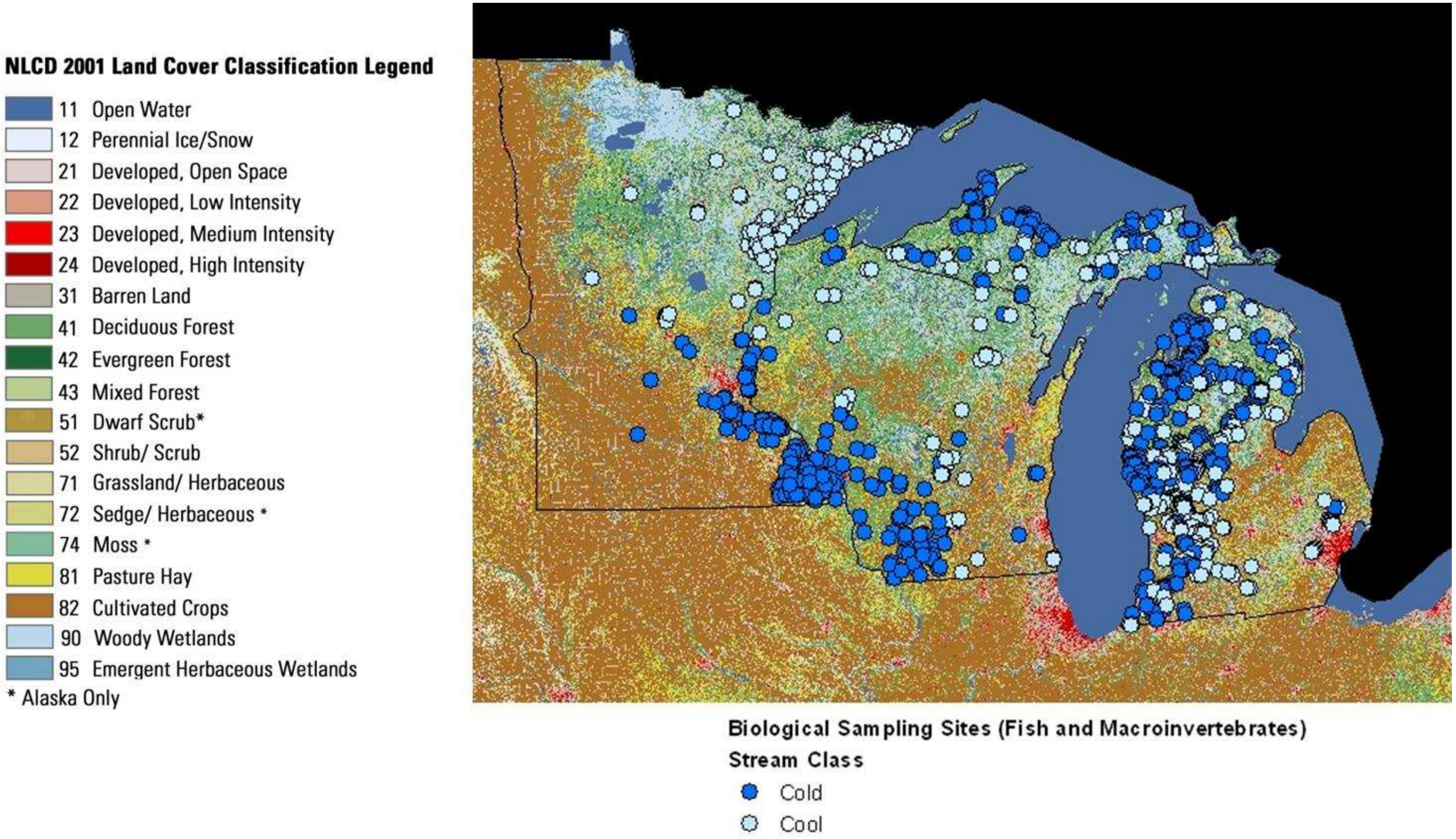


Figure 2-7. Location of biological sampling sites in relation to surrounding land cover.

2.3 Sampling Methods

Biological data that we used in our analyses were collected using similar, but not identical, sampling methods. Fish data were collected by 4 different entities (MDEQ, MPCA, WDNR, Fond du Lac Band (FDL)). Fish sampling methods are summarized in Table 2-1. Each entity used similar equipment and a single pass technique. All available habitat types were sampled, but there were some differences in sampling effort. WDNR and MPCA sampled a reach length equal to 35 times the mean stream width, the FDL samples a reach length of 10 times the stream width, and MDEQ uses a timed effort, sampling for 30 minutes over a reach length of 100-300 feet in small-medium sized streams or over a length of 5-10 channel widths in larger streams and rivers. Each entity samples during the summer when streams are at or near normal flow levels, with MPCA and MDEQ starting their sampling June, and WDNR and the FDL starting their sampling a month earlier, in May. More detailed information on each fish sampling method can be found in each entity's Standard Operating Procedures (SOP) manual (Breneman 1999, WDNR 2001, MDWQ 2008, MPCA 2009).

The macroinvertebrate data that we used in our analyses were collected by 3 different entities (MPCA, WDNR, FDL). Macroinvertebrate sampling methods are summarized in Table 2-2. MPCA, WDNR, and FDL use similar sampling equipment (D-frame dipnets with 500 or 600-micron mesh), and MPCA and FDL sample similar types of habitat (multiple habitats, with consideration given to the proportional occurrence of these habitats). Sampling area/effort, index period and target number of individuals differ across entities. MPCA collects quantitative samples from a total area of approximately 1.8 m^2 during an August-October index period, with a 300-organism target. WDNR has spring and fall index periods. Initially we included spring samples in our analyses, but later the panel decided to exclude them because they differed too much from the fall samples that comprised the majority of the dataset. WDNR collects a quantity of debris about the size of a softball from riffle habitat (where available) over a 3 minute time period, with a target of at least 100 organisms. FDL uses a timed effort (30-seconds per sample) and collects during a May-November index period. More detailed information on each macroinvertebrate sampling method can be found in each entity's SOP manual (Breneman 1999, WDNR 2000, MDWQ 2008, MPCA 2009)[3].

[3] We did not use MDEQ macroinvertebrate data in our analyses because they identify to the family-level. However, we included a summary of MDEQ's macroinvertebrate sampling technique in Table 2-2.

Table 2-1. Fish data collected by 4 different entities (MDEQ, MPCA, WDNR, FDL) were included in our analyses. Their fish sampling techniques are summarized below.

Entity	Gear	Habitat	Sampling Effort	Target # individs	Index Period
MDEQ	DC stream-shocker or backback-shocker	All significant available habitat types, sampled in the approximate proportion that they occur.	Single pass. Sampling occurs for approximately 30 minutes over a reach length of 100-300 ft in small-medium sized streams or over a length of 5-10 channel widths in larger streams and rivers. If target number of fish (100) has not been attained after 45 minutes, sampling is discontinued.	At least 100 individual fish that have lengths greater than 1 inch	June 1-September 30, during periods of stable discharge and at times of low or moderate flow
MPCA	DC backpack, stream-shocker, mini-boom, or boom-shocker, depending on stream width, depth, and accessibility	All available habitat types, sampled in the approximate proportion that they occur.	Single pass over a reach length of 35 times the mean stream width (MSW). Sampling time is recorded.	All fish observed that are greater than 25 mm in total length	Summer index period (mid-June through mid-September), streams are at or near base-flow.
WDNR	DC backpack or boom shocker	All available habitat types (should encompass more than 3 pool-riffle sequences)	Single pass over a reach length of 35 times the MSW	All fish observed that are greater than 26 mm in total length	mid-May-September, streams are at or near normal flow levels
FDL	DC tote-barge or backpack shocker, depending on stream depth, width, and substrate type	All available habitat types	Single pass over a reach length of 10x the stream width. Minimum reach length = 100 m.	All fish observed	May-August

Table 2-2. Genus-level macroinvertebrate data collected by 3 different entities (MPCA, WDNR, FDL) were used in our analyses. We also calibrated the BCG models to a family-level OTU so that they could be used by entities like MDEQ. Macroinvertebrate sampling techniques used by these 4 entities are summarized below.

Entity	Gear	Habitat	Sampling Area/Effort	Target # individs	Index Period	Taxonomic resolution
MDEQ	Triangular dip net with 1 millimeter (mm) mesh or hand picking	All habitats, with consideration given to the proportional occurrence of these habitats	Approximately 20 minutes of total sampling time	300 ± 60 plus large or rare taxa	June 1-September 30, at times of low or moderate flow	Family-level, field identifications (when possible)
MPCA	D-frame dipnet with 500-micron mesh	Dominant, productive habitats (hard bottom, aquatic macrophytes, undercut banks, snags, leaf packs)	20 sampling efforts are divided equally among habitats. A sample effort is a single dip or sweep in a common habitat that covers approximately .09m² of substrate. Total area sampled is ≈ 1.8m².	300	August-October	Genus-level, laboratory identifications
WDNR	Rectangular or D-frame dipnet with 600-micron mesh	Riffles where stream flow velocity is at least 0.3 meters per second and substrate is composed of coarse gravel to larger rubble (< 0.3 meters diameter); if riffles are absent, vegetation caught in logjams, snags, or vegetation overhanging from the stream banks is sampled	A quantity of debris about the size of a softball is collected in approximately 3 minutes or less. If <100 individuals are collected, sampling is extended for a second period of equal duration. If insufficient numbers still exist, sampling is stopped.	> 100	Spring (March – May) or fall (September – November).	Lowest possible level, laboratory identifications

Table 2-2. Continued…

Entity	Gear	Habitat	Sampling Area/Effort	Target # individs	Index Period	Taxonomic resolution
FDL	D-frame kick net with 500-micron mesh	Multiple habitats, with consideration given to the proportional occurrence of these habitats	Effort is timed and measured (approx. 30 seconds per sample and a 10 m distance).	Entire sample unless it takes more than 3-4 hours to process, in which case it is subsampled	May-November, baseflow conditions	Genus-level, laboratory identifications

2.4 Classification

Experience has shown that a robust biological classification is necessary to calibrate the BCG, because the natural biological class indicates the species expected to be found in undisturbed, high-quality sites. As an example, low-gradient prairie or wetland-influenced streams typically contain species that are adapted to slow-moving water and often to hypoxic conditions. These same species found in a high-gradient, forest stream could indicate habitat degradation and organic enrichment. We examined the classification strengths of the defined temperature classes (cold and cool-transitional), as well as catchment area and stream gradient (where available). The classification strengths of the temperature subclasses were evaluated using Nonmetric Multidimensional Scaling (NMS). NMS is an ordination that takes the taxa in the samples and shows in ordination space how closely related the samples and stations are based on their species composition. Grouping variables (i.e. year, month, collection method, taxonomy lab, ecoregion, watershed, etc.) can be overlaid to look for trends. We ran two sets of ordinations. In the first, data from each entity were analyzed separately, using temperature subclass as the grouping variable. In the second, data from each entity were combined into one data set, and temperature subclass, entity, watershed size and gradient were used as grouping variables (see Figure 2-1 for information on size thresholds). Gradient was calculated using a desktop GIS process, in which the distance between the first upstream and first downstream contour lines bracketing each site location were measured on a 1:24K DRG and rise/run was calculated.

Catchment area and gradient have been shown to be important classification variables for fish assemblages in Michigan, Wisconsin and Minnesota (Brenden et al. 2008, Sandberg 2011, unpublished data). Recent analyses by MPCA indicate that in southern Minnesota, species richness for fish is more strongly related to watershed area than to gradient, while in northern Minnesota, species richness is more strongly related to gradient than to watershed area (J. Sandberg, MPCA, unpublished data - Appendix Figures A-2 and A-3). We confirmed these results with multiple regression analysis (not shown), which showed that catchment was the strongest single predictor of fish species richness in coldwater, but both catchment and gradient are important predictors. Large coldwater streams are generally found in southern Minnesota, while further north, outside of groundwater-dominated areas, cold and cold-cool transitional streams tend to be small headwater streams. Fish species richness is positively correlated with catchment, and negatively with gradient. In addition, gradient is also negatively correlated with catchment because small headwater streams are more likely to be steeper than larger streams lower in the watershed. The actual cause (gradient vs. catchment) of changes in taxa richness is not relevant because they are so closely associated, however, one or both needs to be considered in the classification.

Ordination results for the fish data are shown in Figures 2-8 and 2-9. When data from MPCA, MDEQ and WDNR are analyzed separately, temperature subclass shows the strongest classification strength in the MPCA samples, with cold and cold-cool transitional samples forming distinct groups (Figure 2-8B). Distinct patterns are not evident in the MDEQ and WDNR samples (Figure 2-8A & C). When data are combined across entities, temperature subclass shows weak classification strength (Figure 2-7A). No geographic or methodological classes are evident (Figure 2-9B), and no distinct patterns are apparent when samples are grouped by temperature subclass-entity and watershed size-temperature subclass-entity (Figures 2-9C & D).

NMS results for the macroinvertebrate data are shown in Figures 2-10 and 2-11[4]. As with the fish data, temperature subclass shows strong classification strength in the MPCA samples (Figure 2-10A) and weak classification strength in the WDNR (Figure 2-10B) and combined samples (Figure 2-11A). Samples do form distinct groups when grouped by entity (Figure 2-11B), and show slight patterns when grouped by watershed size (Figure 2-11C) and gradient, with the highest gradient samples (>20 m/km) clustering together (Figure 2-11D).

Overall, results show that the temperature subclasses that we used in our analyses are a weak classification scheme regionwide for both fish and macroinvertebrate assemblages, but that temperature class does reflect the identity of species found in an assemblage. The temperature classes (cold and cool-transitional) were retained for the BCG calibration. Gradient/catchment influence the number of fish species expected in a sample, but the NMS results suggests little or no influence of gradient/catchment on macroinvertebrate species composition within the cold and cool-transitional groups. Accordingly, a threshold of 10 square miles was adopted to separate headwaters from larger streams, and to adjust expectations for fish species richness. Other potential stream classes (prairie streams, wetland-influenced streams) had already been identified in earlier efforts by MPCA and had been excluded from these data, as were sites from the Northern Minnesota Wetlands ecoregion since these are known to be low gradient.

[4] MDEQ samples, which are identified to the family-level, were not used in this analysis because all other identifications were genus-level or lower. Fond du Lac samples were not included in this analysis because they are all in the same temperature subclass (cold-cool transitional).

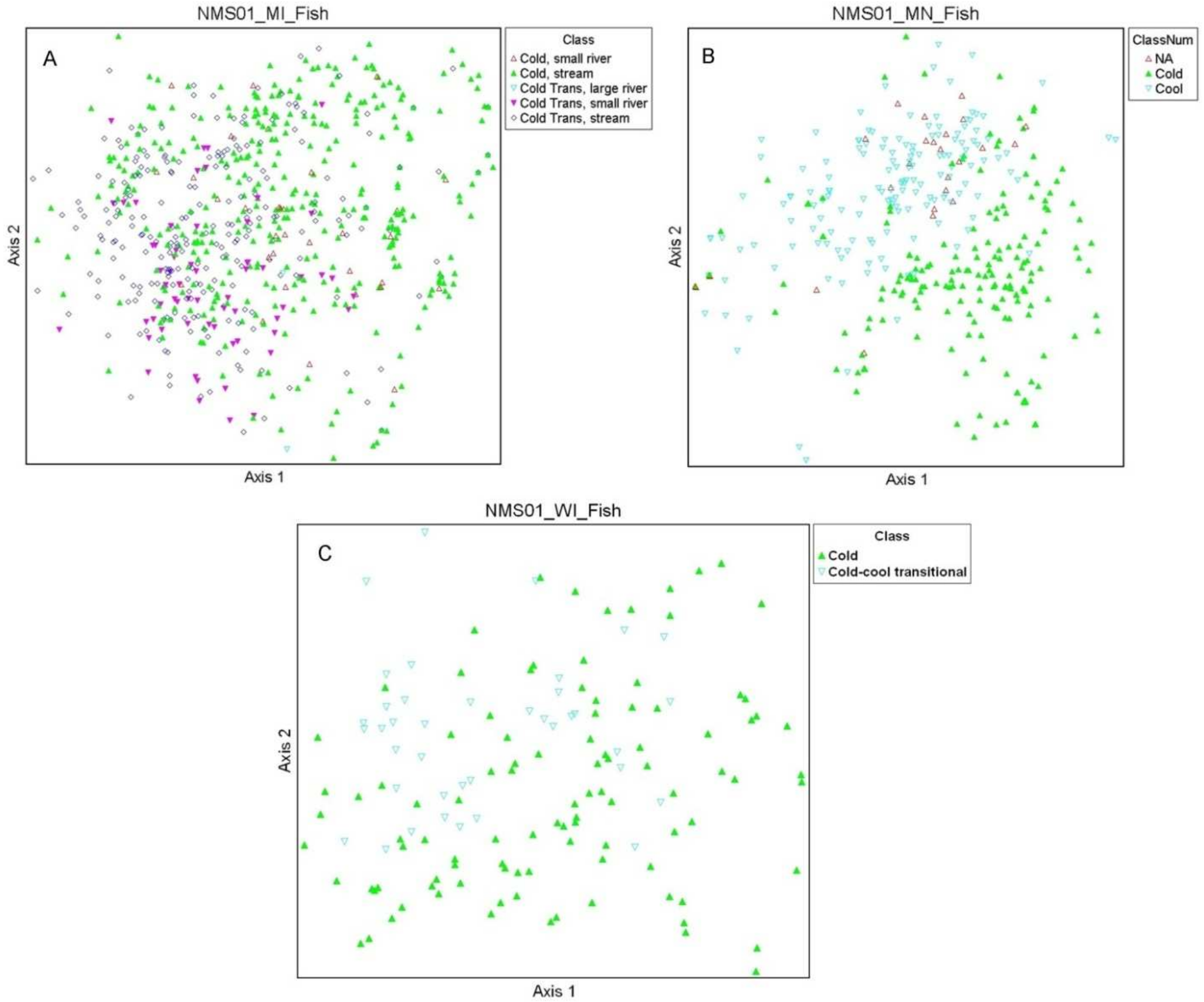


Figure 2-8. Nonmetric Multidimensional Scaling (NMS) plots for fish presence/absence species composition data from (A) Michigan (MDNR), (B) Minnesota (MPCA) and (C) Wisconsin (WNDR). Samples are grouped by the temperature subclasses provided by the states (Figure 2-1). Sites that are close together are similar to each other in their species composition. Ordinations were run using PC-ORD version 4.41 software (McCune and Medford 1999). Sorensen (Bray-Curtis) was used as the distance measure. Note: some of the WDNR samples were reclassified prior to running this ordination (all sites in the Driftless Area ecoregion were placed into the cold water subclass).

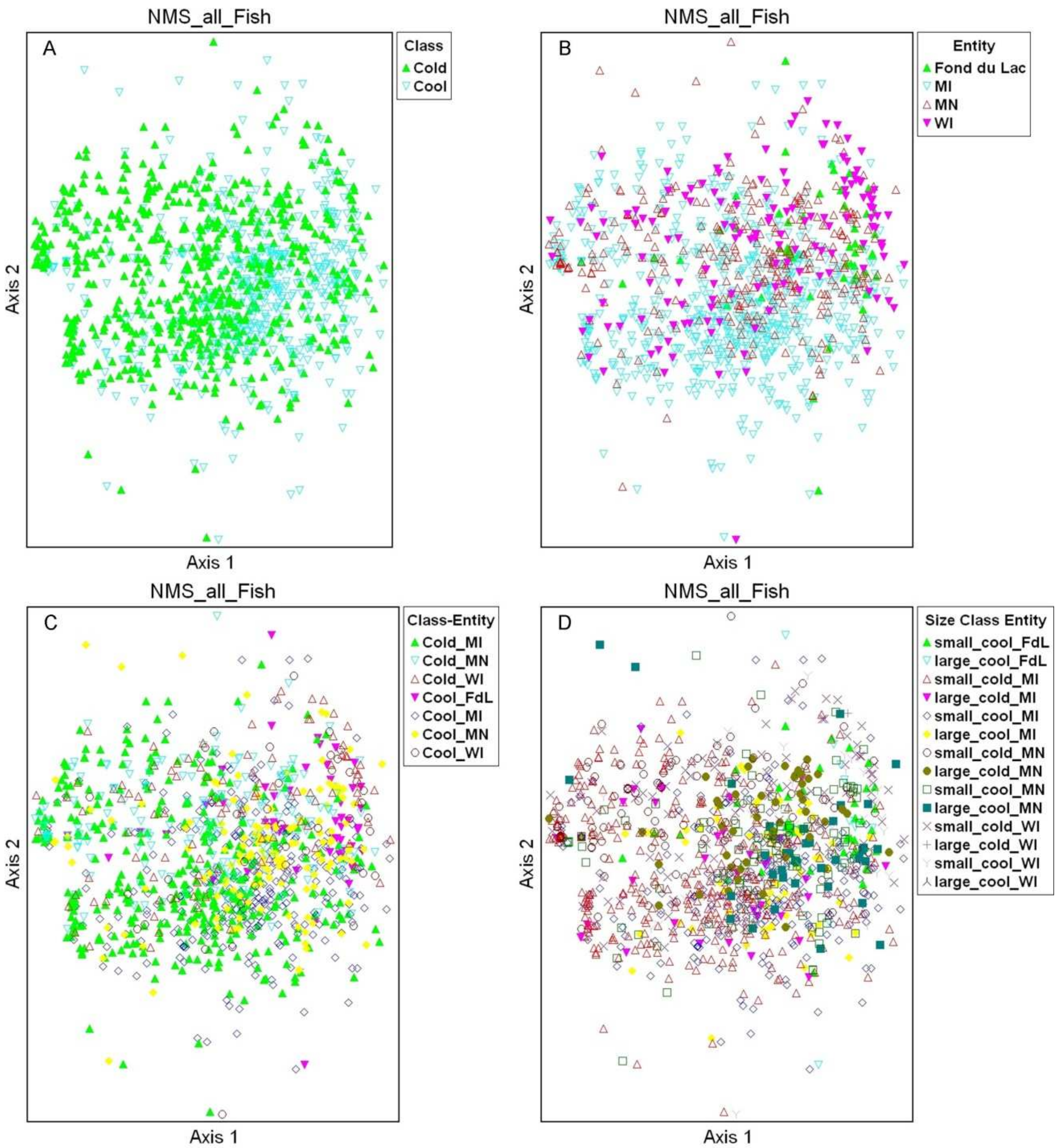


Figure 2-9. NMS plots for fish presence/absence species composition data combined across entities. Samples are grouped by (A) temperature subclass, (B) entity, (C) temperature subclass-entity and (D) size-temperature subclass-entity (small/large size categories are based on the following thresholds: 35 mi^2 MPCA, 50 mi^2 FDL, 80 mi^2 Michigan and Wisconsin (Figure 2-1)). Sites that are close together are similar to each other in their species composition. Ordinations were run using PC-ORD version 4.41 software (McCune and Medford 1999). Sorensen (Bray-Curtis) was used as the distance measure.

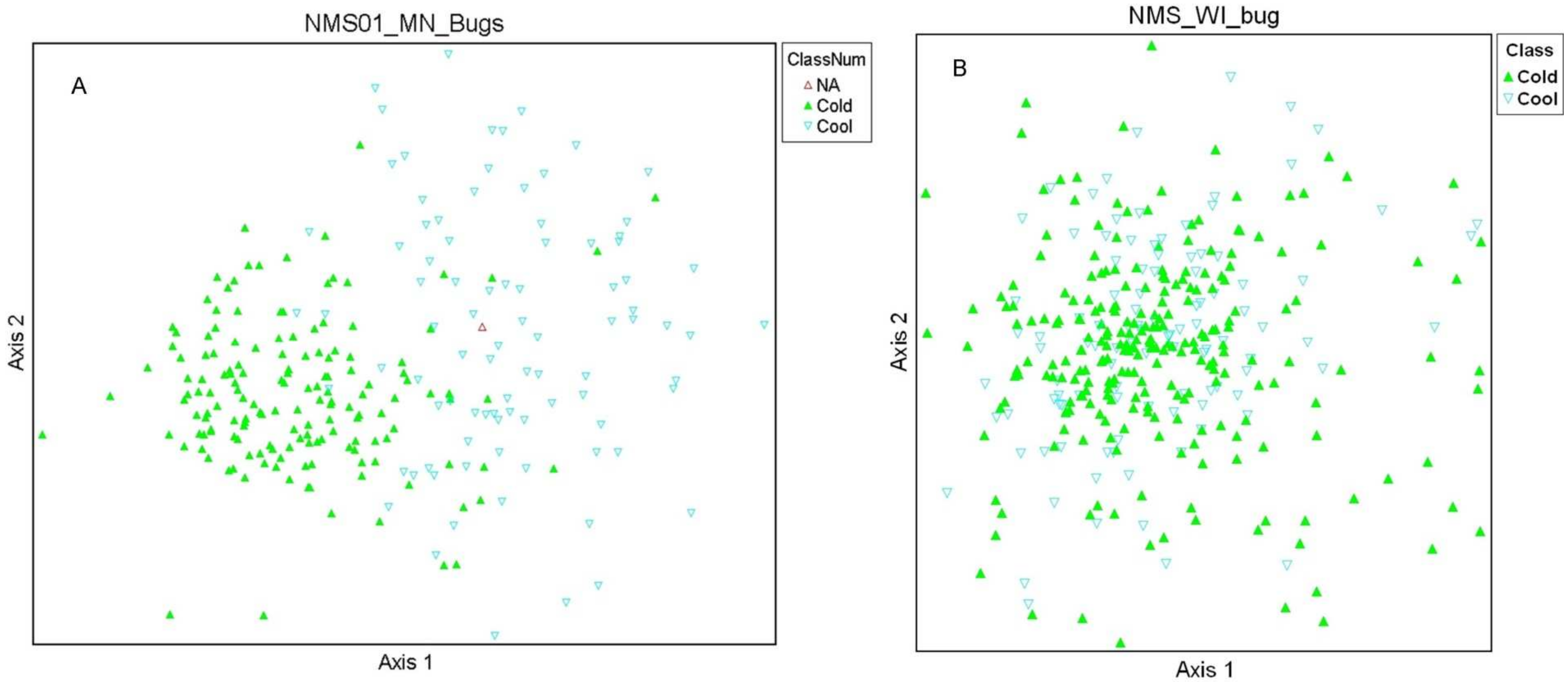


Figure 2-10. NMS plots for macroinvertebrate presence/absence taxonomic composition data from (A) Minnesota and (B) Wisconsin. Samples are grouped by the temperature subclasses provided by each state (Figure 2-1). Sites that are close together are similar to each other in their species composition. A genus-level operational taxonomic unit (OTU) was used for these analyses and only taxa that occurred at > 7 sites were included. Ordinations were run using PC-ORD version 4.41 software (McCune and Medford 1999). Sorensen (Bray-Curtis) was used as the distance measure. Note: some of the WDNR samples were reclassified prior to running this ordination (all sites in the Driftless Area ecoregion were placed into the cold water subclass).

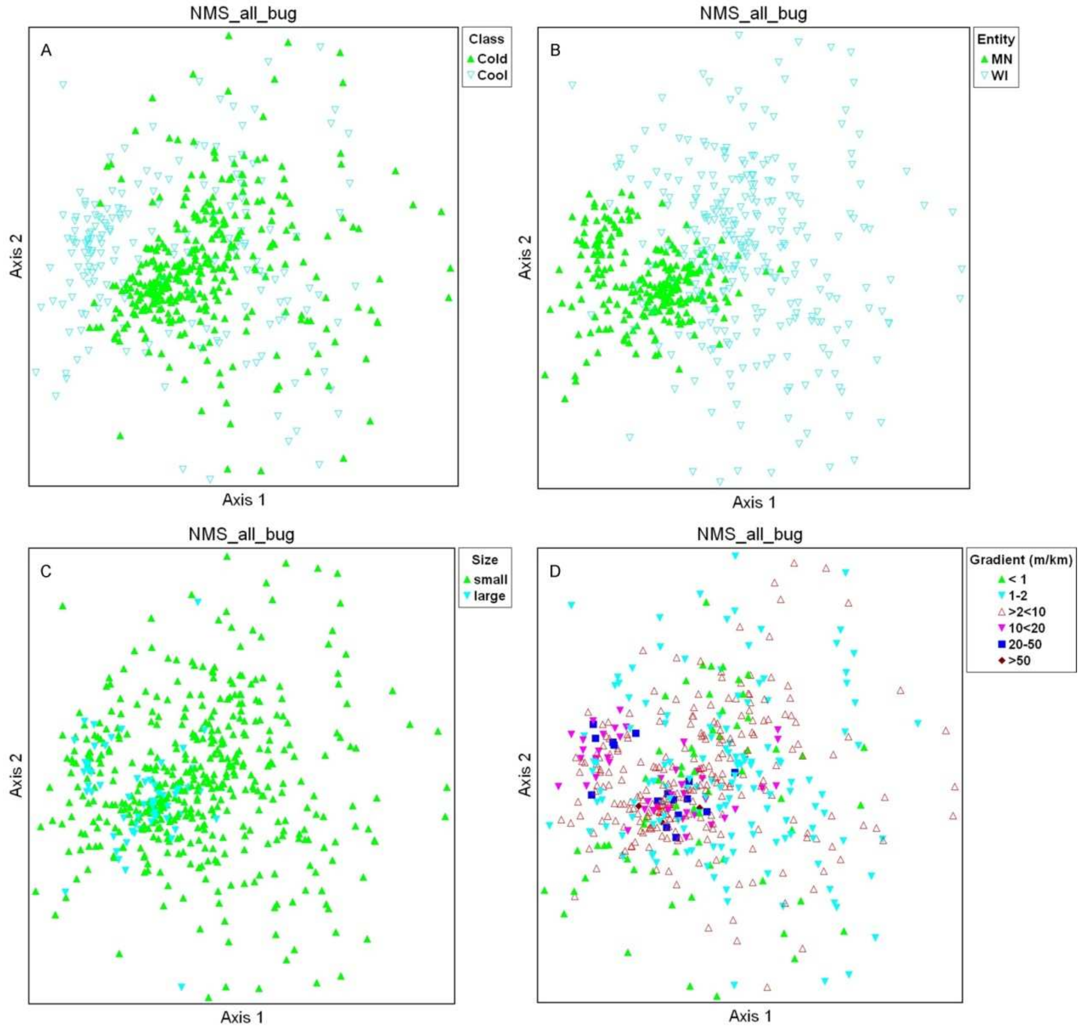


Figure 2-11. NMS plots for macroinvertebrate presence/absence taxonomic composition data for combined MPCA and WDNR samples. Samples are grouped by (A) temperature subclass, (B) entity, (C) size (small/large size categories are based on a 35 mi^2 threshold for MPCA samples and a 80 mi^2 threshold for WDNR samples) (Figure 2-1)) and (D) gradient (gradient classes were arbitrarily assigned). Sites that are close together are similar to each other in their species composition. A genus-level operational taxonomic unit (OTU) was used for these analyses and only taxa that occurred at > 7 sites were included. Also, only samples with gradient data were included in these analyses. Ordinations were run using PC-ORD version 4.41 software (McCune and Medford 1999). Sorensen (Bray-Curtis) was used as the distance measure.

2.5 BCG Calibration Exercise

Development of the BCG for a region is a collective exercise among regional biologists to develop consensus assessments of sites, and then to elicit the rules that the biologists use to assess the sites (Davies and Jackson 2006, US EPA 2007). For this project, both fish and macroinvertebrate assemblages were assessed. The goal was to develop a set of decision criteria rules for assigning sites to the BCG levels for cold and cold-cool transitional water streams. These rules are intended to accommodate differences among the tribal and state monitoring programs (i.e. different sampling methods, different levels of taxonomic resolution).

As part of this process, panelists first assigned BCG attributes to fish and macroinvertebrate taxa (BCG attribute assignments for fish can be found in Appendix C and BCG attribute assignments for macroinvertebrates can be found in Appendix D). This was done during a May 26-27, 2010 workshop in LaCrosse, WI. Next they examined biological data from individual sites and assigned those samples to levels 1 to 6 of the BCG. The intent was to achieve consensus and to identify rules that experts were using to make their assignments. During the LaCrosse workshop, panelists made BCG level assignments on approximately 20 samples from each temperature subclass. During a follow-up webinar (November 18-19, 2010), panelists made BCG level assignments on 25 additional samples from each subclass. Panelists operated on the assumption that samples had been classified correctly as cold or cold-cool transitional[5]. The panelists working on the fish data also developed a list of warmwater fish species, which can be found in Appendix E.

The data that the experts examined when making BCG level assignments were provided in worksheets. The worksheets contained lists of taxa, taxa abundances, BCG attribute levels assigned to the taxa, BCG attribute metrics and limited site information, such as watershed area, size class (i.e. headwater), average July temperature (if available), and % forest. Participants were not allowed to view Station IDs or waterbody names when making BCG level assignments, as this might bias their assignments. Sample fish and macroinvertebrate worksheets can be found in Appendix F. Other information that was gathered but not included in the worksheets was latitude and longitude, gradient, chemical water quality data, physical habitat and habitat assessment data, and additional temperature measurements and land use information. These data were not gathered with the intent of developing causal relationships; rather the intent was to define a stress gradient (mainly from land use data) and to learn more about the full range of anthropogenic disturbances that may be occurring in these streams.

A preliminary set of decision rules were developed based on these calibration worksheets. The rules were automated in an Excel spreadsheet and BCG level assignments were calculated for each sample. The model-assigned BCG level assignments were then compared to the BCG level assignments that had been made by the panelists to evaluate model performance. Another set of webinars was held (one on February 10, 2011 for fish and one on February 16, 2011 for macroinvertebrates) to go over samples that had the greatest differences between the BCG level assignments based on the model versus the panelists. Decision rules were adjusted based on group consensus. Then the panelists worked individually to make BCG level assignments on fifty additional samples (25 coldwater and 25 cold-cool transitional samples) to confirm the model. In fall 2012, we held follow-up calls with the macroinvertebrate and fish groups to reach consensus on selected subsets of these confirmation samples.

[5] In some cases, samples were reclassified based on input from the panelists. Panelists then made assignments based on the new classifications.

3 COMPREHENSIVE DECISION RULES AND BCG MODEL – COLD WATER

3.1 Fish

The coldwater fish BCG model was calibrated using MPCA, MDEQ and WDNR samples. The coldwater fish data set was comprised of 741 samples, and participants made BCG level assignments on 52 of these calibration samples. Consensus BCG level assignments and sample information for these 52 samples are summarized in Appendix G.

3.1.1 Site Assignments and BCG Level Descriptions

The group assigned coldwater fish samples to 5 BCG levels (BCG levels 1-5). There was never a majority opinion for coldwater sites at BCG Level 6, which is the most disturbed condition. The first BCG level described in Davies and Jackson (2006) consists of pristine sites. During the first day of the LaCrosse workshop, panelists made 4 BCG level 1 assignments[6]. The panelists struggled with the question as to whether BCG level 1 samples existed in the Midwest. This was because there is not enough information to know what the historical undisturbed assemblage in this region looked like. They felt that they needed more information, in particular on genetics (stocked vs. native) and age/size class, to discriminate between BCG level 1 & 2 samples. If this information were available, they would assign samples to BCG level 1 if: 1) native, naturally reproducing trout were present (in Michigan, this would have included the arctic grayling [now extirpated]); and 2) a certain proportion of these trout were large (similar to the large sizes reported in historical records). This question of whether or not BCG level 1 sites currently exist in the region needs to be further explored.

3.1.2 BCG Attribute Metrics

Examinations of taxonomic attributes among the BCG levels determined by the panel showed that several of the attributes are useful in distinguishing levels, and indeed, were used by the panel's biologists for decision criteria. The most important considerations were number of total taxa, presence and relative abundances of native and non-native trout species, and percent individuals and percent taxa metrics for Attribute II, II+III, IV and V taxa. Statistical summaries of each attribute metric at each BCG level are provided in Table 3-1, and total taxa, percent individuals and percent taxa metrics are shown graphically in Figures 3-1 through 3-4. Plots for additional metrics can be found in Appendix G.

Total richness showed a relatively monotonic pattern, increasing as the assigned BCG level went from 1 to 5 (Figure 3-1). In the coldwater fish BCG dataset, watershed size is significantly and positively correlated with total fish species richness (r^2=0.20, $p<0.01$) (Figure 3-2)[7]. Expectations of the panelists were in keeping with this relationship. In small, unimpaired coldwater streams, they expect the assemblage to be comprised of 3-4 species. As the streams increases in size, they

[6] More specifically, these were BCG level 1- samples. Within each BCG level, the group assigned samples to 3 different subclasses, which they designated with + (best) and – (worst).

[7] A similar pattern was seen in a separate analysis that was done on cold, cold-cool transitional and warm water samples in the MPCA dataset; species richness increased sharply to 50 mi^2, then increased gradually up to about 500 mi^2, above which there was no further pattern .

expect more species to naturally be present. This posed a challenge for panelists because they had the same expectations with respect to thermal degradation; the more degraded the stream, the more species they expected to be present.

Table 3-1. Ranges of attribute metrics in coldwater fish samples by panel nominal (majority) BCG levels.

		Panel Nominal BCG Level				
Attributes	**Metric**	**1 (n=4)**	**2 (n=12)**	**3 (n=14)**	**4 (n=12)**	**5 (n=9)**
0 General	**Total Taxa**	2	3-13	1-15	4-23	7-20
	Total Ind	22-71	36-263	38-929	59-773	45-3032
II Highly sensitive taxa	**# Taxa**	1	1-3	0-2	0-1	0-1
	Pct Taxa	50	15-67	0-25	0-25	0-8
	Pct Ind	49-93	3-83	0-39	0-9	0-1
III Intermediate sensitive taxa	**# Taxa**	0-1	0-3	0-4	1-3	0-3
	Pct Taxa	0-50	0-60	0-33	7-25	0-17
	Pct Ind	0-51	0-95	0-48	0-26	0-38
II + III All sensitive taxa	**# Taxa**	1-2	1-5	0-4	1-3	0-3
	Pct Taxa	50-100	25-80	0-44	7-50	0-25
	Pct Ind	89-100	37-98	0-48	0-26	0-38
IV Intermediate tolerant taxa	**# Taxa**	0-1	0-6	0-7	0-14	4-10
	Pct Taxa	0-50	0-75	0-63	0-61	27-58
	Pct Ind	0-11	0-41	0-77	0-88	35-90
	Pct Most Dom Ind	0-11	0-30	0-41	0-68	15-61
V Tolerant taxa	**# Taxa**	0	0-1	0-2	0-6	1-6
	Pct Taxa	0	0-20	0-25	0-43	8-35
	Pct Ind	0	0-3	0-20	0-17	3-23
	Pct Most Dom Ind	0	0-3	0-14	0-16	1-13
Va Highly tolerant native taxa	**# Taxa**	0	0-1	0-2	0-3	0-5
	Pct Taxa	0	0-14	0-25	0-23	0-27
	Pct Ind	0	0-8	0-16	0-9	0-15
	Pct Most Dom Ind	0	0-8	0-10	0-8	0-15
VI Non-native or intentionally introduced taxa	**# Taxa**	0	0-2	0-2	0-2	0-1
	Pct Taxa	0	0-33	0-100	0-25	0-8
	Pct Ind	0	0-59	0-100	0-55	0-2
	Pct Most Dom Ind	0	0-59	0-100	0-55	0-2
VIa Highly tolerant non-native taxa	**# Taxa**	0	0	0-1	0-1	0-1
	Pct Taxa	0	0	0-7	0-8	0-8
	Pct Ind	0	0	0-1	0-3	0-1
	Pct Most Dom Ind	0	0	0-1	0-3	0-1

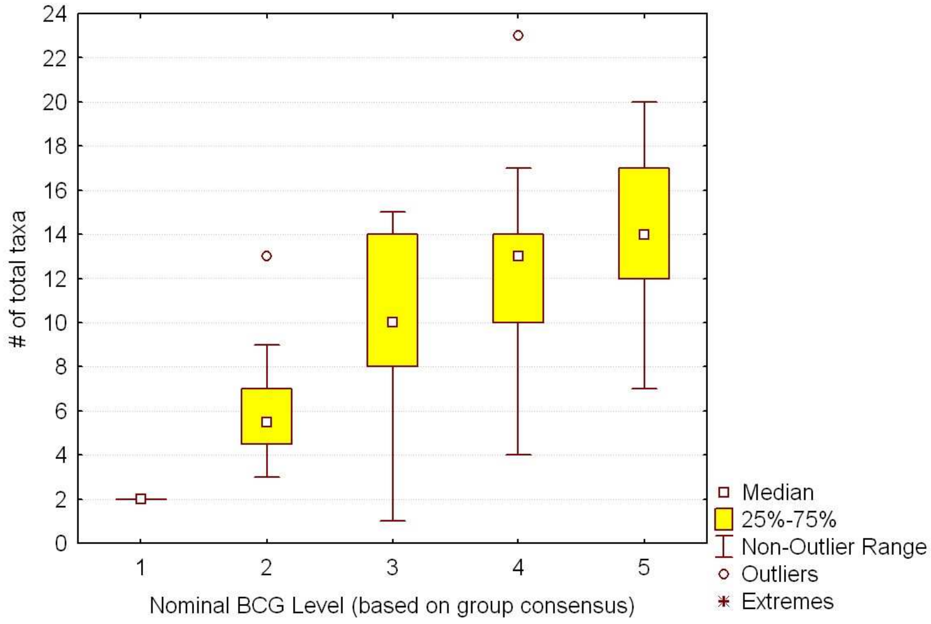


Figure 3-1. Box plots of total taxa metric values for cold water fish samples, grouped by nominal BCG level (panel majority choice). Sample sizes as in Table 3-1.

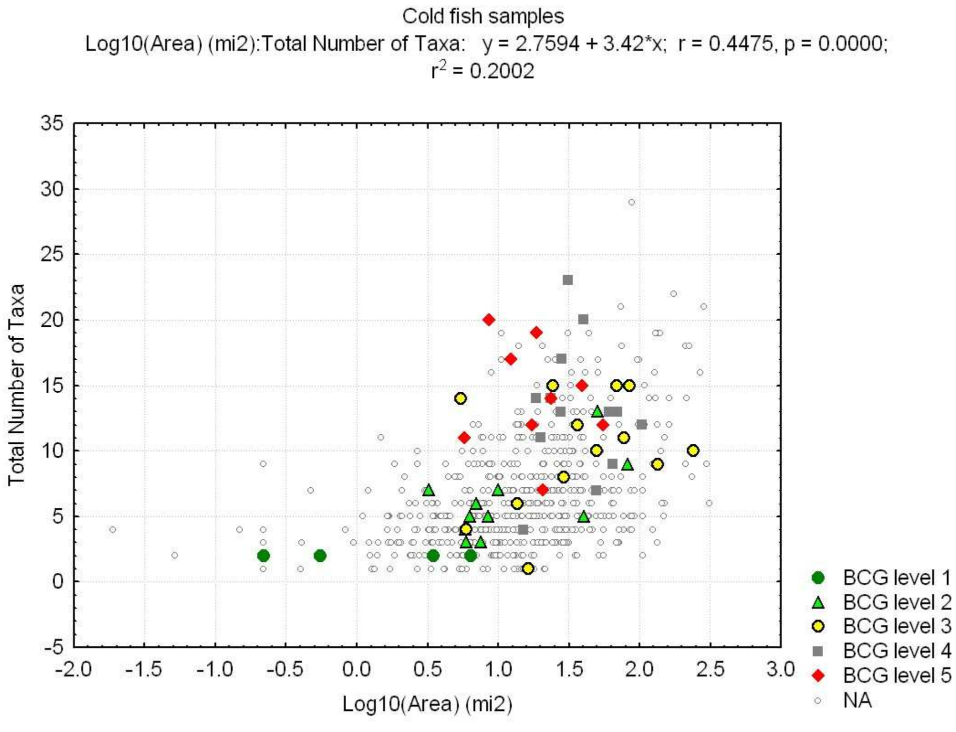


Figure 3-2. Relationship between total taxa metric values and watershed area for cold water fish samples. Samples are coded by nominal BCG level (panel majority choice).

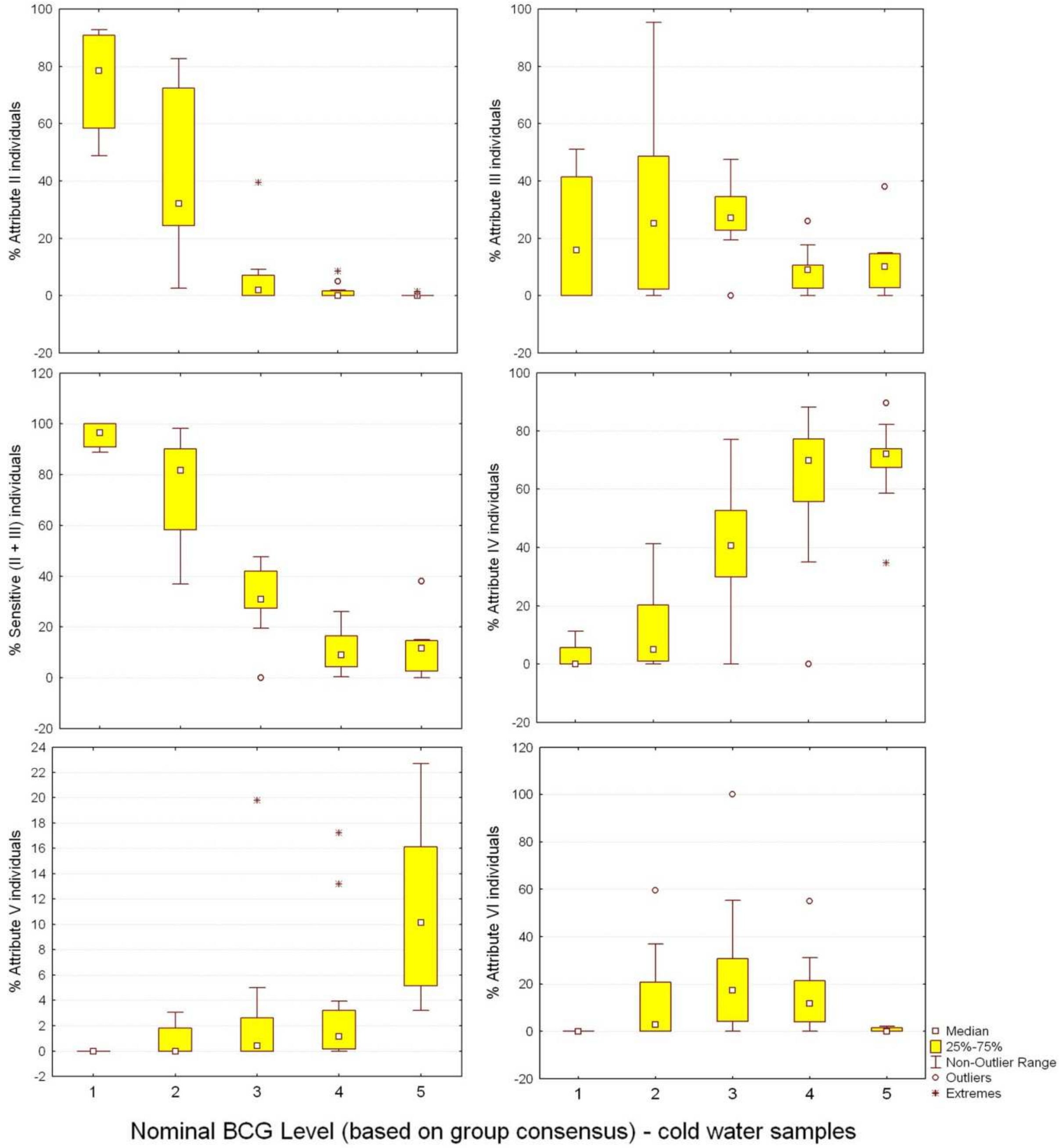


Figure 3-3. Box plots of BCG attribute II-VI percent individual metrics for 51 cold water sites, grouped by nominal BCG level (panel majority choice). Sample sizes as in Table 3-1.

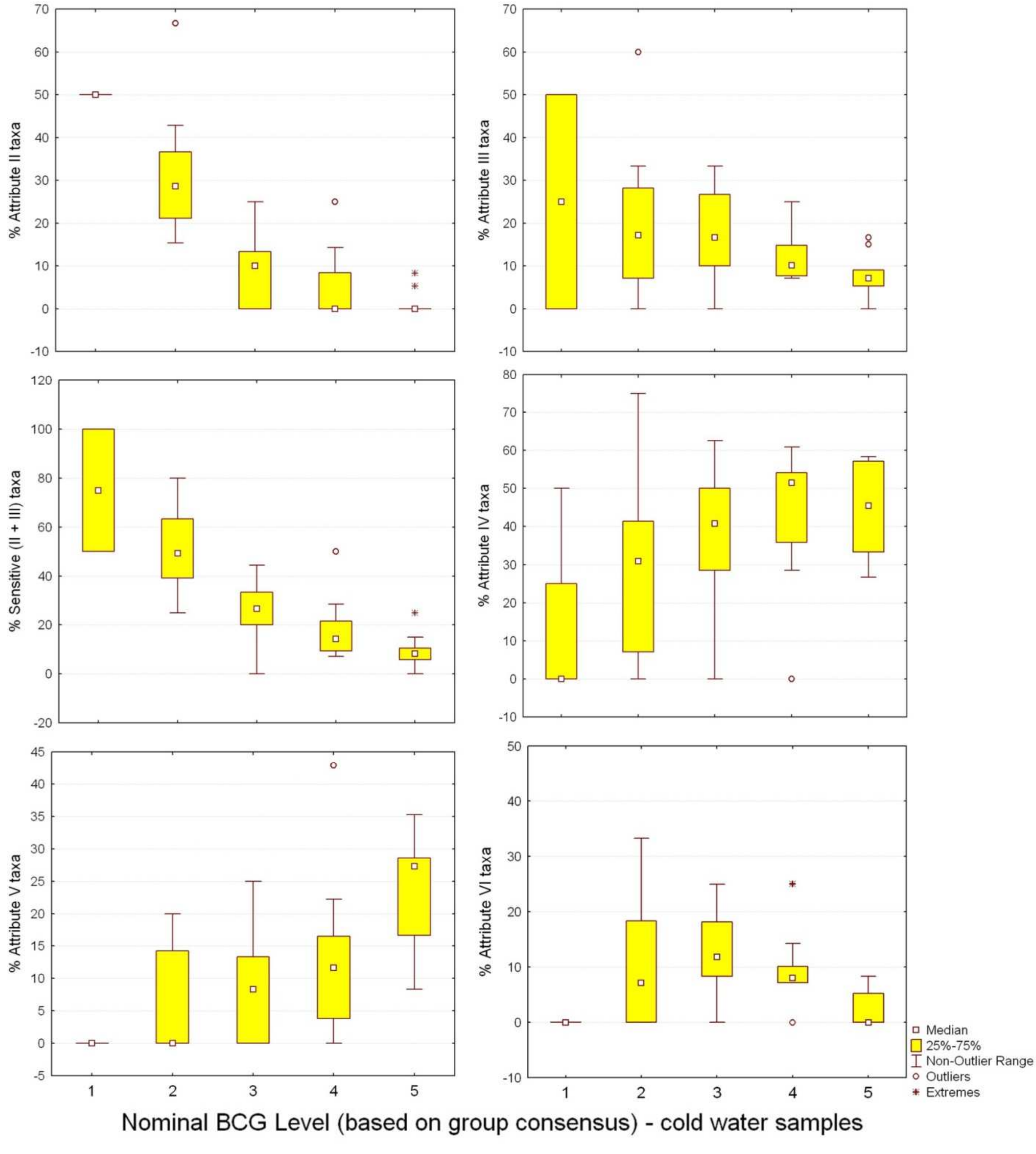


Figure 3-4. Box plots of BCG attribute II-VI percent taxa metrics for 51 cold water sites, grouped by nominal BCG level (group majority choice). Sample sizes as in Table 3-1.

In this data set, the 4 BCG level 1 samples only had 2 taxa (native brook trout and stickleback or sculpin). These samples were from small streams (watershed sizes of the 3 Michigan sites were < 3.5 mi^2 and the Minnesota site was 6.4 mi^2). Panelists consider native brook trout, sculpin and lamprey to be good indicator species in these small, high quality coldwater streams. Most of the BCG level 2 samples were smaller streams as well (<12 mi^2). The 3 larger sites (40, 50 and 82 mi^2) that received BCG level 2 assignments were located in Michigan. Assemblages in these larger streams had 5, 9 and 13 total taxa, and included native brook trout, sculpins and lamprey.

Presence and relative abundance of native and non-native trout species are also important considerations when panelists make BCG level assignments. In the BCG data set, non-native trout consist of brown trout and occasional rainbow trout. These are captured in the Attribute VI metrics. Brook trout are considered to be native at all sites except for ‘above barrier’ sites in Minnesota, which are generally in the northern part of the state. Because we were unable to obtain information on whether or not the trout were naturally reproducing, panelists made BCG level assignments under the assumption that all trout were naturally reproducing. It was difficult for panelists to reach a consensus on how to rate samples with non-native trout. Non-native trout are regarded as indicators of good water quality and coldwater habitat, but they also represent an altered fish assemblage. The general consensus was to ‘bump’ samples down a partial level (i.e. from a 2+ to a 2) for every non-native trout species that was present. Panelists also considered the abundance of non-native trout in relation to native species like brook trout and sculpin. If non-native trout comprised a larger proportion of the assemblage and appeared to be detrimentally impacting the native species, panelists generally downgraded samples by a BCG level (i.e. from a level 2 to a level 3).

For the BCG attribute metrics, the percent individuals and percent taxa metrics were generally more effective at discriminating between BCG levels than richness metrics. In particular, the Attribute II+III, IV and V metrics are informative. The Attribute II+III and IV metrics show relatively monotonic patterns, with Attribute IV metrics increasing and Attribute II+III metrics decreasing as the assigned BCG level goes from 1 to 5 (Figs. 3-3 & 3-4). The total taxa, Attribute II, II+III and IV metrics are most effective at discriminating between BCG levels 2 and 3. The transition from BCG level 3 to 4 is best captured by the Attribute II+III and IV percent individuals metrics and the Attribute II+III percent taxa metric. BCG level 5 is discriminated from other BCG levels by the complete loss of Attribute II taxa and the concomitant increase in number of Attribute V taxa and individuals. Panelists consider centrarchids and northern pike to be good indicator species for disturbed streams.

3.1.3 BCG Rule Development

The coldwater rules, which are shown in Table 3-2, were derived from discussions with the panelists on why individual sites were assessed at a certain level. They follow the observations shown in Table 3-1 and in Figures 3-1 through 3-4. The rules were calibrated with the 52 coldwater fish samples rated by the group, and were adjusted so that the model would replicate the panel's decisions as closely as possible. Inevitably, there were some decisions where the panel may have used different, unstated rules, or where rules were inconsistently applied.

Table 3-2. Decision rules for fish assemblages in coldwater and coolwater (cold-cool transitional) streams. Rules show the midpoints of fuzzy decision levels (see Fig. 3-5), where membership in the given BCG level is 50% for that metric.

BCG Level	Metrics	Coldwater				Coolwater	
		BT Native		BT Non-native		BT Native	BT Non-native
1						Meets Coldwater Level 1, OR Coolwater rules below:	
	# Total taxa	≤4				> 3 and < 14	
	% Most sensitive taxa (Att 1 + 2)	present				present	
	% Brook trout individuals	Present		absent		present	absent
	% Sensitive taxa (Att 1 + 2 + 3)	> 50%				> 40%	
	% Sensitive individuals (Att 1 + 2 + 3)	> 60%				> 40%	
	% Tolerant (Att 5 + 5a + 6a) individuals	< 5%				< 5%	
	% Non-native salmonids (Att 6)	absent				absent	
2	**Metrics**	**BT Native**		**BT Non-native**		**BT Native**	**BT Non-native**
		Alt 1	**Alt 2**	**Alt 1**	**Alt 2**		
	# Total taxa	If watershed size ≤ 10 mi2, < 8 If watershed size > 10 mi2, > 3 and < 14				< 20	
	% Most sensitive taxa (Att 1 + 2)	Present		NA		Present	NA
	% Brook trout individuals	Present		NA		Present	NA
	% Sensitive taxa (Att 1 + 2 + 3)	> 40%	> 20%	> 20%		> 30%	
	% Sensitive individuals (Att 1 + 2 + 3)	NA		> 70%	NA	> 12%	
	% Brook trout: total salmonid individuals	> 40%		NA		> 40%	NA
	% Tolerant non-salmonid (Att 5 + 5a + 6a) individuals	< 10%	Absent	NA	< 10%	< 20%	

Table 3-2. continued…

BCG Level	Metrics	Coldwater Rule	Coldwater Alt Rule	Coolwater Rule	Coolwater Alt Rule
		(brook trout native/non-native status not used)			
3	# Total taxa	If watershed size > 10 mi2, > 5		< 20	
3	% Salmonid individuals	present		--	
3	% Sensitive & non-native salmonid (Att 1 + 2 + 3 + 6) taxa	> 25%		--	
3	% Sensitive & non-native salmonid (Att 1 + 2 + 3 + 6) individuals	> 20%		--	
3	% Non-native salmonid (Att 6): total sensitive(Att 1 + 2 + 3 + 6) individuals	< 70%		--	
3	% Sensitive taxa (Att 1 + 2 + 3)	--		≥ % Tolerant (Att 5 + 5a + 6a) taxa	NA
3	% Sensitive individuals (Att 1 + 2 + 3)	--		NA	≥ 2*Tolerant (Att 5 + 5a + 6a) % individs
3	% Most dominant intermediate tolerant taxa (Att 4)	--		If watershed size > 10 mi2, < 40%	
3	% Extra tolerant individuals (Att 5a + 6a)	--		< 5%	
4	**Metrics**	**(no alternate rules)**			
4	% Sensitive & salmonid taxa (Att 2+3+6)	> 5%		> 5%	
4	% Sensitive & salmonid individuals (Att 2+3+6)	> 5%		> 5%	
4	% Tolerant taxa (Att 5 + 5a + 6a)	< 45%		--	
4	% Extra tolerant individuals (Att 5a + 6a)	< 10%		< 20%	
5	**Metrics**	**(no alternate rules)**			
5	# Total taxa	> 2		> 3	
5	% Intermediate tolerant taxa (Att 4)	> 10%		> 10%	

In the model, rules work as a logical cascade from BCG Level 1 to Level 6. A sample is first tested against the Level 1 rules; if a single rule fails, then the Level fails, and the assessment moves down to Level 2, and so on (Figure 3-5). All required rules must be true for a site to be assigned to a level. As described in Section 3.1.3, membership functions had to be defined for the richness and percent individual metrics. The midpoints, which are shown in Tables 3-3a & 3-3b, were used as approximate rules, with the understanding that the model will allow some variation around the midpoint to allow for ties and near-ties between BCG levels.

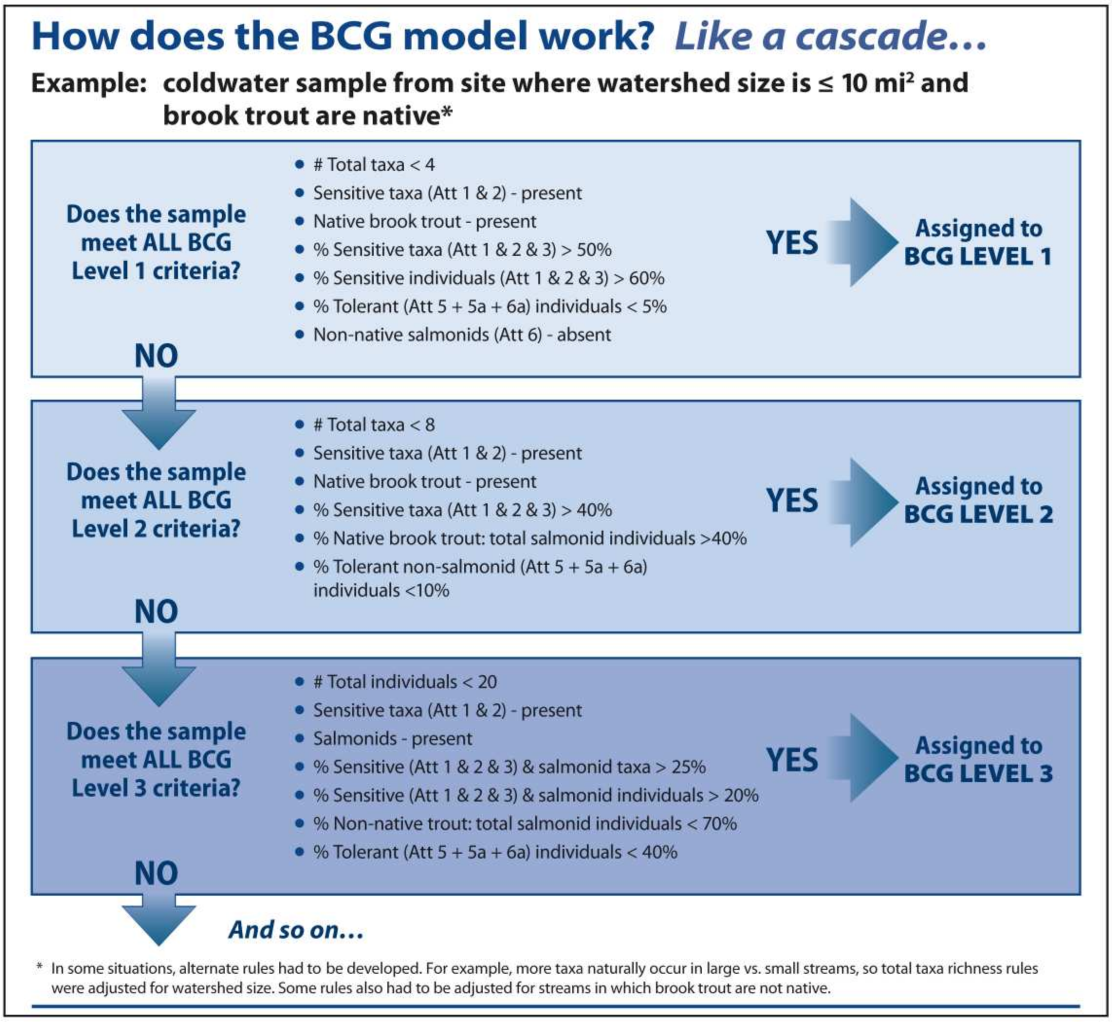


Figure 3-5. Flow chart depicting how rules work as a logical cascade in the BCG model.

The rules shown in Table 3-2 have been developed for distinguishing BCG levels for coldwater and transitional cold-cool fish samples. These rules have been verified by the panelists. They follow a general pattern of decreasing richness of sensitive taxa and increasing relative abundance of tolerant individuals as biological condition degrades. Some levels have alternate rules.

Coldwater BCG Level 1 requires native brook trout and most sensitive (Attribute I & II) taxa to be present and non-native salmonids to be absent. There must be fewer than 5 total taxa, more than half of the assemblage must be comprised of sensitive (Attribute I, II & III) taxa and individuals, and fewer than 5 percent of the individuals may be tolerant (Attribute V, Va and VIa) (Table 3-2).

Table 3-3a. Membership functions for richness metrics.

Midpoint	Fuzzy Range
Present/absent	NA
3.5	± 1.5
8	± 2
13.5	± 2.5
20	± 4
30, 40, 50, 60[1]	± 5

[1]multiple midpoints at decadal abundance.richness

Table 3-3b. Membership functions for percentage metrics.

Midpoint	Fuzzy Range
0.5	± 0.5
2	± 1
5	± 2
10	± 3
20,30,40,50,60,70[1]	± 5%

[1]multiple midpoints at decadal percentages

Watershed size and native/non-native status of brook trout are considerations in the BCG level 2 rules. In streams with watershed sizes of ≤10 square miles, there must be fewer than 8 total taxa. In streams with watershed sizes of greater than 10 square miles, the total number of taxa is required to be greater than 3 and less than 14. The 10 square mile watershed size threshold is based on the best professional judgment of the panelists and unpublished data from MPCA. In streams where brook trout are native, brook trout and most sensitive (Attribute I & II) taxa must be present and the ratio of brook trout individuals to total individuals must be >40%. Two of the metrics - percent sensitive (Attribute I, II & III) taxa and percent tolerant non-salmonid (Attribute V, Va & Via) individuals- are subject to alternate rules. If the value of the percent sensitive taxa metric is > 40%, then the % tolerant non-salmonid individuals must be < 10%. Alternatively, if the percent sensitive taxon metric is > 20%, the % tolerant non-salmonid individuals metric must be < 1%.

BCG level 3 rules are independent of brook trout native/non-native status, but watershed size is still a consideration. In streams with watershed sizes > 10 square miles, there must be more than 5 total taxa Salmonids must be present, the % sensitive and non-native salmonid (Attribute I, II, III & VI) taxa and individuals must exceed thresholds of 25 and 20%, respectively, and the ratio of non-native salmonid to total salmonid individuals must be < 70%.

BCG Level 4 is characterized by decreased richness and abundance of salmonids and sensitive taxa. The disappearance of these sensitive taxa is what discriminates Level 5 from Level 4. However, these taxa must still be present in level 4 samples - the percent sensitive and salmonid (Attribute II, III, and VI) taxa and individuals metrics must be greater than 5%. There is also a level 4 requirement for tolerant taxa. The percent tolerant taxa (Attribute V, Va and VIa) must not exceed 45% and the percent extra tolerant (Attribute Va & VIa) individuals must be < 10%. Level 5 may have substantial total taxa richness (number of total taxa must be > 2). More than 10% of the taxa must be intermediate tolerance (Attribute IV).

3.1.4 Model Performance

To measure model performance with the 52-sample calibration dataset, we considered two matches in BCG Level choice: an exact match, where the BCG decision model's nominal level matched the panel's majority choice; and a "minority match", where the model predicted a BCG level at the panel's minority opinion, and differing by one level of the majority expert opinion. When model performance was evaluated, the coldwater fish model matched exactly with the regional biologists' BCG level assignments on 90.4% of the coldwater samples (Table 3-4). All of the model assignments were within one level of the majority expert opinion. Where there were differences, there was a slight tendency for the model to rate samples better than the panelthe model assigned 3 samples to a BCG level that was 1 level better than the panelists' assignment, and assigned 2 samples to a BCG level that was 1 level worse than the panelists.

In order to confirm the model, panelists made BCG level assignments on 25 additional coldwater samples. When nominal level assignments from the BCG decision model were compared to the panelists' nominal level assignments, the coldwater fish model matched exactly with the regional biologists' BCG level assignments on 84% of the coldwater confirmation samples. Once again, all of the model assignments were within one level of the majority expert opinion, and the tendency was for the model to rate samples better than the panel (Table 3-4). Among the samples where model and panel disagreed, panelists considered 2 to have 'strange assemblages' and 1 to be questionable due to low density. Based on the combined results, in 88.3% of cases, the coldwater fish model predicts the same BCG level as the majority expert opinion[8].

Table 3-4. Model performance – cold water fish samples

Difference	Calibration	Confirmation
2 better	0	0
1 better	3	3
same	47	21
1 worse	2	1
2 worse	0	0
Total # Samples	**52**	**25**
% Correct	**90.4%**	**84%**

[8] It should be noted that in 4 instances, the model output was a tie between two BCG levels. We considered these to be matches if the range of model assignments matched with the range of panelist calls. For example, if the model output was a tie between BCG levels 1 and 2 and the panelist calls ranged from 1 to 2, we called this a match. If the model output was a tie between BCG levels 1 and 2 and the panelist calls ranged from 2 to 3, we considered this to be a difference of 1 BCG level.

3.2 Macroinvertebrates

3.2.1 Site Assignments and BCG Level Descriptions

The coldwater macroinvertebrate BCG model was calibrated using MPCA and WDNR samples[9]. The data set was comprised of 406 samples, and participants initially made BCG level assignments on 45 calibration samples. Panelists later decided to exclude spring samples, which reduced the calibration dataset to 42 samples. Consensus BCG level assignments and sample information for these 42 samples are summarized in Appendix H.

The group assigned coldwater macroinvertebrate samples to 4 BCG levels (BCG levels 2-5). Only one of the 42 calibration samples was assigned to BCG level 2 (many of the coldwater sites are impacted by agricultural activities, as shown in Figure 2-7). The panelists considered developing a different set of rules for samples with very cold water temperatures (i.e. less than 15°C) but in the end, decided to assess the coldwater samples as one group. Efforts were made to exclude low gradient samples from this exercise.

3.2.2 BCG Attribute Metrics

Because one entity, WDNR, identifies organisms to the species-level, and MPCA identifies taxa to the genus-level, differences in taxonomic resolution across samples had to be resolved before BCG attribute metrics could be calculated. A genus-level operational taxonomic unit (OTU) was deemed to be most appropriate for this dataset, and species-level identifications were collapsed to the genus-level OTU prior to calculating the metrics.

Examinations of taxonomic attributes among the BCG levels showed that several of the attributes are useful in distinguishing levels. These attributes were used by the panel's biologists for decision criteria. The most important considerations were number of total taxa, percent individuals and percent taxa metrics for Attribute II, II+III, IV and V taxa, and metrics pertaining to Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa. Statistical summaries of each attribute metric at each BCG level are provided in Table 3-5, and total taxa, percent individuals and percent taxa metrics are shown graphically in Figures 3-6 through 3-9. Plots for additional metrics can be found in Appendix H.

Although decision rules pertaining to number of total taxa were included in the BCG coldwater macroinvertebrate model, this metric was generally ineffective at discriminating between BCG levels. The panelists instead tended to focus on the species that were present and the BCG attribute metrics. Panelists considered the following taxa to be indicators of cold water temperature – *Baetis tricaudatus, Gammarus, Micropsectra, Caecidotea brevicauda brevicauda*[10] and Naididae. Because organisms were only identified to the genus-level in the MPCA and FDL samples, panelists sometimes had to make assumptions about what species were present. For example, if a MPCA sample had Baetis plus other cold water taxa, the panelists generally assumed that the organism was *Baetis tricaudatus*. Similarly, if Oligochaeta were

9 We did not use MDEQ samples in the macroinvertebrate analyses because we used a genus-level operational taxonomic unit, and MDEQ identifies to the family-level.

10 This species is associated with strong groundwater inputs in WI (Dimick and Schmude, personal communication).

present in samples with other cold water taxa, panelists generally assumed that the organism was Naididae. It should be noted that these organisms are regarded as indicators of cold water but not of good water quality.

Table 3-5. Ranges of attribute metrics in coldwater macroinvertebrate samples by panel nominal (majority) BCG levels.

Attributes	Metric	2 (n=1)	3 (n=15)	4 (n=24)	5 (n=5)
0 General	**Total Taxa**	26	11-41	12-50	28-36
	Total Ind	301	236-340	111-3151	195-335
II Highly sensitive taxa	**# Taxa**	4	0-5	0-3	0-2
	Pct Taxa	15	0-25	0-14	0-7
	Pct Ind	11	0-17	0-5	0-1
III Intermediate sensitive taxa	**# Taxa**	8	2-11	2-12	4-6
	Pct Taxa	31	15-44	13-32	13-21
	Pct Ind	50	1-38	1-28	2-15
II + III All sensitive taxa	**# Taxa**	12	2-15	3-12	4-8
	Pct Taxa	46	15-69	13-45	13-29
	Pct Ind	61	1-52	2-28	2-15
	SensEPT # Taxa	7	0-8	1-6	0-4
	SensEPT_Pct Ind	33	0-48	0-24	0-3
IV Intermediate tolerant taxa	**# Taxa**	7	4-15	5-29	10-19
	Pct Taxa	27	25-56	32-66	36-61
	Pct Ind	29	26-95	33-96	36-73
	Pct Most Dom Ind	13	9-67	10-87	11-27
V Tolerant taxa	**# Taxa**	5	0-5	0-10	5-8
	Pct Taxa	19	0-23	0-26	18-26
	Pct Ind	6	0-18	0-47	12-54
	Pct Most Dom Ind	3	0-16	0-47	4-39

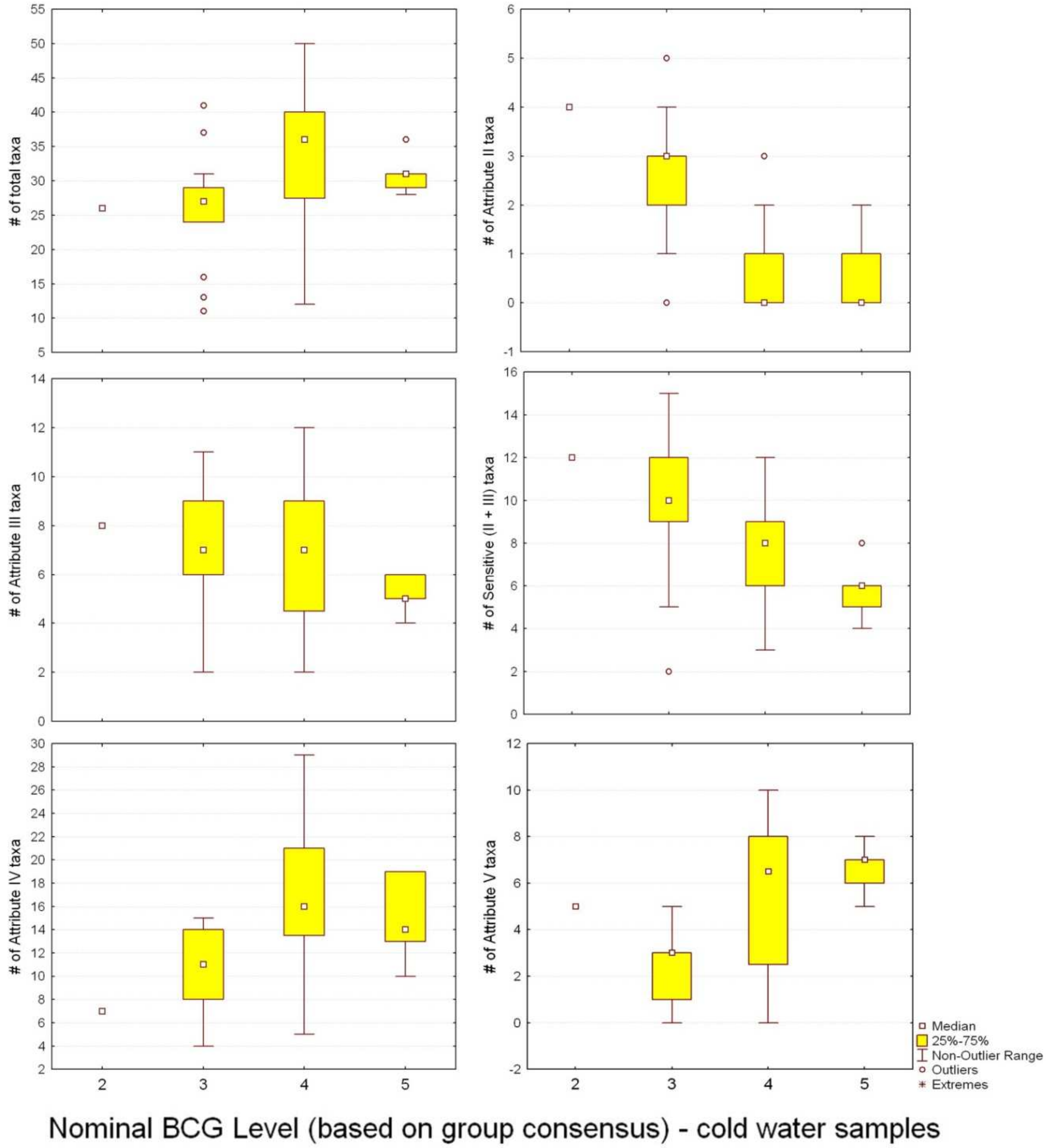


Figure 3-6. Box plots of total taxa and BCG attribute II-V richness metrics for 45 coldwater macroinvertebrate samples, grouped by nominal BCG level (panel majority choice). Sample sizes as Table 3-4.

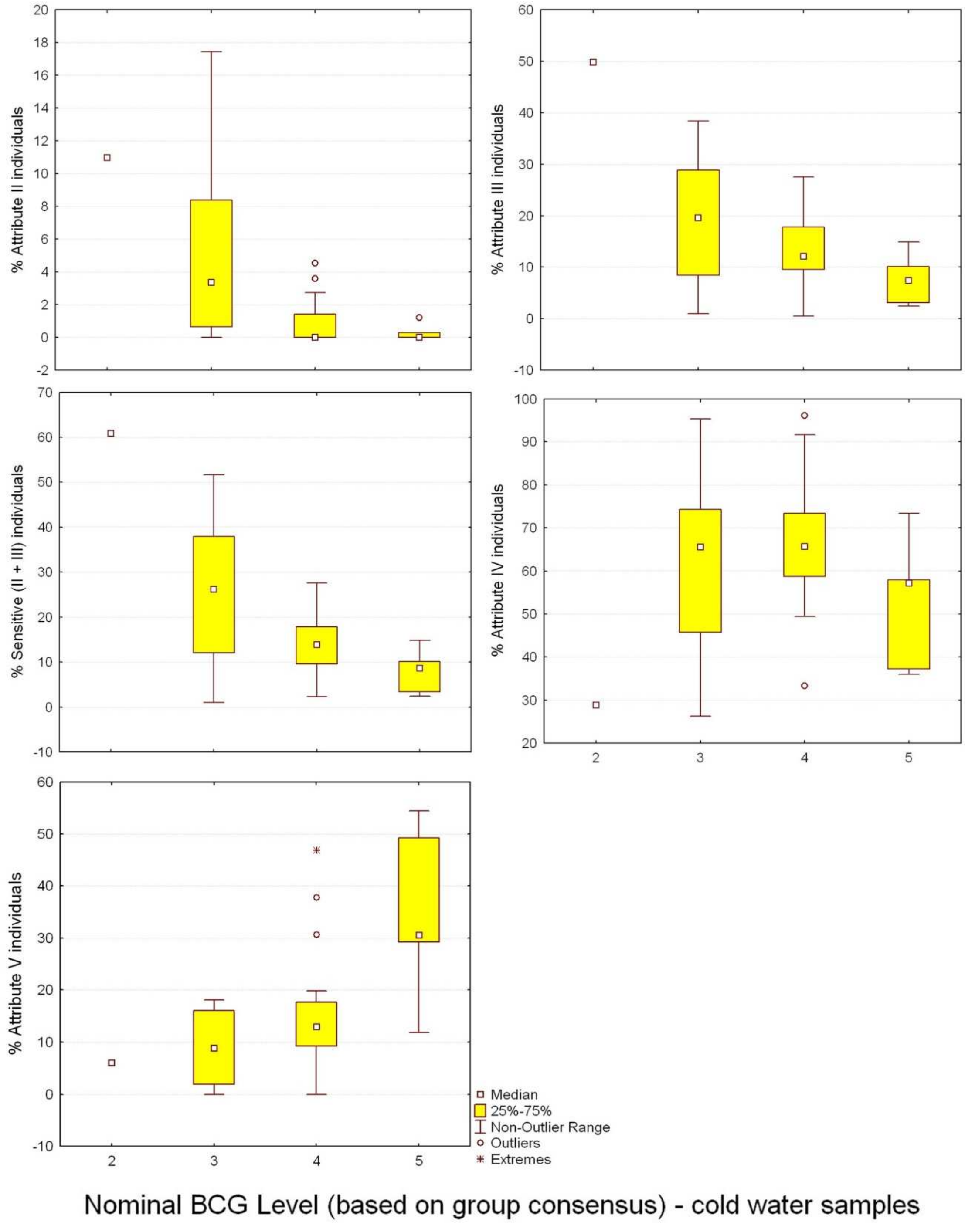


Figure 3-7. Box plots of BCG attribute II-V percent individual metrics for 45 coldwater macroinvertebrate samples, grouped by nominal BCG level (panel majority choice). Sample sizes as Table 3-4.

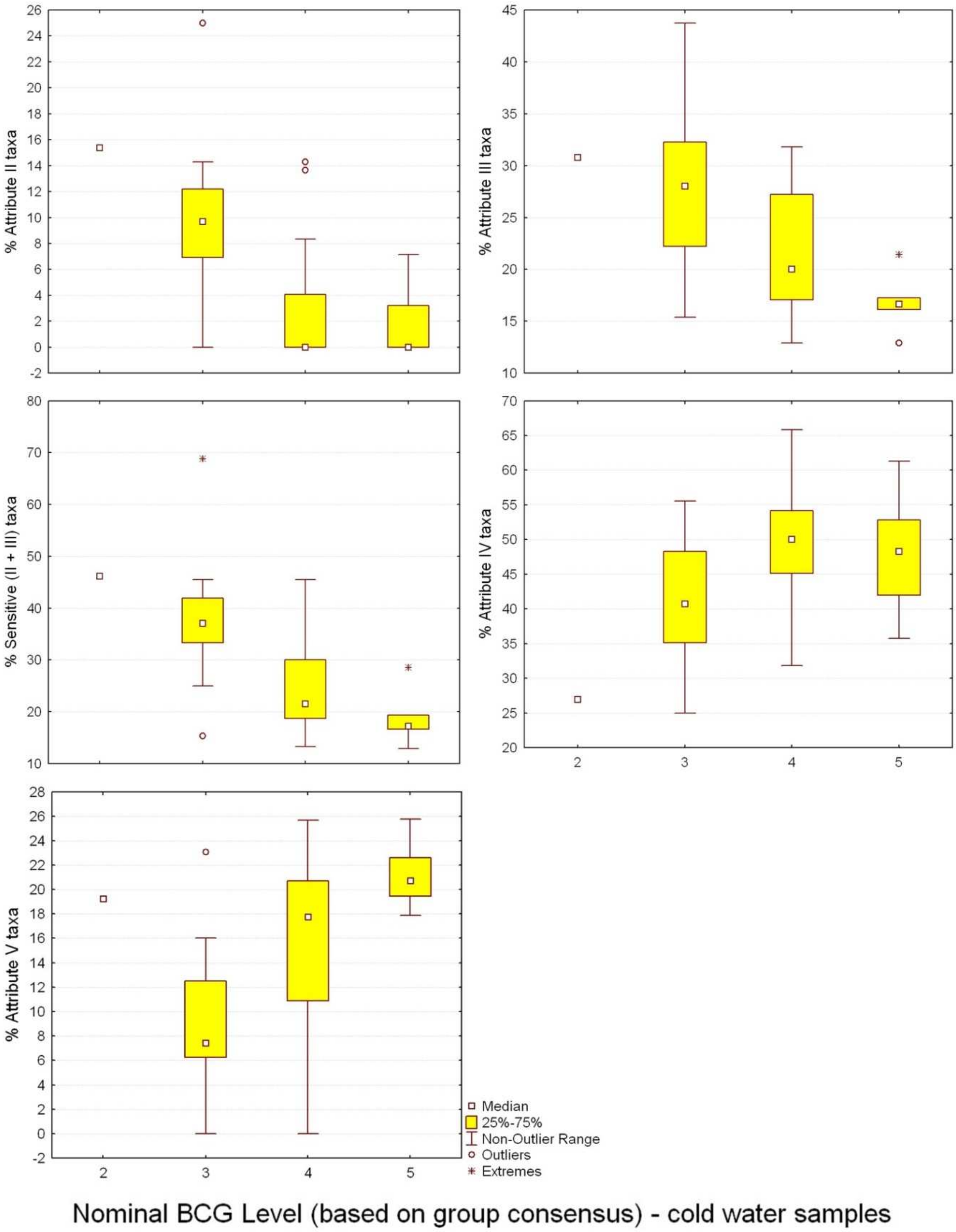


Figure 3-8. Box plots of BCG attribute II-V percent taxa metrics for 45 coldwater macroinvertebrate samples, grouped by nominal BCG level (panel majority choice). Sample sizes as Table 3-4.

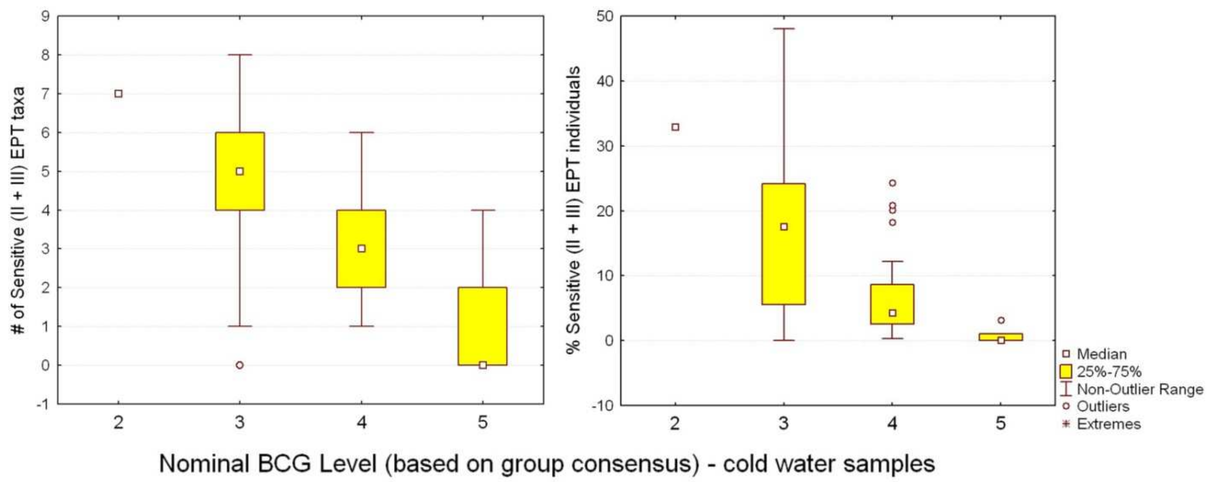


Figure 3-9. Box plots of EPT sensitive (attribute II + III) taxa and percent individual metrics for 45 coldwater macroinvertebrate samples, grouped by nominal BCG level (panel majority choice). Sample sizes as Table 3-4.

3.2.3 BCG Rule Development

As discussed in Section 3.1.4, rules work as a logical cascade from BCG Level 1 to Level 6. A sample is first tested against the Level 1 rules; if a single rule fails, then the Level fails, and the assessment moves down to Level 2, and so on. All required rules must be true for a site to be assigned to a level.

The coldwater rules, which are shown in Table 3-6, were derived from discussions with the panelists on why individual sites were assessed at a certain level. They follow the observations shown in Table 3-5 and in Figures 3-6 through 3-9. The rules were calibrated with the 42 coldwater macroinvertebrate samples rated by the group, and were adjusted so that the model would replicate the panel's decisions as closely as possible As described in Section 3.1.3, membership functions had to be defined when developing the model. The metric midpoints, which were used as approximate rules, are shown in Tables 3-3a and 3-3b.

Coldwater BCG Level 2 requires a strong presence of sensitive (Attribute II & III) taxa. More specifically, the percent most sensitive (Attribute I & II) taxa must be > 10% and percent sensitive (Attribute II & III) taxa and individuals must be > 30% (Table 3-5a). Other level 2 rules require that 8 or more taxa be present in samples with less than 200 total individuals and 14 or more taxa be present in samples with more than 200 total individuals, the most dominant tolerant taxa (Attribute V) must comprise < 5 % and % sensitive EPT taxa must be greater than 10%.

The balance between sensitive and tolerant organisms is also an important consideration in the BCG level 3 rules. As with the level 2 rule, 8 or more taxa must be present in samples with less than 200 total individuals and 14 or more taxa must be present in samples with more than 200 total individuals . Level 3 rules require that sensitive EPT taxa (Attribute I & II & III) comprise > 10% of the assemblage, that the most dominant intermediate tolerant (Attribute IV) taxa must comprise < 50% of the assemblage and that the percent tolerant (Attribute V) individuals must be < 20%. Two metrics - percent sensitive (Attribute I, II & III) taxa and individuals - are subject to alternate rules. If the value of the percent sensitive taxa metric is > 20%, then the % sensitive individuals must be > 10%. Alternatively, if the value of the percent sensitive taxa metric is > 40%, then the % sensitive individuals metric must be > 5%.

BCG Level 4 is characterized by decreased richness and abundance of sensitive taxa. However, sensitive taxa must still be present. Percent sensitive taxa and individuals metrics must be greater than 10% and 5%, respectively, and sensitive EPT taxa must be present. It is also required that the percent tolerant (Attribute V) individuals metric not exceed 40%, and that 6 or more taxa be present in samples with less than 200 total individuals and 8 or more taxa be present in samples with more than 200 total individuals. The disappearance of sensitive taxa is what discriminates Level 5 from Level 4, as well as an increase in the percent tolerant (Attribute V) individuals.

Table 3-6. Decision rules for macroinvertebrate assemblages in coldwater and coolwater (transitional cold-cool) streams. Rules show the midpoints of fuzzy decision levels (see Fig. 3-5), where membership in the given BCG level is 50% for that metric.

BCG Level	Metrics	Coldwater Rule	Coldwater Alt Rule	Coolwater Rule	Coolwater Alt Rule
2	# Total taxa	If total individs < 200, ≥ 8; else ≥ 14		If total individs < 200, ≥ 12; else ≥ 20	
2	% Most sensitive taxa (Att 1 + 2)	> 10%		> 5%	
2	% Most sensitive individuals (Att 1 & 2)	--		> 8%	
2	% Sensitive taxa (Att 1 + 2 + 3)	> 30%		> 30%	
2	% Sensitive individuals (Att 1 + 2 + 3)	> 30%		> 30%	
2	% Most dominant tolerant taxa (Att 5)	< 5%		--	
2	% Sensitive EPT taxa (Att 1 + 2 + 3)	> 10%		> 10%	
		Rule	**Alt Rule**	**Rule**	**Alt Rule**
3	# Total taxa	If total individs < 200, ≥ 8; else ≥ 14		If total individs < 200, ≥ 12; else ≥ 20	
3	# Most sensitive (Att 1+2) taxa	--		present	NA
3	% Sensitive taxa (Att 1 + 2 + 3)	> 20%	> 40%	> 20%	
3	% Sensitive individuals (Att 1 + 2 + 3)	> 10%	> 5%	> 10%	> 40%
3	% Most dominant intermediate tolerant taxa (Att 4)	< 50%		--	
3	% Tolerant (Att 5) individuals	< 20%		--	
3	% Most dominant tolerant taxa (Att 5)	--		< 10%	
3	% Sensitive EPT taxa (Att 1 + 2 + 3)	> 10%		> 10%	

Table 6.continued…

BCG Level	Metrics	Rule	Rule
4	# Total taxa	If total individs < 200, ≥ 6; else ≥ 8	If total individs < 200, ≥ 8; else ≥ 14
	% Sensitive taxa (Att 1 + 2 + 3)	> 10%	> 10%
	% Sensitive individuals (Att 2 + 3)	> 5%	> 6%
	% Tolerant (Att 5) individuals	< 40%	< 60%
	Number of sensitive EPT taxa (Att 1 + 2 + 3)	present	present
		Rule	**Rule**
5	# Total taxa	If total individs < 200, ≥ 6; else ≥ 8	If total individs < 200, ≥ 8; else ≥ 14
	% Tolerant (Att 5) individuals	< 60%	--
	% Most dominant tolerant taxa (Att 5)	--	< 60%

3.2.4 Model Performance

To measure model performance with the 42-sample calibration dataset, we considered two matches in BCG Level choice: an exact match, where the BCG decision model's nominal level matched the panel's majority choice; and a "minority match", where the model predicted a BCG level within one level of the majority expert opinion .When model performance was evaluated in this calibration dataset, the coldwater macroinvertebrate model matched exactly with the regional biologists' BCG level assignments on 97.6% of the coldwater samples (Table 3-7). In the single sample without agreement, the model assignment was one level better than the majority expert opinion.

In order to confirm the model, panelists made BCG level assignments on 18 additional coldwater samples[11]. We later excluded 2 of these samples because they were collected during the spring. When nominal level assignments from the BCG decision model were compared to the panelists' nominal level assignments in the confirmation dataset, the coldwater macroinvertebrate model matched exactly with the regional biologists' BCG level assignments on 81.3% of the samples (Table 3-7). In the 3 samples rated differently by model and panel, the model rated the samples as being 1 BCG level better than the majority expert opinion. It should be noted that 2 of these 3 samples were very close to being in agreement. In one, the model assignment was a tie between

[11] Originally, panelists assessed 25 confirmation samples, but later decided to exclude 7 WDNR samples due to low number of individuals (<100) and/or potential data quality issues that we were unable to resolve.

BCG levels 3 and 4, but all of the panelists unanimously assigned the sample to BCG level 4; in the other, the panelist assignment was a tie between BCG levels 2 and 3 and the primary and secondary model assignments were both a 2.
Based on the combined results, in 93.1% of cases, the coldwater macroinvertebrate model predicts the same BCG level as the majority expert opinion.

Table 3-7. Model performance – coldwater macroinvertebrate samples.

Difference	Calibration	Confirmation
2 better	0	0
1 better	1	3
same	41	13
1 worse	0	0
2 worse	0	0
Total # Samples	**42**	**16**
% Correct	**97.6%**	**81.3%**

3.3 Description of Coldwater Assemblages in Each BCG Level

When panelists assess samples, they often associate particular taxa (and abundances of these taxa) with certain BCG levels. In Table 3-8, we provide narrative descriptions of each of the BCG levels that were assessed during this exercise (modified after Davies and Jackson (2006)), as well as lists of fish and macroinvertebrate taxa that were commonly found in samples from each BCG level.

Table 3-8. Description of coldwater fish and macroinvertebrate assemblages in each assessed BCG level. Definitions are modified after Davies and Jackson (2006).

BCG level 1	**Definition:** Natural or native condition - *native structural, functional and taxonomic integrity is preserved; ecosystem function is preserved within the range of natural variability*
	Fish: If the stream is in a location where brook trout are native, ***native brook trout*** must be present. Non-native salmonids must be absent. Up to two additional taxa, preferably highly sensitive (Attribute I, II & III) species such as ***slimy sculpin*** and ***brook lamprey***, may also be present. Historically, in some Michigan streams, ***arctic grayling*** [now extirpated] would have also been present. A proportion of the trout are large (similar to the sizes reported in historical records). If tolerant taxa are present, they occur in very low numbers.
	Macroinvertebrates: We lack sufficient information to know what the historical undisturbed macroinvertebrate assemblage looked like.

Table 3-8. continued…

BCG level 2	**Definition:** Minimal changes in structure of the biotic community and minimal changes in ecosystem function - *virtually all native taxa are maintained with some changes in biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability*
	Fish: Overall taxa richness and density is as naturally occurs (watershed size is a consideration). Non-native salmonids may be present. If the stream is in a location where brook trout are native, ***native brook trout*** are present and are not negatively impacted by non-native salmonids such as ***brown trout***. Other highly sensitive (Attribute II) and intermediate sensitive (Attribute III) taxa such as ***sculpins (mottled or slimy), dace (pearl, finescale, northern red belly, longnose)*** and ***brook lamprey*** are also present. If the stream is in a location where brook trout are not native, the majority of individuals must be comprised of highly sensitive and intermediate sensitive taxa. If tolerant non-salmonid taxa are present, they occur in low numbers.
	Macroinvertebrates: Overall taxa richness and density is as naturally occurs. Most sensitive (Attribute II) taxa (e.g. *Trichoptera*: ***Glossosoma, Rhyacophila, Lepidostoma, Dolophilodes;*** *Ephemeroptera*: ***Ephemerella, Epeorus;*** *Plecoptera*: ***Leuctridae***) and EPT taxa are present. These plus intermediate sensitive (Attribute III) taxa (e.g. *Ephemeroptera*: ***Paraleptophlebia***; *Plecoptera*: ***Acroneuria, Isoperla, Paragnetina***; *Trichoptera*: ***Brachycentrus, Chimarra***) occur in higher abundances than in BCG level 3 samples.
BCG level 3	**Definition:** Evident changes in structure of the biotic community and minimal changes in ecosystem function - *Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but intermediate sensitive taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system*
	Fish: Overall taxa richness and density is as naturally occurs (watershed size is a consideration). Salmonids such as ***brook trout*** or ***brown trout*** are present, as well as other sensitive taxa, such as ***sculpins (mottled or slimy), dace (pearl, finescale, northern red belly, longnose)*** and ***brook lamprey.*** Non-native salmonids may be impacting native brook trout. Taxa of intermediate tolerance (Attribute IV) such as ***white suckers***, ***blacknose dace***, ***common shiners***, ***darters (johnny, fantail)*** and ***creek chub*** are common. Some tolerant (Attribute V) taxa such as ***central stonerollers*** and ***bluegill*** may be present, but highly tolerant taxa are absent.
	Macroinvertebrates: Overall taxa richness and density is as naturally occurs. Similar to BCG level 2 assemblage except sensitive taxa (e.g. *Ephemeroptera:* ***Paraleptophlebia***; *Plecoptera:* ***Acroneuria, Isoperla, Paragnetina***; *Trichoptera:* ***Brachycentrus, Chimarra***; *Diptera:* ***Diamesa, Eukiefferiella, Tvetenia***) occur in slightly lower numbers and most sensitive (Attribute II) taxa may be absent. Taxa of intermediate tolerance (Attribute IV) (e.g. ***Gammarus, Oligochaeta, Simulium***; *Coleoptera:* ***Optioservus, Stenelmis***; *Ephemeroptera:* ***Baetis, Stenonema***; *Trichoptera:* ***Hydropsyche, Cheumatopsyche***) are common, and some tolerant taxa (Attribute V) may be present as well. The assemblage is not dominated by a single taxon.

Table 3-8. continued…

BCG level 4	**Definition:** Moderate changes in structure of the biotic community and minimal changes in ecosystem function **-** *Moderate changes in structure due to replacement of some intermediate sensitive taxa by more tolerant taxa, but reproducing populations of some sensitive taxa are maintained; overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes*
	Fish: Salmonids such as ***brook trout*** and ***brown trout*** are present but occur in very low numbers. Taxa of intermediate tolerance (Attribute IV) such as ***white suckers***, ***blacknose dace***, ***common shiners***, ***darters (johnny, fantail), brook stickleback, creek chub, rock bass and smallmouth bass*** are common**,** as well as tolerant taxa like ***central mudminnows, bluegill, northern pike*** and ***largemouth bass***. Extra tolerant taxa such as ***green sunfish*** and ***bluntnose*** and ***fathead minnows*** are present but in low numbers.
	Macroinvertebrates: Overall taxa richness is slightly reduced. Sensitive taxa (including EPT taxa) are present but occur in low numbers. Taxa of intermediate tolerance (Attribute IV) **(e.g. *Gammarus, Oligochaeta, Simulium***; *Coleoptera:* ***Optioservus, Stenelmis***; *Ephemeroptera:* ***Baetis, Stenonema***; *Trichoptera:* ***Hydropsyche, Cheumatopsyche***) are common, as are tolerant (Attribute V) taxa (e.g. *Diptera:* ***Cricotopus, Dicrotendipes, Paratanytarsus***; ***Hyalella; Physa; Turbellaria***).
BCG level 5	**Definition:** Major changes in structure of the biotic community and moderate changes in ecosystem function **-** *Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity and redundancy; increased build-up or export of unused materials*
	Fish: Overall taxa richness may be reduced. Sensitive taxa and salmonids may be absent. Taxa of intermediate tolerance (Attribute IV) such as ***white suckers, blacknose dace, common shiners, darters (johnny, fantail), brook stickleback***, and ***creek chub*** are common. There is an influx of tolerant, warm water taxa such as ***bluegill***, ***yellow perch, largemouth bass, northern pike, central stonerollers, bluntnose minnows, fathead minnows*** and ***green sunfish***.
	Macroinvertebrates: Overall taxa richness is slightly reduced. Taxa of intermediate tolerance (Attribute IV) **(**e.g. ***Gammarus, Oligochaeta, Simulium***; *Coleoptera:* ***Optioservus, Stenelmis***; *Ephemeroptera:* ***Baetis, Stenonema***; *Trichoptera:* ***Hydropsyche, Cheumatopsyche***) and tolerant (Attribute V) taxa (e.g. *Diptera:* ***Cricotopus, Dicrotendipes, Paratanytarsus; Hyalella; Physa; Turbellaria***) are common. Tolerant taxa occur in higher relative abundances than in BCG level 4 samples.

4 COMPREHENSIVE DECISION RULES AND BCG MODEL – COLD-COOL TRANSITIONAL

4.1 Fish

4.1.1 Site Assignments and BCG Level Descriptions

The cold-cool transitional fish BCG model was calibrated using samples from MPCA, MDEQ, WDNR and FDL. The cold-cool transitional fish data set was comprised of 558 samples, and participants made BCG level assignments on 42 of these samples. Consensus BCG level assignments and sample information for these 42 samples are summarized in Appendix I.

As with the coldwater fish samples (discussed in Section 3.1.1.), the group assigned cold-cool transitional fish samples to 5 BCG levels (BCG levels 1-5). Only one sample was assigned to BCG level 1. Panelists felt that they needed to have more information, in particular on genetics (stocked vs. native) and age/size class, to better distinguish between BCG level 1 and level 2 cold-cool transitional samples.

4.1.2 BCG Attribute Metrics

Examinations of taxonomic attributes among the BCG levels determined by the panel showed that several of the attributes are useful in distinguishing levels, and indeed, were used by the panel's biologists for decision criteria. Considerations were similar to those used for the coldwater fish samples (described in Section 3.1.2), with the most important ones being number of total taxa, presence and relative abundances of native and non-native trout species, and percent individuals and percent taxa metrics for Attribute II, II+III and IV taxa. Statistical summaries of each attribute metric at each BCG level are provided in Table 4-1, and total taxa, percent individuals and percent taxa metrics are shown graphically in Figures 4-1 through 4-4. Plots for additional metrics can be found in Appendix I.

As with the coldwater fish samples (Section 3.1.2), total richness showed a relatively monotonic pattern, increasing as the assigned BCG level went from 1 to 5 (Figure 4-1), and watershed size is significantly and positively correlated with total fish species richness (r^2=0.20, p<0.01) (Figure 4-2). In the cold-cool transitional data set, the 1 BCG level 1 sample, which was collected from a 21 mi^2 watershed in Minnesota (Station 97LS074 - Greenwood River), had 9 taxa (non-native brook trout, burbot, creek chub, eastern blacknose dace, lake chub, longnose dace, longnose sucker, mottled sculpin and white sucker; longnose dace and lake chub comprised 67% of the individuals in this assemblage). Panelists consider brook trout and longnose suckers to be good indicator species in these high quality cold-cool transitional streams. Samples that were assigned to BCG level 2 were collected from sites that had watershed sizes ranging from 1.8-27 mi^2. The total number of taxa in these samples ranged from 1 (brook trout only) to 15. Brook trout were present in all but one of the BCG level 2 samples. The sample that did not have brook trout was comprised of a relatively high proportion of Attribute III taxa (finescale dace, longnose dace, mottled sculpin, redbelly dace and pearl dace).

Table 4-1. Ranges of attribute metrics in cold-cool transitional fish samples by panel nominal (majority) BCG levels.

Attributes	Metric	1 (n=1)	2 (n=13)	3 (n=14)	4 (n=9)	5 (n=7)
0 General	**Total Taxa**	9	1-15	4-18	10-24	10-17
	Total Ind	470	11-207	8-598	109-534	102-1483
II Highly sensitive taxa	**# Taxa**	2	0-2	0-2	0-1	0
	Pct Taxa	22	0-100	0-25	0-7	0
	Pct Ind	7	0-100	0-20	0-1	0
III Intermediate sensitive taxa	**# Taxa**	3	0-5	0-5	1-4	0-1
	Pct Taxa	33	0-67	0-36	4-22	0-10
	Pct Ind	68	0-72	0-60	0-44	0-4
II + III All sensitive taxa	**# Taxa**	5	1-5	0-6	1-4	0-1
	Pct Taxa	56	33-100	0-50	4-22	0-10
	Pct Ind	75	14-100	0-60	0-44	0-4
IV Intermediate tolerant taxa	**# Taxa**	4	0-9	1-10	4-12	3-8
	Pct Taxa	44	0-60	18-63	40-60	29-55
	Pct Ind	25	0-83	14-88	39-83	13-93
	Pct Most Dom Ind	14	0-39	8-63	18-68	7-48
V Tolerant taxa	**# Taxa**	0	0-1	0-5	3-8	3-7
	Pct Taxa	0	0-17	0-36	20-40	19-70
	Pct Ind	0	0-13	0-20	4-30	1-43
	Pct Most Dom Ind	0	0-13	0-16	2-18	1-19
Va Highly tolerant native taxa	**# Taxa**	0	0-1	0-2	0-3	0-5
	Pct Taxa	0	0-11	0-13	0-13	0-36
	Pct Ind	0	0-1	0-1	0-18	0-85
	Pct Most Dom Ind	0	0-1	0-1	0-18	0-56
VI Non-native or intentionally introduced taxa	**# Taxa**	0	0-1	0-3	0-1	0-1
	Pct Taxa	0	0-20	0-43	0-6	0-9
	Pct Ind	0	0-25	0-41	0-7	0-2
	Pct Most Dom Ind	0	0-25	0-41	0-7	0-2
VIa Highly tolerant non-native taxa	**# Taxa**	0	0	0	0-1	0-1
	Pct Taxa	0	0	0	0-4	0-6
	Pct Ind	0	0	0	0	0-3
	Pct Most Dom Ind	0	0	0	0	0-3

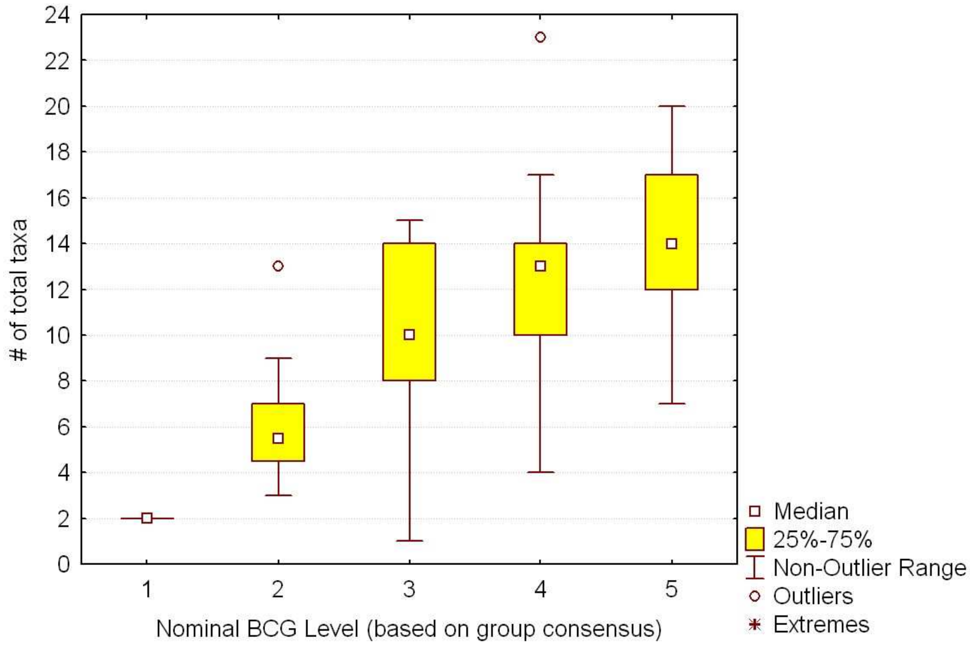


Figure 4-1. Box plots of total taxa metric values for cold-cool transitional fish samples, grouped by nominal BCG level (panel majority choice). Sample sizes as given in Table 4-1.

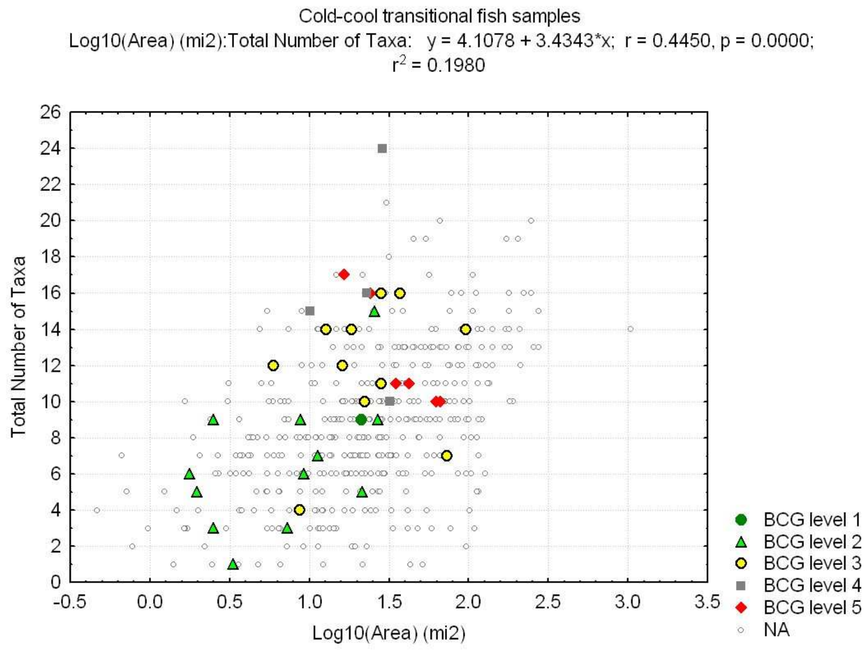


Figure 4-2. Relationship between total taxa metric values and watershed area for cold-cool transitional water samples. Samples are coded by nominal BCG level (panel majority choice).

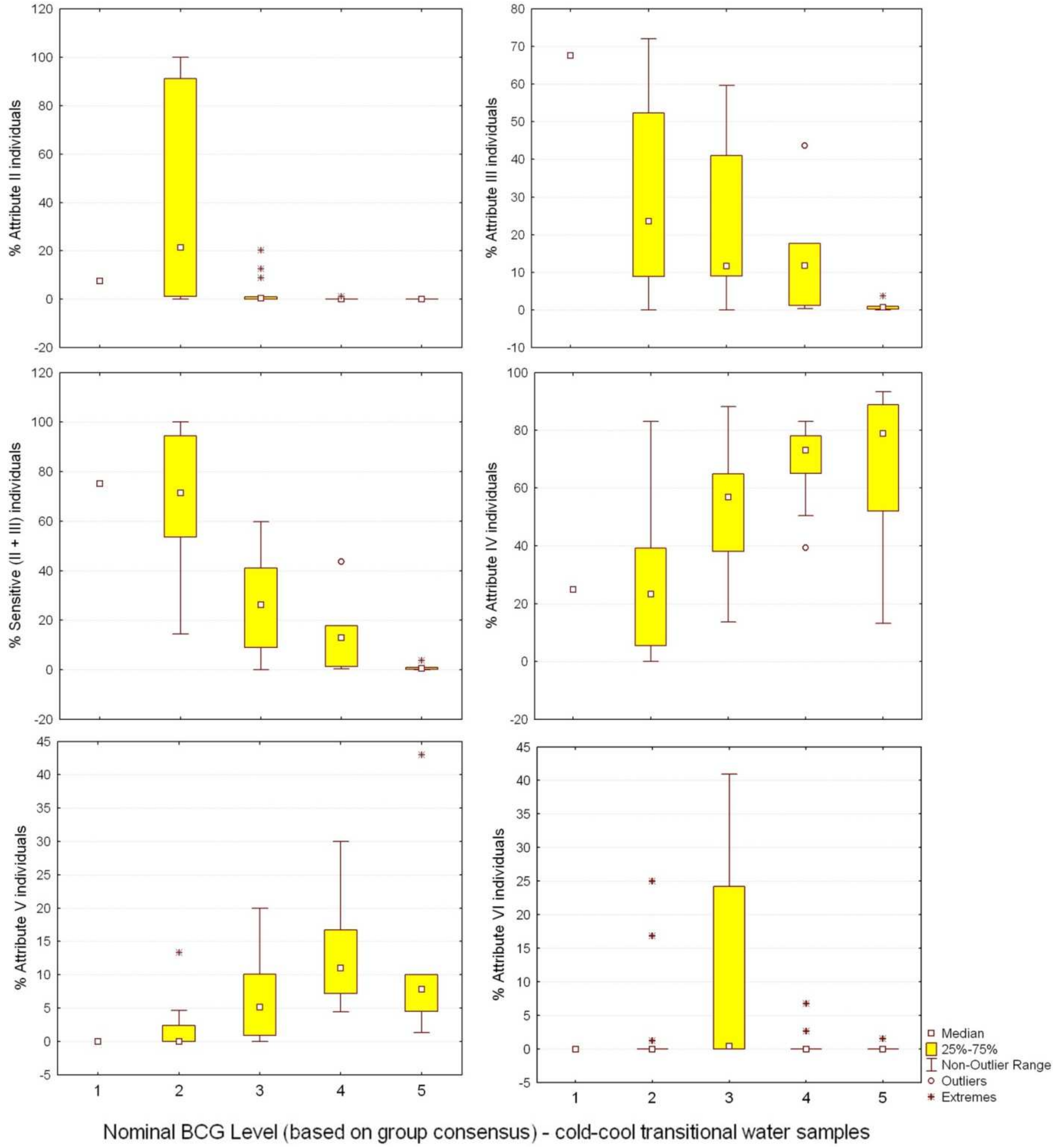


Figure 4-3. Box plots of BCG attribute II-VI percent individual metrics for 44 cold-cool transitional fish samples, grouped by nominal BCG level (panel majority choice). Sample sizes as given in Table 4-1.

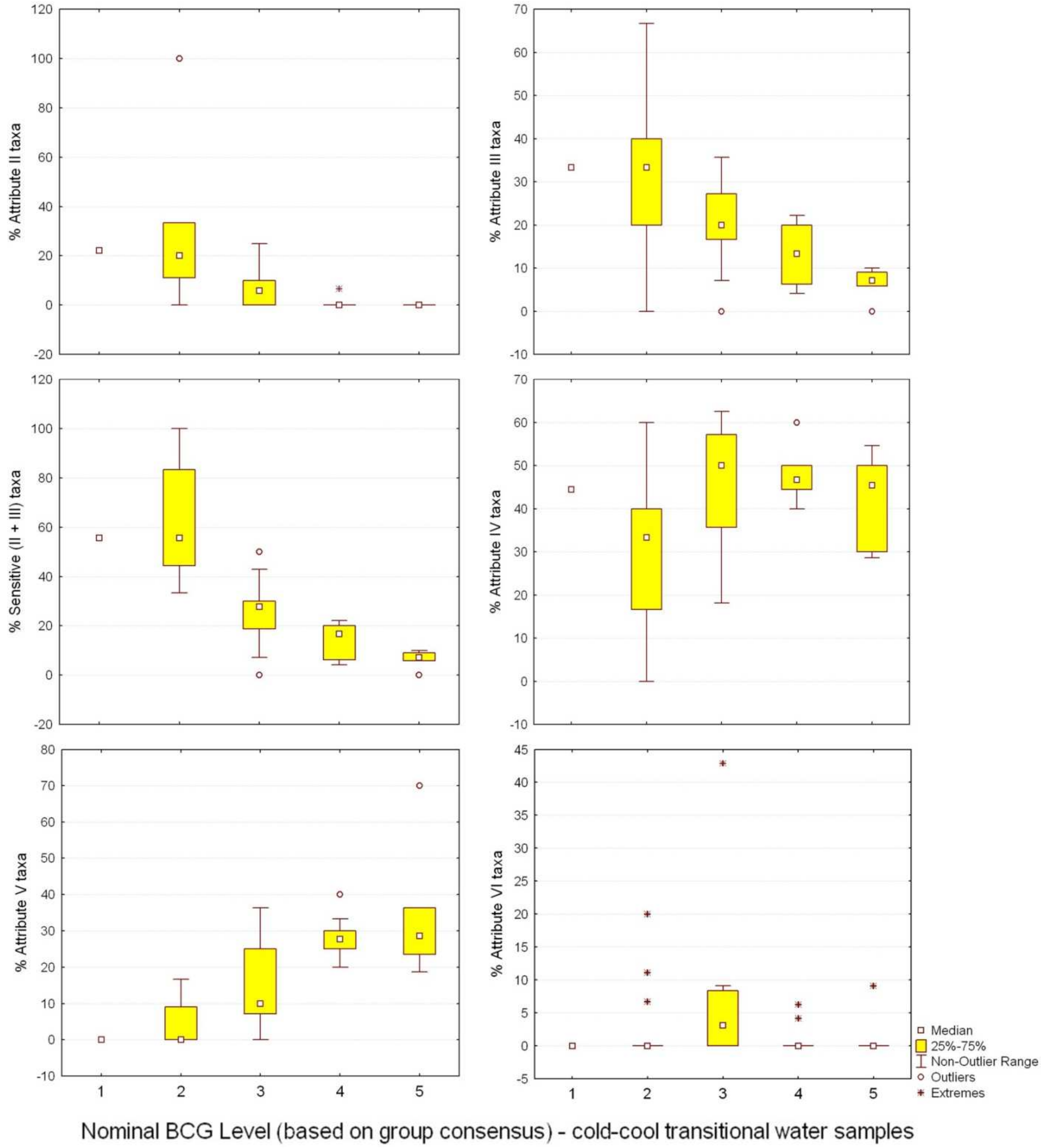


Figure 4-4. Box plots of BCG attribute II-VI percent taxa metrics for 44 cold-cool transitional fish samples, grouped by nominal BCG level (panel majority choice). Sample sizes as given in Table 4-1.

Presence and relative abundance of native and non-native trout species are also important considerations when panelists make BCG level assignments. Panelists followed similar guidelines to those described in Section 3.1.2 when making BCG level assignments: they generally 'bumped' samples down a partial level (i.e. from a 2+ to a 2) for every non-native trout species that was present, and if non-native trout comprised a large proportion of the assemblage and appeared to be detrimentally impacting the native species, panelists generally downgraded samples by a BCG level. Although brook trout are not native at many of the cold-cool transitional sites in Minnesota, this species was regarded as an indicator of high quality cold-cool transitional habitat.

A variety of BCG attribute metrics are effective at discriminating between BCG levels. The Attribute II+III and IV metrics show relatively monotonic patterns, with Attribute IV metrics increasing and Attribute II+III metrics decreasing as the assigned BCG level goes from 1 to 5 (Figs. 4-3 & 4-4). The total taxa, Attribute II, II+III and IV metrics are most effective at discriminating between BCG levels 2 and 3. The Attribute V and VI metrics were also informative; they show a shift towards higher proportions of tolerant taxa and non-native trout species in the BCG level 3 samples. The transition from BCG level 3 to 4 is marked by a decrease in sensitive (Attribute II+III) and Attribute III taxa, an increase in percent Attribute IV individuals and an increase in Attribute V metrics. Discriminating between BCG level 4 and 5 is more challenging. In the BCG level 5 samples, there is a complete loss of Attribute II taxa and a loss of sensitive (Attribute II+III) and Attribute III taxa.

4.1.3 BCG Rule Development

The cold-cool transitional fish rules, which are shown in Table 3-2, were derived from discussions with the panelists on why individual sites were assessed at a certain level. They follow the observations shown in Table 4-1 and in Figures 4-1 through 4-4. The rules were calibrated with the 42 cold-cool transitional fish samples rated by the group, and were adjusted so that the model would replicate the panel's decisions as closely as possible. Inevitably, there were some places where the panel may have used different, unstated rules, or where rules were inconsistently applied. Membership functions for the richness and percent individual metrics are included in Tables 3-3a and 3-3b.

The rules shown in Table 3-2 have been developed for distinguishing BCG levels for cold-cool transitional fish samples. These rules have been verified by the panelists. They follow a general pattern of decreasing richness of sensitive taxa and increasing relative abundance of tolerant individuals as biological condition degrades. Some levels have alternate rules.

Similar to the coldwater rules, cold-cool transitional water BCG Level 1 requires native brook trout and most sensitive (Attribute I & II) taxa to be present and non-native salmonids to be absent. There must be > 3 and <14 total taxa, more than 40% of the assemblage must be comprised of sensitive (Attribute I, II & III) taxa and individuals, and less than 5 percent may be tolerant (Attribute V, Va and Via) individuals (Table 3-2).

Unlike the coldwater rules, watershed size is not a BCG level 2 consideration for the total number of taxa metric. BCG level 2 samples must have fewer than 20 total taxa. In streams where brook trout are native, brook trout and most sensitive (Attribute I & II) taxa must be present and the ratio of brook trout individuals to total individuals must be >40%. In all samples (regardless of brook trout native/non-native status), the percent sensitive (Attribute I, II & III) taxa metric must be > 30%, the percent sensitive individuals metric must be > 12% and the % tolerant non-salmonid individuals must be < 20%.

BCG level 3 rules are independent of brook trout native/non-native status. BCG level 3 samples have the same total taxa requirement as BCG level 2 samples (<20). All BCG level 3 samples must have < 5% extra tolerant (Attribute Va & VIa) individuals, and in streams with watershed sizes > 10 square miles, the % most dominant intermediate tolerant (Attribute 4) taxa must be < 40%. The percent sensitive (Attribute I, II & III) taxa and percent sensitive (Attribute I, II & III) taxa individuals metrics are subject to alternate rules. If % sensitive taxa is greater than or equal to % tolerant (Attribute V, Va & VIa) taxa, then the sample meets level 3 requirements; if this requirement is not met, the alternative for meeting level 3 requirements is that % sensitive individuals must be greater than or equal to two times the % tolerant (Attribute V, Va & VIa) individuals.

BCG Level 4 is characterized by decreased richness and abundance of sensitive taxa. The disappearance of these sensitive taxa is what discriminates Level 5 from Level 4. However, these taxa must still be present in level 4 samples - the percent sensitive and salmonid (Attribute II, III, and VI) taxa and individuals metrics must be greater than 5%. There is also a level 4 requirement for extra tolerant (Attribute Va & VIa) individuals (< 20%). In Level 5 samples, there must be > 3 taxa, and more than 10% of the taxa must be intermediate tolerance (Attribute IV).

4.1.4 Model Performance

To measure model performance with the 42-sample calibration dataset, we considered two matches in BCG Level choice: an exact match, where the BCG decision model's nominal level matched the panel's majority choice; and a "minority match", where the model predicted a BCG level within one level of the majority expert opinion .When model performance was evaluated, the cold-cool transitional water fish model matched exactly with the regional biologists' BCG level assignments on 90% of the cold-cool transitional water samples (Table 4-2). All of the model assignments were within one level of the majority expert opinion. Where there were differences, the tendency was for the model to rate samples better than the panel; the model assigned 3 samples to a BCG level that was 1 level better than the panelists' assignment, and assigned 1 sample to a BCG level that was 1 level worse than the panelists.

Table 4-2. Model performance – coolwater fish samples

Difference	Calibration	Confirmation
2 better	0	1
1 better	3	5
same	38	17
1 worse	1	2
2 worse	0	0
Total # Samples	**42**	**25**
% Correct	**90%**	**68%**

In order to confirm the model, panelists made BCG level assignments on 25additional cold-cool water transitional samples. When nominal level assignments from the BCG decision model were compared to the panelists' nominal level assignments, the cold-cool transitional water fish model matched exactly with the regional biologists' BCG level assignments on 68% of the confirmation samples. All but 1 model assignment were within one level of the majority expert opinion, and there was a strong tendency for the model to rate samples better than the panel (Table 4-2). One of the confirmation samples was flagged for low density. Based on the combined results, in 82% of cases, the cold-cool transitional water fish model predicts the same BCG level as the majority expert opinion.

4.2 Macroinvertebrates

4.2.1 Site Assignments and BCG Level Descriptions

Data from MPCA, WDNR and FDL were used to calibrate the cold-cool transitional macroinvertebrate BCG model. There were 319 samples in the cold-cool transitional data set, and participants made BCG level assignments on 42 of these samples. This number was reduced to 34 samples after the group decided to exclude samples if: 1) they had fewer than 100 total individuals; 2) appeared to have data quality issues; or 3) were collected in the spring. Consensus BCG level assignments and sample information for these 34 samples are summarized in Appendix J. The group assigned cold-cool transitional macroinvertebrate samples to 5 BCG levels (BCG levels 2-6). Only one of the calibration samples was assigned to BCG level 6, and only two were assigned to BCG level 5. Efforts were made to exclude low gradient samples from this exercise.

4.2.2 BCG Attribute Metrics

As mentioned in Section 3.2.2, one entity, WDNR, identifies organisms to the species-level, while MPCA and FDL identify taxa to the genus-level. To resolve these differences in taxonomic resolution, we collapsed the species-level identifications to the genus-level OTU prior to calculating the metrics.

Examinations of taxonomic attributes among the BCG levels determined by the panel showed that several of the attributes are useful in distinguishing levels, and indeed, were used by the panel's biologists for decision criteria. The most important considerations were richness and percent individuals metrics for Attribute II, II & III, and V taxa, and metrics pertaining to EPT taxa. Statistical summaries of each attribute metric at each BCG level are provided in Table 4-3, and total taxa, percent individuals and percent taxa metrics are shown graphically in Figures 4-5 through 4-8. Plots for additional metrics can be found in Appendix J.

Decision rules pertaining to number of total taxa were included in the BCG cold-cool transitional water macroinvertebrate model, but this metric was generally ineffective at discriminating between BCG levels (Appendix J, Figure J-1). As with the coldwater samples, the panelists tended to focus on the species that were present and the BCG attribute metrics. Indicator taxa were similar to those identified during the coldwater exercise.

The number of taxa, percent taxa, and percent individual BCG attribute metrics had similar degrees of effectiveness at discriminating between BCG levels. The Attribute II, II+III and V metrics are particulary informative. A general rule that emerged was that panelists had a higher tolerance for Attribute V individuals in samples that contained high numbers of Attribute II & III taxa and individuals. The Attribute II+III and V metrics show relatively monotonic patterns, with

Attribute V metrics increasing and Attribute II+III metrics decreasing as the assigned BCG level goes from 2 to 6 (Figs. 4-5, 4-6 and 4-7). The transition from BCG level 2 to 3 is best captured by the Attribute II, Attribute II & III and sensitive EPT metrics. Several metrics are effective at discriminating between BCG level 3 and 4, in particular number and percent of Attribute II & III taxa, % Attribute IV taxa and the sensitive EPT metrics. BCG level 5 is discriminated from other BCG levels by the loss of Attribute II taxa, a decrease in the number and percent of sensitive (Attribute II & III) taxa and individuals, and the concomitant increase in number of Attribute V taxa and individuals.

Table 4-3. Ranges of attribute metrics in cold-cool transitional macroinvertebrate samples by panel nominal (majority) BCG levels.

Attributes	Metric	2 (n=19)	3 (n=13)	4 (n=7)	5 (n=2)	6 (n=1)
0 General	Total Taxa	20-63	20-64	13-58	31-56	31
	Total Ind	91-359	134-407	138-336	294-321	192
II Highly sensitive taxa	# Taxa	3-11	0-7	0-1	0	4
	Pct Taxa	8-28	0-15	0-3	0	13
	Pct Ind	6-42	0-7	0-1	0	34
III Intermediate sensitive taxa	# Taxa	6-19	7-19	4-17	2-6	16
	Pct Taxa	19-61	18-49	9-31	6-11	52
	Pct Ind	13-55	17-54	3-83	1-9	44
II + III All sensitive taxa	# Taxa	10-26	10-24	4-17	2-6	20
	Pct Taxa	30-71	22-57	11-31	6-11	65
	Pct Ind	31-76	20-56	3-83	1-9	78
	SensEPT # Taxa	6-20	6-14	1-6	2-4	13
	SensEPT_Pct Ind	18-71	14-47	2-17	1-2	60
IV Intermediate tolerant taxa	# Taxa	7-28	7-29	8-32	16-29	9
	Pct Taxa	26-49	35-53	50-65	52	29
	Pct Ind	23-53	43-71	17-87	26-30	21
	Pct Most Dom Ind	6-31	8-34	5-27	5-15	7
V Tolerant taxa	# Taxa	0-10	1-11	0-9	9-11	0
	Pct Taxa	0-17	3-22	0-16	20-29	0
	Pct Ind	0-22	0-12	0-59	40-72	0
	Pct Most Dom Ind	0-17	0-6	0-57	17-59	0

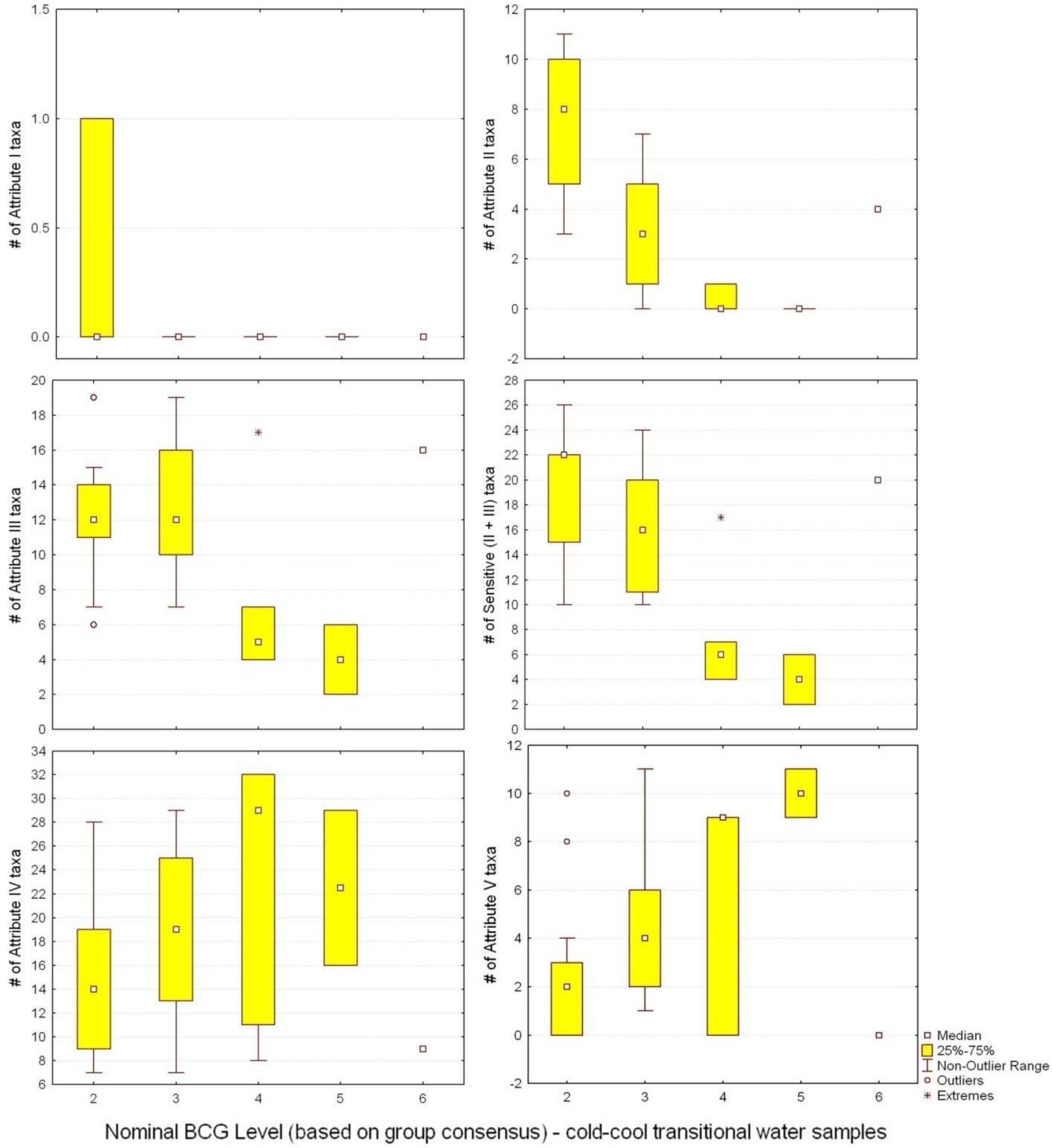


Figure 4-5. Box plots of BCG attribute I-V richness metrics for 42 cold-cool water transitional macroinvertebrate samples, grouped by nominal BCG level (panel majority choice). Sample sizes as given in Table 4-3.

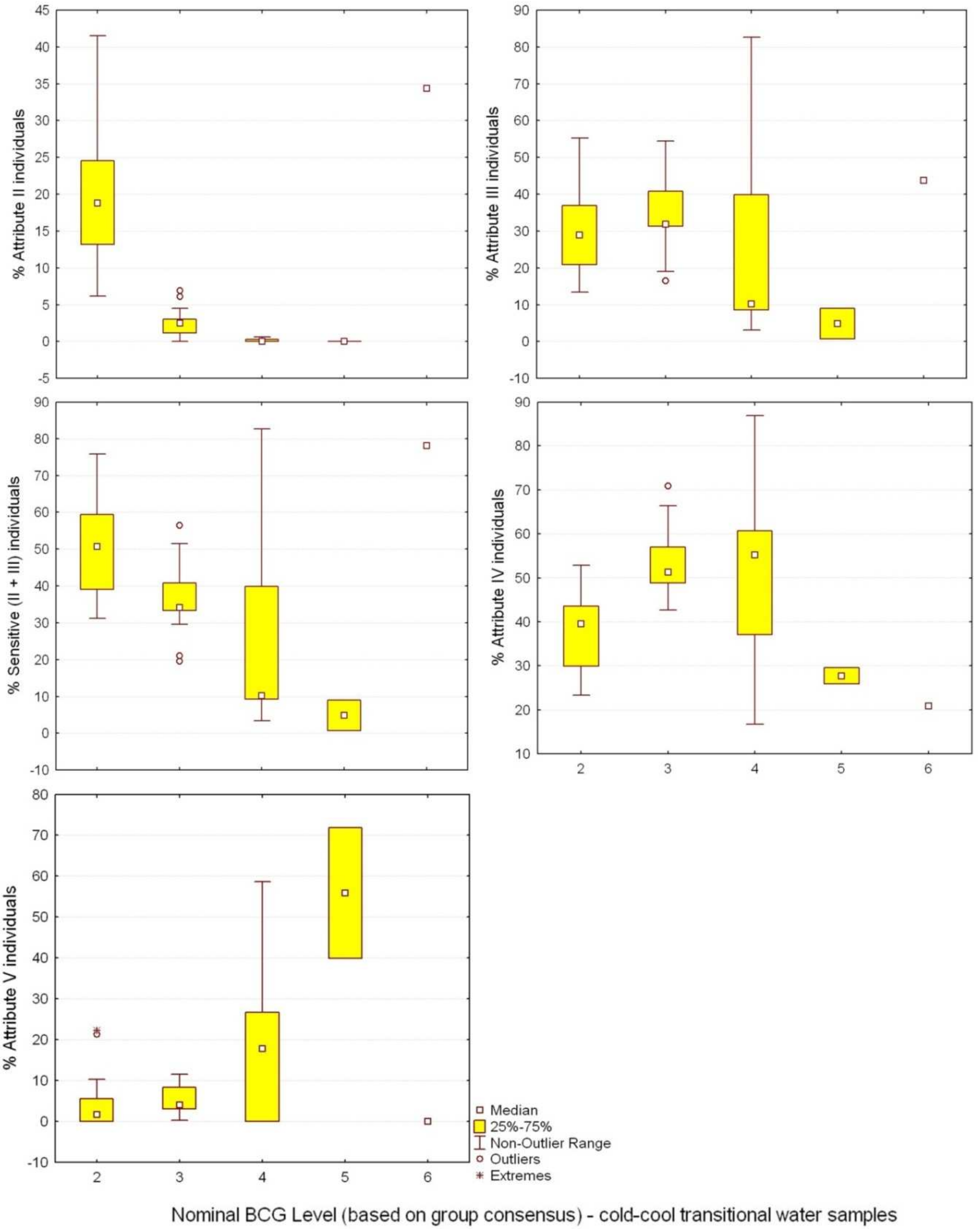


Figure 4-6. Box plots of BCG attribute II-V percent individual metrics for 42 cold-cool water transitional macroinvertebrate samples, grouped by nominal BCG level (panel majority choice). Sample sizes as given in Table 4-3.

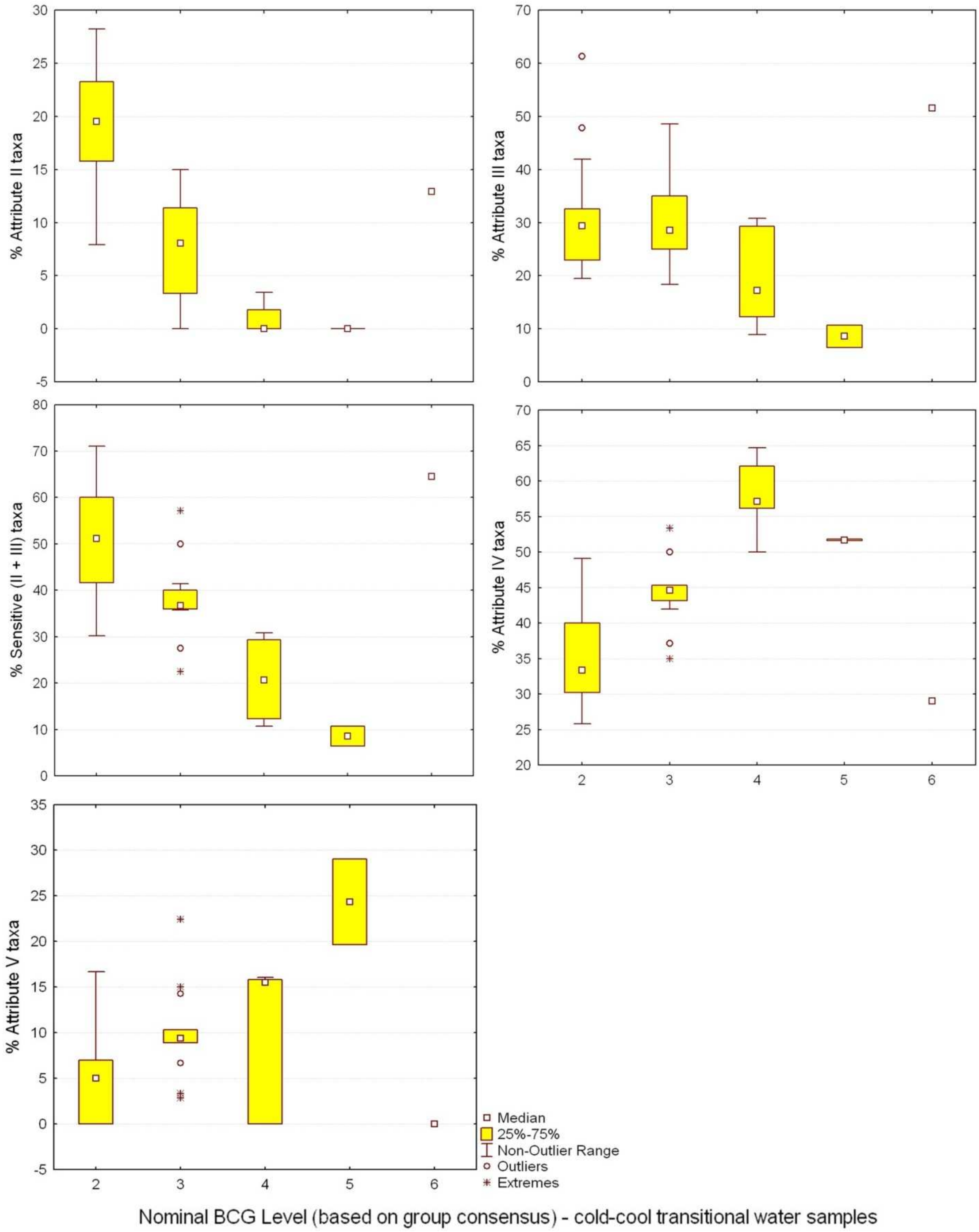


Figure 4-7. Box plots of BCG attribute I-V percent taxa metrics for 42 cold-cool water transitional macroinvertebrate samples, grouped by nominal BCG level (panel majority choice). Sample sizes as given in Table 4-3.

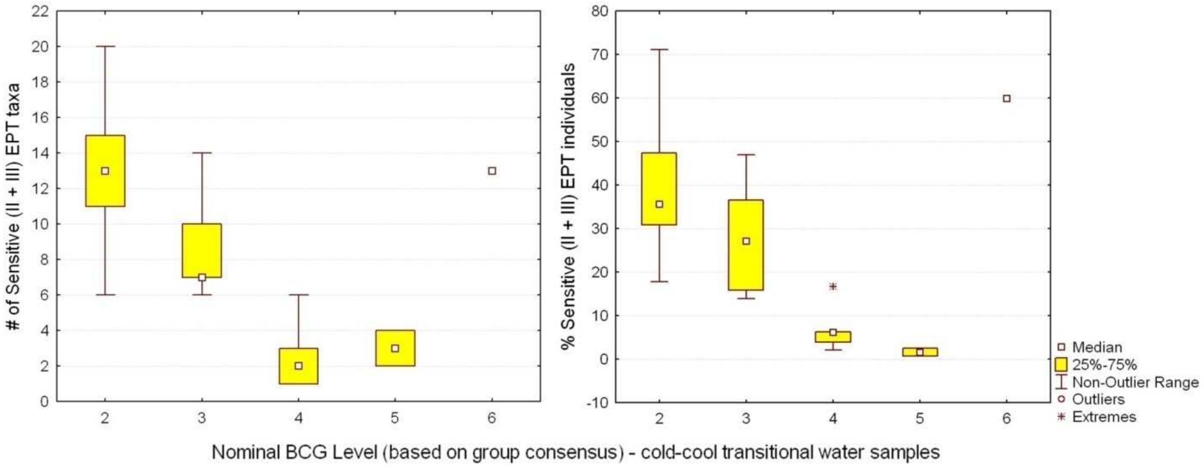


Figure 4-8. Box plots of EPT sensitive taxa (attribute II + III) metrics for 42 cold-cool water transitional macroinvertebrate samples, grouped by nominal BCG level (panel majority choice). Sample sizes as given in Table 4-3.

4.2.3 BCG Rule Development

As discussed in Section 3.1.4, the BCG rules work as a logical cascade from BCG Level 1 to Level 6. A sample is first tested against the Level 1 rules; if a single rule fails, then the Level fails, and the assessment moves down to Level 2, and so on. All required rules must be true for a site to be assigned to a level.

The cold-coolwater transitional rules, which are shown in Table 3-6, were derived from discussions with the panelists on why individual sites were assessed at a certain level. They follow the observations shown in Table 4-4 and in Figures 4-5 through 4-8. The rules were calibrated with the 42 cold-cool transitional macroinvertebrate samples rated by the group, and were adjusted so that the model would replicate the panel's decisions as closely as possible As described in Section 3.1.3, membership functions had to be defined when developing the model. The metric midpoints, which were used as approximate rules, are shown in Tables 3-3a and 3-3b.

Cold-cool transitional water BCG Level 2 requires a strong presence of sensitive (Attribute II & III) taxa. The percent most sensitive (Attribute I & II) taxa and individuals metrics must be > 5% and > 8%, respectively, and percent sensitive (Attribute II & III) taxa and individuals must be > 30% (Table 3-6). Other level 2 rules require that 12 or more taxa be present in samples with less than 200 total individuals and 20 or more taxa be present in samples with more than 200 total individuals and that % sensitive EPT taxa must be greater than 10%.

Richness and abundance of sensitive organisms is also an important consideration in the BCG level 3 rules. Level 3 rules require that sensitive (Attribute I & II & III) taxa comprise > 20% of the assemblage and that the percent sensitive EPT taxa must be > 10%. Two metrics – number of most sensitive (Attribute II) taxa and percent sensitive (Attribute I, II & III) individuals - are subject to alternate rules. If Attribute II taxa are present, there must be > 10% sensitive individuals; if Attribute II taxa are absent, the % sensitive individuals metric must be > 40%. In addition, in all level 3 samples there must be 12 or more taxa in samples with less than 200 total

individuals and 20 or more taxa in samples with more than 200 total individuals, and the most dominant tolerant (Attribute V) taxon must comprise < 10% of the assemblage.
BCG Level 4 is characterized by decreased richness and abundance of sensitive taxa and increased abundance of tolerant individuals. In level 4 samples, percent sensitive (Attribute II & III) taxa and individuals metrics must be greater than 10% and 6%, respectively, and sensitive EPT taxa must be present. Another requirement is that the percent tolerant (Attribute V) individuals metric must not exceed 60%, and that 8 or more taxa be present in samples with less than 200 total individuals and 14 or more taxa be present in samples with more than 200 total individuals. There are only two rules for Level 5 - the percent most dominant tolerant (Attribute V) taxon must comprise < 60% of the assemblage and 8 or more taxa must be present in samples with less than 200 total individuals and 14 or more taxa must be present in samples with more than 200 total individuals.

4.2.4 Model Performance

To measure model performancewith the 34-sample calibration dataset, we considered two matches in BCG Level choice: an exact match, where the BCG decision model's nominal level matched the panel's majority choice; and a "minority match", where the model predicted a BCG level within one level of the majority expert opinion. When model performance was evaluated in this calibration dataset, the cold-cool transitional macroinvertebrate model matched exactly with the regional biologists' BCG level assignments on 91.2% of the cold-cool transitional samples (Table 4-4). All of the model assignments were within one level of the majority expert opinion. Where there were differences, the model assigned 1 sample to a BCG level that was 1 level better than the panelists' assignment, and 2 samples to a BCG level that was 1 level worse than the panelists.

Table 4-4. Model performance – coolwater macroinvertebrate samples.

Difference	Calibration	Confirmation
2 better	0	0
1 better	1	3
same	31	15
1 worse	2	0
2 worse	0	0
3 worse	0	0
Total # Samples	**34**	**18**
% Correct	**91.2%**	**83.3%**

In order to confirm the model, panelists made BCG level assignments on 20 additional cold-cool transitional samples[12]. Two of these were later excluded because they were spring samples. When nominal level assignments from the BCG decision model were compared to the panelists' nominal level assignments in the confirmation dataset, the model matched exactly with the

[12] there were originally 25 samples in the confirmation dataset, but the panelists decided to exclude 5 WDNR samples due to low number of individuals (<100) and/or potential data quality issues that we were unable to resolve.

regional biologists' BCG level assignments on 83% of the samples. In the 3 samples that did not have exact agreement, the model rated samples 1 level better than the panel(Table 4-4)..
It should be noted that all 3 of the confirmation samples where panel and model disagreed were very close to being in agreement. In two, the model assignments were a tie between BCG levels 2 and 3, but all of the panelists unanimously assigned the samples to BCG level 3.

Based on the combined results, in 88.5% of cases, the cold-cool transitional macroinvertebrate model predicts the same BCG level as the majority expert opinion.

4.3 Description of Transitional Cold-Cool Assemblages in each BCG Level

When panelists assess samples, they often associate particular taxa (and abundances of these taxa) with certain BCG levels. In Table 4-5, we provide narrative descriptions of each of the BCG levels that were assessed during this exercise (modified after Davies and Jackson (2006)), as well as lists of fish and macroinvertebrate taxa that were commonly found in samples from each BCG level.

Table 4-5. Description of transitional cold-cool assemblages in each assessed BCG level. Definitions are modified after Davies and Jackson (2006).

BCG level 1	**Definition:** Natural or native condition - *native structural, functional and taxonomic integrity is preserved; ecosystem function is preserved within the range of natural variability*
	Fish: If the stream is in a location where brook trout are native, ***native brook trout*** must be present. Non-native salmonids must be absent. Up to twelve additional taxa, including highly sensitive (Attribute I, II & III) species such as ***slimy sculpin*** and ***brook lamprey***, are also be present. If tolerant taxa are present, they occur in very low numbers.
	Macroinvertebrates: We lack sufficient information to know what the historical undisturbed macroinvertebrate assemblage looked like.
BCG level 2	**Definition:** Minimal changes in structure of the biotic community and minimal changes in ecosystem function - *virtually all native taxa are maintained with some changes in biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability*
	Fish: Overall taxa richness and density is as naturally occurs. Non-native salmonids may be present. If the stream is in a location where brook trout are native, ***native brook trout*** must be present and must not be negatively impacted by non-native salmonids such as ***brown trout***. Other highly sensitive (Attribute II) and intermediate sensitive (Attribute III) taxa such as ***sculpins (mottled or slimy), dace (pearl, finescale, northern red belly, longnose)*** and ***brook lamprey*** are also present. Tolerant taxa may be present but in low numbers.
	Macroinvertebrates: Overall taxa richness and density is as naturally occurs. Most sensitive (Attribute II) taxa (e.g. *Trichoptera*: ***Glossosoma, Rhyacophila, Lepidostoma, Dolophilodes;*** *Ephemeroptera*: ***Ephemerella, Epeorus;*** *Plecoptera*: ***Leuctridae***) and other taxa must be present. These plus intermediate sensitive (Attribute III) taxa (e.g. *Ephemeroptera*: ***Paraleptophlebia***; *Plecoptera*: ***Acroneuria, Isoperla, Paragnetina***; *Trichoptera*: ***Brachycentrus, Chimarra***) occur in higher relative abundances than in BCG level 3 samples. Tolerant taxa occur in low numbers.

Table 4-5. continued…

BCG level 3	**Definition:** Evident changes in structure of the biotic community and minimal changes in ecosystem function - *Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but intermediate sensitive taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system*
	Fish: Overall taxa richness and density is as naturally occurs. Sensitive taxa such as ***dace (pearl, finescale, northern red belly, longnose)*** and ***nothern hog suckers*** must outnumber tolerant taxa such as ***central stonerollers*** and ***bluegill.*** Taxa of intermediate tolerance (Attribute IV) such as ***white suckers***, ***blacknose dace, common shiners, darters (johnny, fantail)*** and ***creek chub*** are common, and some tolerant (Attribute V) taxa such as ***northern pike, yellow perch*** and ***stonerollers*** may be present. If extra tolerant taxa such as ***green sunfish*** and ***bluntnose*** and ***fathead minnows*** are present, they occur in very low numbers.
	Macroinvertebrates: Overall taxa richness and density is as naturally occurs. Similar to BCG level 2 assemblage except sensitive taxa (e.g. Ephemeroptera: Paraleptophlebia; Plecoptera: Acroneuria, Isoperla, Paragnetina; Trichoptera: Brachycentrus, Chimarra; Diptera: Diamesa, Eukiefferiella, Tvetenia) occur in lower relative abundance and the most sensitive (Attribute II) taxa may be absent. Taxa of intermediate tolerance (Attribute IV) (e.g. ***Gammarus, Oligochaeta, Simulium***; *Coleoptera:* ***Optioservus, Stenelmis***; *Ephemeroptera:* ***Baetis, Stenonema***; *Trichoptera:* ***Hydropsyche, Cheumatopsyche***) are common, and some tolerant taxa (Attribute V) occur in low numbers.
BCG level 4	**Definition:** Moderate changes in structure of the biotic community and minimal changes in ecosystem function - *Moderate changes in structure due to replacement of some intermediate sensitive taxa by more tolerant taxa, but reproducing populations of some sensitive taxa are maintained; overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes*
	Fish: Sensitive taxa such as ***dace (pearl, finescale, northern red belly, longnose)*** and ***nothern hog suckers*** are present but occur in very low numbers. Taxa of intermediate tolerance (Attribute IV) such as ***white suckers, blacknose dace, common shiners, darters (johnny, fantail)*** and ***creek chub*** are common, and some tolerant (Attribute V) taxa such as ***northern pike, yellow perch*** and ***stonerollers*** are present. When compared to BCG level 3 samples, highly tolerant taxa such as ***green sunfish*** and ***bluntnose*** and ***fathead minnows*** are present in greater numbers.
	Macroinvertebrates: Overall taxa richness is slightly reduced. Sensitive taxa (including EPT taxa) are present but occur in low numbers. Taxa of intermediate tolerance (Attribute IV) **(e.g. *Gammarus, Oligochaeta, Simulium***; *Coleoptera:* ***Optioservus, Stenelmis***; *Ephemeroptera:* ***Baetis, Stenonema***; *Trichoptera:* ***Hydropsyche, Cheumatopsyche***) are common, as are tolerant (Attribute V) taxa (e.g. *Diptera:* ***Cricotopus, Dicrotendipes, Paratanytarsus***; ***Hyalella; Physa; Turbellaria***).

Table 4-5. continued…

BCG level 5	**Definition:** Major changes in structure of the biotic community and moderate changes in ecosystem function - *Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity and redundancy; increased build-up or export of unused materials*
	Fish: Overall taxa richness may be reduced. Sensitive taxa drop out. Taxa of intermediate tolerance (Attribute IV) such as ***white suckers, blacknose dace, common shiners, darters (johnny, fantail)*** and ***creek chub*** are common. There is an influx of tolerant and highly tolerant taxa such as ***bluegill***, ***yellow perch, largemouth bass, northern pike, central stonerollers, bluntnose minnows, fathead minnows*** and ***green sunfish***.
	Macroinvertebrates: Overall taxa richness is slightly reduced. Sensitive taxa may be absent. Taxa of intermediate tolerance (Attribute IV) **(**e.g. ***Gammarus, Oligochaeta, Simulium****; Coleoptera:* ***Optioservus, Stenelmis****; Ephemeroptera:* ***Baetis, Stenonema****; Trichoptera:* ***Hydropsyche, Cheumatopsyche***) and tolerant (Attribute V) taxa (e.g. *Diptera:* ***Cricotopus, Dicrotendipes, Paratanytarsus; Hyalella; Physa; Turbellaria***) are common. Tolerant taxa occur in higher abundances than in BCG level 4 samples.

5 RECOMMENDATIONS AND DISCUSSION

5.1 Technical Recommendations

We were able to accomplish a great deal through this process. One participant has already applied the fish and macroinvertebrate cold and transitional-cool BCG models to data collected by Little River Band of Ottawa Indians in the lower Big Manistee watershed in Michigan. Results met with her expectations and provided an accurate reflection of the condition of LRBOI streams (Appendix L). However, improvements can and should be made. We conclude by making the following recommendations:

- **The Quantitative BCG models should be further refined.** Confirmation results showed the coolwater fish BCG had poorer performance in predicting the panel's assessments on the test sites. This model may be "overfitted" to the original calibration data set, where rules are developed for single sites. In addition, most of the model confirmation BCG level assignments were based on solo calls that panelists made several months after the last webinar. During a follow-up call in fall 2012, we were able to resolve some of the differences by going through subsets of the confirmation samples as a group. Where discrepancies still exist, rules may need to be revised.

- **The classification framework should be further refined**. Overall, results show that the temperature subclasses that we used in our analyses are a weak classification scheme regionwide for both fish and macroinvertebrate assemblages. More work needs to be done to ensure that samples are appropriately classified and are truly comparable. In many instances, discerning between cold and cold-cool transitional sites was problematic. This was due to a number of factors, such as lack of knowledge about what the historical condition was (i.e. has the surrounding land use changed in a way that would degrade the site and impact the thermal regime?), lack of consistent temperature data (for many sites, we had to rely on modeled temperature data, which is informative but is not always accurate). We worked around this issue by operating under the assumption that our cold and cold-cool transitional classification assignments were correct, but we recommend that better data be gathered and incorporated into future efforts. Macroinvertebrate assemblages are affected by stream gradient (water velocity). We excluded known low-gradient sites from the calibration set. Accordingly, it would be worth taking a closer look at gradient, to determine whether high and low-gradient qualify as a classification variable.

- **Certain types of site information should be gathered and considered from the start of the exercise**. Watershed size, gradient, and temperature data were key components of our analyses. Not all of these data were available from all entities. When they were, these data were sometimes difficult to compare across entities because they were collected or measured using different techniques. It would be valuable to have these data standardized and available for all sites, regardless of state or entity.

- **The collection of more detailed data should be encouraged.** If feasible, these should include:

  - Fish data on genetics (stocked vs. native) and age/size class
  - Species-level identifications for macroinvertebrates that have been identified as good thermal indicators (i.e. *Baetis*, *Gammarus*, *Caecidotea* and Naididae)
  - Continuous water temperature data for as many sites as possible
  - Flow alteration data, where available
  - Better baseflow/groundwater data, where available
  - Historic site information, where available

- **Data quality was uneven and troublesome among some of the entities.** Data quality has always been an issue in multi-state assessments.

- **Applying the BCG: methods matter.** The BCG calibration was done with data sets collected in standardized ways: for fish, electrofishing using the methods of Minnesota PCA, Wisconsin DNR, and Michigan DEP; for benthic macroinvertebrates, the methods of Minnesota PCA, Wisconsin DNR, Fond du Lac Band, Oneida Nation, and Little River Band. Macroinvertebrates must be identified to genus or lower. Applying the BCG models in this document to data collected with substantially different methods will have unpredictable results

5.2 BCG Calibration

The US EPA and state and tribal agencies in Minnesota, Michigan and Wisconsin partnered to develop a common assessment system based on the BCG for fish and macroinvertebrate assemblages in cold and cold-cool transitional wadeable streams. This was a collective exercise among regional biologists to develop consensus on assessments of samples. We elicited the rules that the biologists used to assess the samples, and developed a set of quantitative decision criteria rules for assigning fish and macroinvertebrate samples to BCG levels. The assessment system accommodates differences among the tribal and state monitoring programs (i.e. different sampling methods, different levels of taxonomic resolution).

The regional biologists were able to establish and quantify their differing expectations for cold and cold-cool transitional streams. Sometimes this line was blurry. For example, except for a few macroinvertebrate taxa (i.e. *Gammarus*), the regional biologists used the same BCG attribute assignments for taxa in the cold and cold-cool transitional samples. Also, in a number of instances there was overlap in the sets of cold and cold-cool transitional decision rules. However, some clear differences did emerge, particularly in the rules that were developed for level 3 samples. Differences were also evident in the total number of taxa. The biologists expected to see greater numbers of taxa in the cold-cool transitional water streams, and for fish assemblages in coldwater streams, watershed size was an important consideration when setting expectations for total taxa richness.

The biologists working on the fish and macroinvertebrate samples worked independently, and each group faced some unique challenges. The fish biologists struggled to reach a consensus on how to rate samples with non-native trout. Non-native trout are regarded as indicators of good water quality and coldwater habitat, but they also represent an altered fish assemblage. The general consensus was that BCG level 1 required absence of non-native trout, and that non-native trout could not outnumber natives in BCG Level 2. The biologists also developed rules that take into account the abundances of native or non-native trout in relation to the total number of salmonids.

Another question that the fish biologists struggled with was whether BCG level 1 samples exist in the Midwest. The reason this question is such a challenge is because there is not enough information to know what the historical undisturbed assemblage in this region looked like. The biologists felt that they needed more information, in particular on genetics (stocked vs. native) and age/size class, to discriminate between BCG level 1 and 2 samples. In future BCG exercises, efforts should be made to gather this type of information (if available) to help inform assessments.

The macroinvertebrate biologists also faced challenges associated with data limitations. Because organisms were only identified to the genus-level in the MPCA and Fond du Lac samples, panelists sometimes had to make assumptions about what thermal indicator species were present. Another challenge – one that limited model effectiveness on WDNR samples - was the fact that entities not only used different collection methods, but also used different index periods as well. As mentioned, the fish and macroinvertebrate biologists worked independently on this project. However, there were 8 overlapping sites (all coldwater) at which both fish and macroinvertebrate BCG level assignments were made. Five of the samples were collected during the same year, but on different collection dates (Appendix K). There was exact agreement at 4 of the sites. Fish and macroinvertebrate BCG level assignments differed by 1 BCG level at 3 of the sites and by 2 levels at the last site.

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APPENDIX A

Additional Classification Information

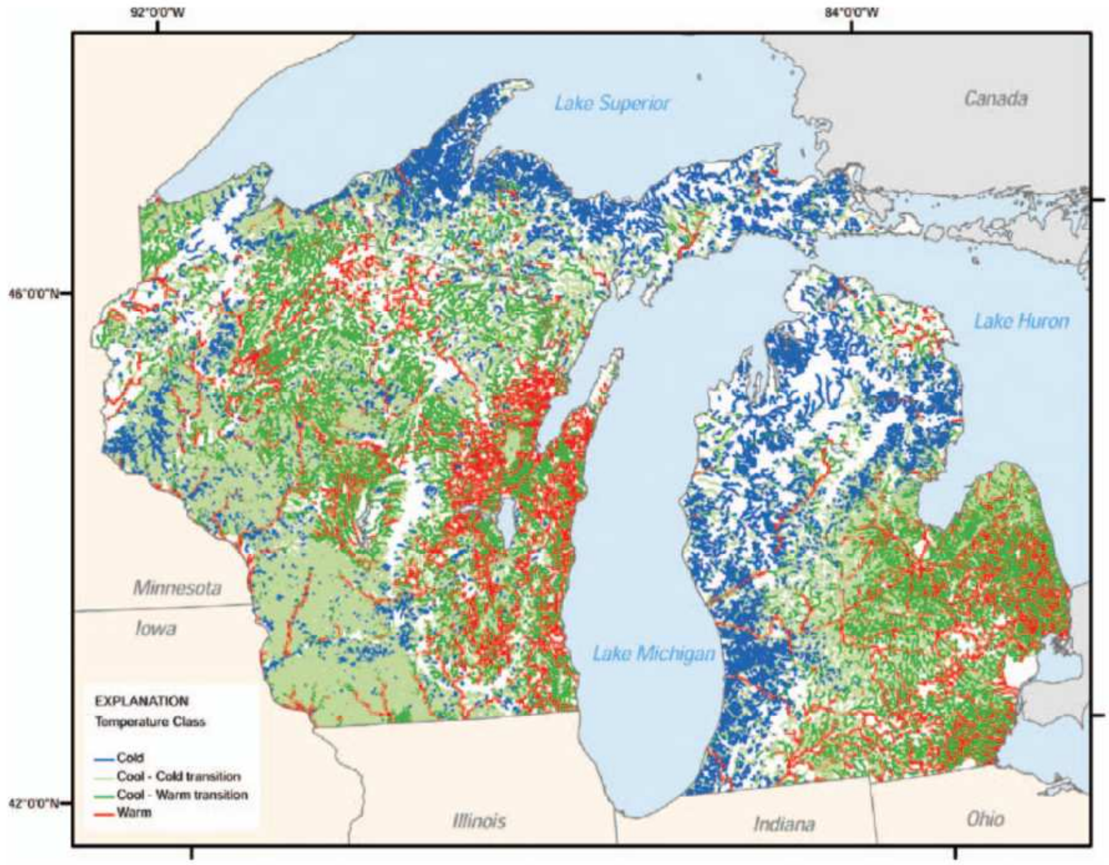

Figure A-1. Distributions of coldwater, cold transition, warm transition and warmwater streams in Michigan and Wisconsin, based on summer water temperature predictions (Figure 4 in Lyons et al. 2009).

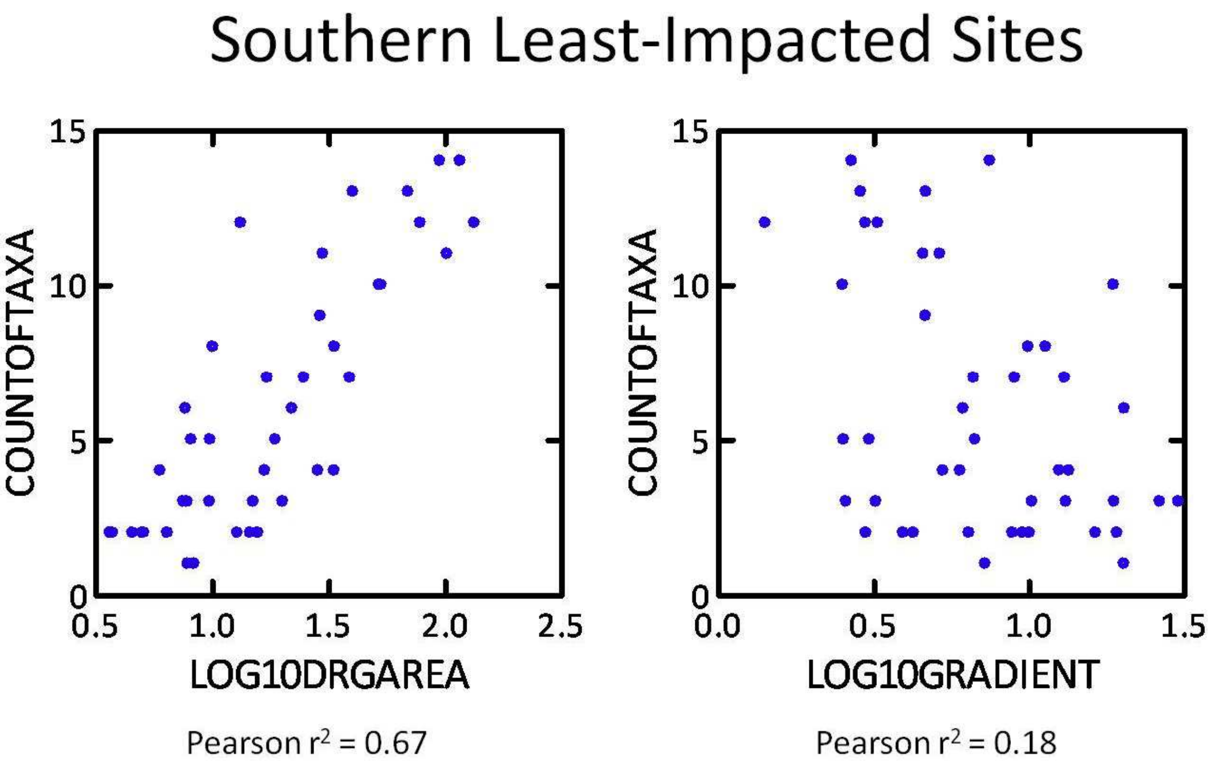

Figure A-2. Plots showing the relationships between number of fish taxa, watershed area and gradient in southern least-impacted coldwater sites in Minnesota (unpublished data from John Sandberg, MPCA). In the southern region, species richness is more strongly related to watershed area than to gradient.

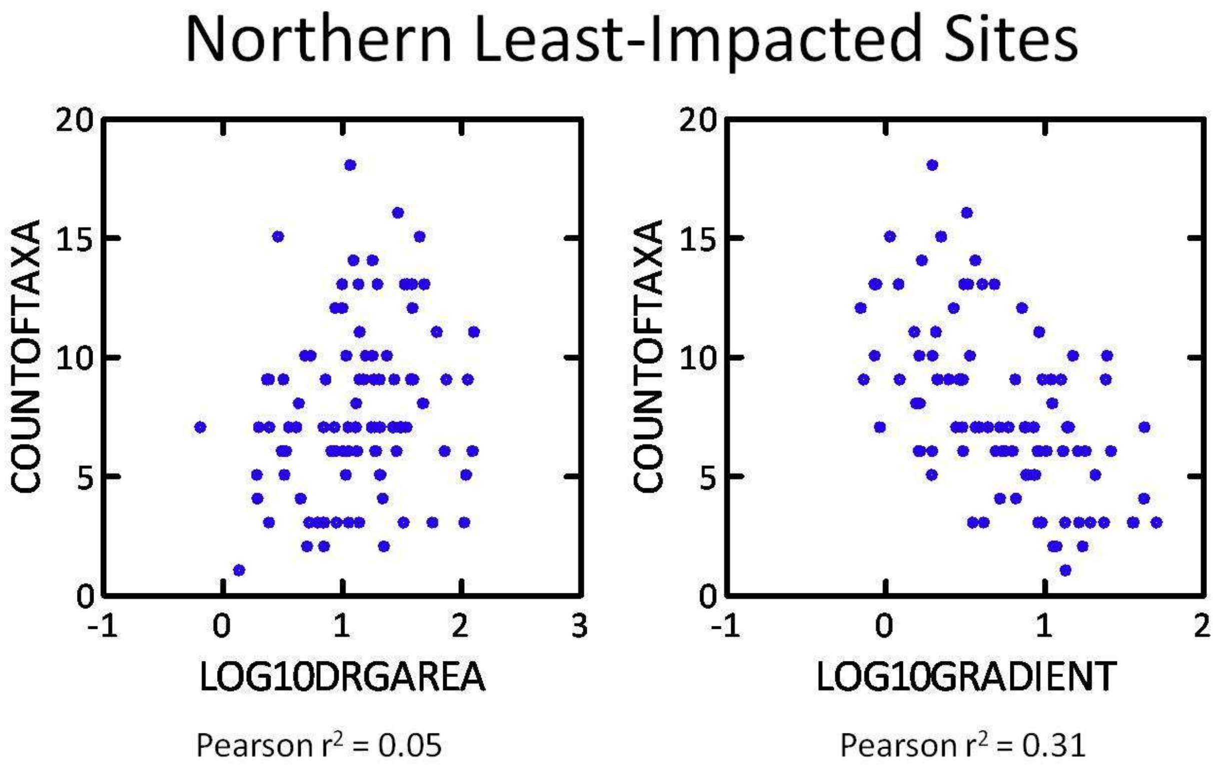

Figure A-3. Plots showing the relationships between number of fish taxa, watershed area and gradient in northern least-impacted coldwater sites in Minnesota (unpublished data from John Sandberg, MPCA). In the northern region, species richness is more strongly related to gradient than to watershed area.

APPENDIX B

Additional BCG Background Information

Table B1. Narrative descriptions of the 10 attributes that distinguish the six tiers of the Biological Condition Gradient (Davies and Jackson 2006).

	Biological Condition Gradient Tiers					
	1 Natural or native condition	2 Minimal changes in structure of the biotic community and minimal changes in ecosystem function	3 Evident changes in structure of the biotic community and minimal changes in ecosystem function	4 Moderate changes in structure of the biotic community and minimal changes in ecosystem function	5 Major changes in structure of the biotic community and moderate changes in ecosystem function	6 Severe changes in structure of the biotic community and major loss of ecosystem function
	General Description of Biological Condition					
Attributes	Native structural, functional and taxonomic integrity is preserved; ecosystem function is preserved within the range of natural variability	Virtually all native taxa are maintained with some changes in biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability	Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but sensitive-ubiquitous taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system	Moderate changes in structure due to replacement of some sensitive-ubiquitous taxa by more tolerant taxa, but reproducing populations of some sensitive taxa are maintained; overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes	Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity and redundancy; increased build-up or export of unused materials	Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism condition is often poor; ecosystem functions are severely altered

Table B1. Continued…

	1 Natural or native condition	2 Minimal changes in structure of the biotic community and minimal changes in ecosystem function	3 Evident changes in structure of the biotic community and minimal changes in ecosystem function	4 Moderate changes in structure of the biotic community and minimal changes in ecosystem function	5 Major changes in structure of the biotic community and moderate changes in ecosystem function	6 Severe changes in structure of the biotic community and major loss of ecosystem function
I Historically documented, sensitive, long-lived or regionally endemic taxa	As predicted for natural occurrence except for global extinctions	As predicted for natural occurrence except for global extinctions	Some may be absent due to global extinction or local extirpation	Some may be absent due to global, regional or local extirpation	Usually absent	Absent
II Sensitive-rare taxa	As predicted for natural occurrence, with at most minor changes from natural densities	Virtually all are maintained with some changes in densities	Some loss, with replacement by functionally equivalent sensitive-ubiquitous taxa	May be markedly diminished	Absent	Absent
III Sensitive-ubiquitous taxa	As predicted for natural occurrence, with at most minor changes from natural densities	Present and may be increasingly abundant	Common and abundant; relative abundance greater than sensitive-rare taxa	Present with reproducing populations maintained; some replacement by functionally equivalent taxa of intermediate tolerance	Frequently absent or markedly diminished	Absent

Table B1. Continued…

	1 Natural or native condition	2 Minimal changes in structure of the biotic community and minimal changes in ecosystem function	3 Evident changes in structure of the biotic community and minimal changes in ecosystem function	4 Moderate changes in structure of the biotic community and minimal changes in ecosystem function	5 Major changes in structure of the biotic community and moderate changes in ecosystem function	6 Severe changes in structure of the biotic community and major loss of ecosystem function
IV Taxa of intermediate tolerance	As predicted for natural occurrence, with at most minor changes from natural densities	As naturally present with slight increases in abundance	Often evident increases in abundance	Common and often abundant; relative abundance may be greater than sensitive-ubiquitous taxa	Often exhibit excessive dominance	May occur in extremely high or extremely low densities; richness of all taxa is low
V Tolerant taxa	As predicted for natural occurrence, at most minor changes from natural densities	As naturally present with slight increases in abundance	May be increases in abundance of functionally diverse tolerant taxa	May be common but do not exhibit significant dominance	Often occur in high densities and may be dominant	Usually comprise the majority of the assemblage; often extreme departures from normal densities (high or low)
VI Non-native or intentionally introduced taxa	Non-native taxa, if present, do not displace native taxa or alter native structural or functional integrity	Non-native taxa may be present, but occurrence has a non-detrimental effect on native taxa	Sensitive or intentionally introduced non-native taxa may dominate some assemblages (e.g., fish or macrophytes)	Some replacement of sensitive non-native taxa with functionally diverse assemblage of non-native taxa of intermediate tolerance	Some assemblages (e.g., fish or macrophytes) are dominated by tolerant non-native taxa	Often dominant; may be the only representative of some assemblages (e.g., plants, fish, bivalves)

Table B1. Continued…

	1	2	3	4	5	6
	Natural or native condition	Minimal changes in structure of the biotic community and minimal changes in ecosystem function	Evident changes in structure of the biotic community and minimal changes in ecosystem function	Moderate changes in structure of the biotic community and minimal changes in ecosystem function	Major changes in structure of the biotic community and moderate changes in ecosystem function	Severe changes in structure of the biotic community and major loss of ecosystem function
VII Organism condition (especially of long-lived organisms)	Any anomalies are consistent with naturally occurring incidence and characteristics	Any anomalies are consistent with naturally occurring incidence and characteristics	Anomalies are infrequent	Incidence of anomalies may be slightly higher than expected	Biomass may be reduced; anomalies increasingly common	Long-lived taxa may be absent; biomass reduced; anomalies common and serious; minimal reproduction except for extremely tolerant groups
VIII Ecosystem functions	All are maintained within the range of natural variability	All are maintained within the range of natural variability	Virtually all are maintained through functionally redundant system attributes; minimal increase in export except at high storm flows	Virtually all are maintained through functionally redundant system attributes though there is evidence of loss of efficiency (e.g., increased export or decreased import)	Apparent loss of some ecosystem functions manifested as increased export or decreased import of some resources, and changes in energy exchange rates (e.g., P/R, decomposition)	Most functions show extensive and persistent disruption
IX Spatial and temporal extent of detrimental effects	N/A A natural disturbance regime is maintained	Limited to small pockets and short duration	Limited to the reach scale and/or limited to within a season	Mild detrimental effects may be detectable beyond the reach scale and may include more than one season	Detrimental effects extend far beyond the reach scale leaving only a few islands of adequate conditions; effect extends across multiple seasons	Detrimental effects may eliminate all refugia and colonization sources within the catchment and affect multiple seasons

Table B1. Continued…

	1 Natural or native condition	2 Minimal changes in structure of the biotic community and minimal changes in ecosystem function	3 Evident changes in structure of the biotic community and minimal changes in ecosystem function	4 Moderate changes in structure of the biotic community and minimal changes in ecosystem function	5 Major changes in structure of the biotic community and moderate changes in ecosystem function	6 Severe changes in structure of the biotic community and major loss of ecosystem function
X Ecosystem connectance	System is highly connected in space and time, at least annually	Ecosystem connectance is unimpaired	Slight loss of connectance but there are adequate local recolonization sources	Some loss of connectance but colonization sources and refugia exist within the catchment	Significant loss of ecosystem connectance is evident; recolonization sources do not exist for some taxa	Complete loss of ecosystem connectance in at least one dimension (i.e., longitudinal, lateral, vertical, or temporal) lowers reproductive success of most groups; frequent failures in reproduction and recruitment

APPENDIX C

Fish BCG Attribute Assignments

Appendix C. Table C -1. BCG attribute assignments for fish. Assignments are the same for both cold and cold-cool transitional subclasses. This list is sorted first by family, then by common name.

BCG Attribute	Order	Family	Scientific Name	Common Name
5	Amiiformes	Amiidae	*Amia calva*	bowfin
x	Percopsiformes	Aphredoderidae	*Aphredoderus sayanus*	pirate perch
x	Atheriniformes	Atherinopsidae	*Labidesthes sicculus*	brook silverside
4	Cypriniformes	Catostomidae	*Ictiobus cyprinellus*	bigmouth buffalo
4	Cypriniformes	Catostomidae	*Moxostoma duquesnei*	black redhorse
x	Cypriniformes	Catostomidae	*Erimyzon oblongus*	creek chubsucker
4	Cypriniformes	Catostomidae	*Moxostoma erythrurum*	golden redhorse
4	Cypriniformes	Catostomidae	*Moxostoma valenciennesi*	greater redhorse
x	Cypriniformes	Catostomidae	*Erimyzon sucetta*	lake chubsucker
2	Cypriniformes	Catostomidae	*Catostomus catostomus*	longnose sucker
3	Cypriniformes	Catostomidae	*Hypentelium nigricans*	northern hog sucker
x	Cypriniformes	Catostomidae	*Carpiodes cyprinus*	quillback
x	Cypriniformes	Catostomidae	*Moxostoma*	redhorse
x	Cypriniformes	Catostomidae	*Carpiodes carpio*	river carpsucker
x	Cypriniformes	Catostomidae	*Moxostoma carinatum*	river redhorse
4	Cypriniformes	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse
4	Cypriniformes	Catostomidae	*Moxostoma anisurum*	silver redhorse
x	Cypriniformes	Catostomidae	*Catostomus*	sucker
4	Cypriniformes	Catostomidae	*Catostomus commersonii*	white sucker
5	Perciformes	Centrarchidae	*Pomoxis nigromaculatus*	black crappie
5	Perciformes	Centrarchidae	*Lepomis macrochirus*	bluegill
x	Perciformes	Centrarchidae	*Lepomis hybrid 5*	bluegill - green sunfish hybrid
x	Perciformes	Centrarchidae	*Lepomis hybrid 6*	bluegill - pumpkinseed hybrid
x	Perciformes	Centrarchidae	*Lepomis hybrid 1*	bluegill - sunfish hybrid
x	Perciformes	Centrarchidae	*Lepomis hybrid 4*	bluegill hybrid

Table C -1 continued…

BCG Attribute	Order	Family	Scientific Name	Common Name
5a	Perciformes	Centrarchidae	*Lepomis cyanellus*	green sunfish
x	Perciformes	Centrarchidae		green sunfish - pumpkinseed hybrid
x	Perciformes	Centrarchidae	*Lepomis hybrid 2*	green sunfish - unknown hybrid
5	Perciformes	Centrarchidae	*Micropterus salmoides*	largemouth bass
x	Perciformes	Centrarchidae	*Lepomis megalotis*	longear sunfish
5a	Perciformes	Centrarchidae	*Lepomis humilis*	orangespotted sunfish
5	Perciformes	Centrarchidae	*Lepomis gibbosus*	pumpkinseed
x	Perciformes	Centrarchidae	*Lepomis hybrid 3*	pumpkinseed - sunfish hybrid
4	Perciformes	Centrarchidae	*Ambloplites rupestris*	rock bass
4	Perciformes	Centrarchidae	*Micropterus dolomieu*	smallmouth bass
x	Perciformes	Centrarchidae	*Centrarchidae hybrid*	sunfish hybrid
x	Perciformes	Centrarchidae	*Lepomis gulosus*	warmouth
x	Perciformes	Centrarchidae	*Pomoxis annularis*	white crappie
x	Clupeiformes	Clupeidae	*Dorosoma cepedianum*	gizzard shad
3	Scorpaeniformes	Cottidae	*Cottus bairdii*	mottled sculpin
3	Scorpaeniformes	Cottidae	*Cottus*	sculpin
2	Scorpaeniformes	Cottidae	*Cottus cognatus*	slimy sculpin
5a	Cypriniformes	Cyprinidae	*Notropis dorsalis*	bigmouth shiner
4	Cypriniformes	Cyprinidae	*Notropis heterodon*	blackchin shiner
4	Cypriniformes	Cyprinidae	*Notropis heterolepis*	blacknose shiner
5a	Cypriniformes	Cyprinidae	*Pimephales notatus*	bluntnose minnow
5	Cypriniformes	Cyprinidae	*Hybognathus hankinsoni*	brassy minnow
4	Cypriniformes	Cyprinidae	*Pimephales vigilax*	bullhead minnow
4	Cypriniformes	Cyprinidae	*Notropis percobromus*	carmine shiner
x	Cypriniformes	Cyprinidae	*Notropis dorsalis dorsalis*	central bigmouth shiner

Table C -1 continued…

BCG Attribute	Order	Family	Scientific Name	Common Name
5	Cypriniformes	Cyprinidae	*Campostoma anomalum*	central stoneroller
6a	Cypriniformes	Cyprinidae	*Cyprinus carpio*	common carp
4	Cypriniformes	Cyprinidae	*Luxilus cornutus*	common shiner
4	Cypriniformes	Cyprinidae	*Semotilus atromaculatus*	creek chub
x	Cypriniformes	Cyprinidae		creek chub - unknown hybrid
4	Cypriniformes	Cyprinidae	*Rhinichthys atratulus*	eastern blacknose dace
4	Cypriniformes	Cyprinidae	*Notropis atherinoides*	emerald shiner
4	Cypriniformes	Cyprinidae	*Cyprinidae*	Fam: minnows
5a	Cypriniformes	Cyprinidae	*Pimephales promelas*	fathead minnow
3	Cypriniformes	Cyprinidae	*Phoxinus neogaeus*	finescale dace
4	Cypriniformes	Cyprinidae	*Notropis*	Gen: Notropis
4	Cypriniformes	Cyprinidae	*Phoxinus*	Gen: Phoxinus
4	Cypriniformes	Cyprinidae	*Notemigonus crysoleucas*	golden shiner
4	Cypriniformes	Cyprinidae	*Nocomis biguttatus*	hornyhead chub
3	Cypriniformes	Cyprinidae	*Couesius plumbeus*	lake chub
5	Cypriniformes	Cyprinidae	*Campostoma oligolepis*	largescale stoneroller
3	Cypriniformes	Cyprinidae	*Rhinichthys cataractae*	longnose dace
4	Cypriniformes	Cyprinidae	*Notropis volucellus*	mimic shiner
3	Cypriniformes	Cyprinidae	*Phoxinus eos*	northern redbelly dace
4	Cypriniformes	Cyprinidae	*Notropis nubilus*	Ozark minnow
3	Cypriniformes	Cyprinidae	*Margariscus margarita*	pearl dace
5	Cypriniformes	Cyprinidae	*Cyprinella lutrensis*	red shiner
3	Cypriniformes	Cyprinidae	*Clinostomus elongatus*	redside dace
x	Cypriniformes	Cyprinidae	*Nocomis micropogon*	river chub
4	Cypriniformes	Cyprinidae	*Notropis blennius*	river shiner

Table C -1 continued…

BCG Attribute	Order	Family	Scientific Name	Common Name
x	Cypriniformes	Cyprinidae	*Notropis rubellus*	rosyface shiner
5a	Cypriniformes	Cyprinidae	*Notropis stramineus*	sand shiner
x	Cypriniformes	Cyprinidae	*Luxilus*	shiner
x	Cypriniformes	Cyprinidae	*Notropis photogenis*	silver shiner
4	Cypriniformes	Cyprinidae	*Phoxinus erythrogaster*	southern redbelly dace
4	Cypriniformes	Cyprinidae	*Cyprinella spiloptera*	spotfin shiner
4	Cypriniformes	Cyprinidae	*Notropis hudsonius*	spottail shiner
x	Cypriniformes	Cyprinidae	*Campostoma*	stoneroller
4	Cypriniformes	Cyprinidae	*Phenacobius mirabilis*	suckermouth minnow
4	Cypriniformes	Cyprinidae	*Rhinichthys obtusus*	western blacknose dace
x	Esociformes	Esocidae	*Esox americanus vermiculatus*	grass pickerel
5	Esociformes	Esocidae	*Esox masquinongy*	muskellunge
5	Esociformes	Esocidae	*Esox lucius*	northern pike
4	Gadiformes	Gadidae	*Lota lota*	burbot
4	Gasterosteiformes	Gasterosteidae	*Culaea inconstans*	brook stickleback
x	Gasterosteiformes	Gasterosteidae	*Culaea*	stickleback
x	Gasterosteiformes	Gasterosteidae	*Gasterosteus aculeatus*	threespine stickleback
6a	Perciformes	Gobiidae	*Neogobius melanostomus*	round goby
x	Hiodontiformes	Hiodontidae	*Hiodon tergisus*	mooneye
5a	Siluriformes	Ictaluridae	*Ameiurus melas*	black bullhead
5	Siluriformes	Ictaluridae	*Ameiurus nebulosus*	brown bullhead
x	Siluriformes	Ictaluridae	*Ictaluridae*	catfish
x	Siluriformes	Ictaluridae	*Ictalurus punctatus*	channel catfish
x	Siluriformes	Ictaluridae	*Noturus*	madtom
x	Siluriformes	Ictaluridae	*Noturus stigmosus*	northern madtom

Table C -1 continued…

BCG Attribute	Order	Family	Scientific Name	Common Name
4	Siluriformes	Ictaluridae	*Noturus flavus*	stonecat
5	Siluriformes	Ictaluridae	*Noturus gyrinus*	tadpole madtom
5	Siluriformes	Ictaluridae	*Ameiurus natalis*	yellow bullhead
4	Perciformes	Percidae	*Etheostoma zonale*	banded darter
4	Perciformes	Percidae	*Percina maculata*	blackside darter
x	Perciformes	Percidae	*Etheostoma chlorosoma*	bluntnose darter
4	Perciformes	Percidae	*Etheostoma flabellare*	fantail darter
4	Perciformes	Percidae	*Etheostoma blennioides*	greenside darter
4	Perciformes	Percidae	*Etheostoma exile*	Iowa darter
4	Perciformes	Percidae	*Etheostoma nigrum*	johnny darter
x	Perciformes	Percidae	*Etheostoma microperca*	least darter
4	Perciformes	Percidae	*Percina caprodes*	logperch
4	Perciformes	Percidae	*Etheostoma asprigene*	mud darter
4	Perciformes	Percidae	*Etheostoma caeruleum*	rainbow darter
x	Perciformes	Percidae	*Percina phoxocephala*	slenderhead darter
5	Perciformes	Percidae	*Sander vitreus*	walleye
5	Perciformes	Percidae	*Perca flavescens*	yellow perch
4	Percopsiformes	Percopsidae	*Percopsis omiscomaycus*	trout-perch
2	Petromyzontiformes	Petromyzontidae	*Lampetra appendix*	American brook lamprey
3	Petromyzontiformes	Petromyzontidae	*Ichthyomyzon castaneus*	chestnut lamprey
x	Petromyzontiformes	Petromyzontidae	*Petromyzontidae*	lamprey
x	Petromyzontiformes	Petromyzontidae	*Petromyzontidae larva*	lamprey ammocoete
2	Petromyzontiformes	Petromyzontidae	*Ichthyomyzon fossor*	northern brook lamprey
6a	Petromyzontiformes	Petromyzontidae	*Petromyzon marinus*	sea lamprey
3	Petromyzontiformes	Petromyzontidae	*Ichthyomyzon unicuspis*	silver lamprey

Table C -1 continued…

BCG Attribute	Order	Family	Scientific Name	Common Name
2	Salmoniformes	Salmonidae	*Salvelinus fontinalis*	brook trout
6	Salmoniformes	Salmonidae	*Salmo trutta*	brown trout
6	Salmoniformes	Salmonidae	*Oncorhynchus tshawytscha*	Chinook salmon
6	Salmoniformes	Salmonidae	*Oncorhynchus kisutch*	coho salmon
6	Salmoniformes	Salmonidae	*Oncorhynchus gorbuscha*	pink salmon
6	Salmoniformes	Salmonidae	*Oncorhynchus mykiss*	rainbow trout
x	Salmoniformes	Salmonidae	*Prosopium cylindraceum*	round whitefish
6	Salmoniformes	Salmonidae	*Salmo trutta X Salvelinus fontinalis*	tiger trout
x	Percopsiformes	Salmonidae	*Salmonidae*	trout
4	Perciformes	Sciaenidae	*Aplodinotus grunniens*	freshwater drum
5	Esociformes	Umbridae	*Umbra limi*	central mudminnow

APPENDIX D

BCG Attribute Assignments - Macroinvertebrates

Appendix D. Table D1. BCG attribute assignments for macroinvertebrates. Some assignments differ between the cold (COLD) and cold-cool transitional (COOL) subclasses. This list is sorted first by order, then family, then final ID (=lowest level of taxonomic resolution).

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	x			Acari
x	x			Annelida
5	5			Hirudinea
x	x			Nematomorpha
x	x			Ostracoda
5	5			Turbellaria
x	x	Amphipoda		Amphipoda
4	4	Amphipoda	Crangonyctidae	Crangonyx
x	4	Amphipoda	Crangonyctidae	Crangonyx gracilis
4	x	Amphipoda	Gammaridae	Gammaridae
4	3	Amphipoda	Gammaridae	Gammarus
4	3	Amphipoda	Gammaridae	Gammarus pseudolimnaeus
5	5	Amphipoda	Hyalellidae	Hyalella
5	5	Amphipoda	Hyalellidae	Hyalella azteca
x	5	Arhynchobdellida	Erpobdellidae	Dina dubia
5	5	Arhynchobdellida	Erpobdellidae	Dina parva
x	5	Arhynchobdellida	Erpobdellidae	Erpobdella
5	5	Arhynchobdellida	Erpobdellidae	Erpobdellidae
x	5	Arhynchobdellida	Erpobdellidae	Mooreobdella microstoma
5	5	Arhynchobdellida	Erpobdellidae	Nephelopsis
5	5	Arhynchobdellida	Hirudinidae	Hirudinidae
x	x	Basommatophora	Ancylidae	Ancylidae
4	4	Basommatophora	Ancylidae	Ferrissia
x	x	Basommatophora	Ancylidae	Laevapex
4	4	Basommatophora	Lymnaeidae	Fossaria

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
4	4	Basommatophora	Lymnaeidae	Lymnaea
4	4	Basommatophora	Lymnaeidae	Lymnaeidae
4	4	Basommatophora	Lymnaeidae	Pseudosuccinea
4	4	Basommatophora	Lymnaeidae	Stagnicola
4	4	Basommatophora	Physidae	Bivalvia
5	5	Basommatophora	Physidae	Physa
5	5	Basommatophora	Physidae	Physella
5	5	Basommatophora	Physidae	Physidae
5	5	Basommatophora	Planorbidae	Gyraulus
5	5	Basommatophora	Planorbidae	Helisoma
4	4	Basommatophora	Planorbidae	Planorbella
4	4	Basommatophora	Planorbidae	Planorbidae
4	4	Branchiobdellida		Branchiobdellida
4	4	Branchiobdellida	Branchiobdellidae	Branchiobdellidae
x	x	Coleoptera	Carabidae	Carabidae
x	x	Coleoptera	Chrysomelidae	Chrysomelidae
x	x	Coleoptera	Coleoptera	Coleoptera
x	x	Coleoptera	Curculionidae	Listronotus
3	3	Coleoptera	Dryopidae	Helichus
x	3	Coleoptera	Dryopidae	Helichus striatus
4	4	Coleoptera	Dytiscidae	Agabus
x	x	Coleoptera	Dytiscidae	Dytiscidae
3	3	Coleoptera	Dytiscidae	Heterosternuta
x	x	Coleoptera	Dytiscidae	Hydroporus larsoni
x	x	Coleoptera	Dytiscidae	Hygrotus

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	x	Coleoptera	Dytiscidae	Ilybius
4	4	Coleoptera	Dytiscidae	Laccophilus
x	4	Coleoptera	Dytiscidae	Laccophilus maculosus
4	4	Coleoptera	Dytiscidae	Liodessus
4	4	Coleoptera	Dytiscidae	Neoporus
4	4	Coleoptera	Elmidae	Ancyronyx
4	4	Coleoptera	Elmidae	Dubiraphia
4	4	Coleoptera	Elmidae	Dubiraphia bivittata
4	4	Coleoptera	Elmidae	Dubiraphia minima
4	4	Coleoptera	Elmidae	Dubiraphia quadrinotata
4	4	Coleoptera	Elmidae	Dubiraphia vittata
x	x	Coleoptera	Elmidae	Elmidae
4	4	Coleoptera	Elmidae	Macronychus
4	4	Coleoptera	Elmidae	Macronychus glabratus
x	x	Coleoptera	Elmidae	Microcylloepus
4	4	Coleoptera	Elmidae	Optioservus
4	4	Coleoptera	Elmidae	Optioservus fastiditus
3	3	Coleoptera	Elmidae	Optioservus trivittatus
4	4	Coleoptera	Elmidae	Stenelmis
4	4	Coleoptera	Elmidae	Stenelmis crenata
x	x	Coleoptera	Elmidae	Stenelmis decorata
x	x	Coleoptera	Elmidae	Stenelmis grossa
x	x	Coleoptera	Elmidae	Stenelmis musgravei
4	4	Coleoptera	Gyrinidae	Gyrinus
x	x	Coleoptera	Haliplidae	Brychius

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	x	Coleoptera	Haliplidae	Haliplidae
5	5	Coleoptera	Haliplidae	Haliplus
4	4	Coleoptera	Haliplidae	Peltodytes
4	4	Coleoptera	Helophoridae	Helophorus
x	x	Coleoptera	Hydraenidae	Gymnochthebius
3	3	Coleoptera	Hydraenidae	Hydraena
x	x	Coleoptera	Hydraenidae	Hydraenidae
4	4	Coleoptera	Hydraenidae	Ochthebius
4	4	Coleoptera	Hydrochidae	Hydrochus
4	4	Coleoptera	Hydrophilidae	Anacaena
x	4	Coleoptera	Hydrophilidae	Anacaena lutescens
4	4	Coleoptera	Hydrophilidae	Crenitis
5	5	Coleoptera	Hydrophilidae	Enochrus
4	4	Coleoptera	Hydrophilidae	Hydrobius
x	x	Coleoptera	Hydrophilidae	Hydrochara
4	4	Coleoptera	Hydrophilidae	Hydrophilidae
4	4	Coleoptera	Hydrophilidae	Paracymus
4	4	Coleoptera	Hydrophilidae	Tropisternus
x	x	Coleoptera	Psephenidae	Ectopria leechi sp.1
x	x	Coleoptera	Psephenidae	NERVOSA SP.2
4	4	Coleoptera	Scirtidae	Cyphon
4	4	Coleoptera	Scirtidae	Scirtes
x	x	Coleoptera	Sphaeriusidae	Sphaeriusidae
x	x	Coleoptera	Staphylinidae	Staphylinidae
x	x	Collembola		Collembola

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	x	Cyclopoida	Cyclopidae	Cyclopidae
x	x	Decapoda		Decapoda
x	x	Decapoda	Astacidae	Astacidae
x	x	Decapoda	Cambaridae	Cambaridae
4	4	Decapoda	Cambaridae	Orconectes
6	6	Decapoda	Cambaridae	Orconectes rusticus
4	4	Decapoda	Cambaridae	Orconectes virilis
x	x	Diptera		Diptera
3	3	Diptera	Athericidae	Atherix
3	3	Diptera	Athericidae	Atherix variegata
4	4	Diptera	Ceratopogonidae	Alluaudomyia
4	4	Diptera	Ceratopogonidae	Atrichopogon
4	4	Diptera	Ceratopogonidae	Bezzia
x	4	Diptera	Ceratopogonidae	Bezzia/Palpomyia
4	4	Diptera	Ceratopogonidae	Ceratopogon
x	4	Diptera	Ceratopogonidae	Ceratopogon culicoidithorax
4	4	Diptera	Ceratopogonidae	Ceratopogonidae
x	x	Diptera	Ceratopogonidae	Ceratopogoninae
4	4	Diptera	Ceratopogonidae	Culicoides
4	4	Diptera	Ceratopogonidae	Dasyhelea
4	4	Diptera	Ceratopogonidae	Forcipomyia
4	4	Diptera	Ceratopogonidae	Mallochohelea
4	4	Diptera	Ceratopogonidae	Nilobezzia
4	4	Diptera	Ceratopogonidae	Probezzia
4	4	Diptera	Ceratopogonidae	Serromyia

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
4	4	Diptera	Ceratopogonidae	Stilobezzia
4	4	Diptera	Chironomidae	Ablabesmyia
4	4	Diptera	Chironomidae	Acricotopus
x	x	Diptera	Chironomidae	Apsectrotanypus
x	x	Diptera	Chironomidae	Arctopelopia
3	3	Diptera	Chironomidae	Brillia
3	3	Diptera	Chironomidae	Brillia flavifrons
3	3	Diptera	Chironomidae	Brillia flavifrons Gp.
3	3	Diptera	Chironomidae	Brillia parva
4	4	Diptera	Chironomidae	Cardiocladius
3	3	Diptera	Chironomidae	Chaetocladius
x	x	Diptera	Chironomidae	Chironomidae
x	x	Diptera	Chironomidae	Chironominae
x	x	Diptera	Chironomidae	Chironominae sp.4
x	x	Diptera	Chironomidae	Chironomini
x	x	Diptera	Chironomidae	Chironomini sp.4
5	5	Diptera	Chironomidae	Chironomus
x	x	Diptera	Chironomidae	Cladopelma
4	4	Diptera	Chironomidae	Cladotanytarsus
4	4	Diptera	Chironomidae	CLADOTANYTARSUS SP. GP. A
4	4	Diptera	Chironomidae	Cladotanytarsus vanderwulpi Gp.
4	4	Diptera	Chironomidae	Clinotanypus
x	x	Diptera	Chironomidae	Coelotanypus
4	4	Diptera	Chironomidae	Conchapelopia
x	x	Diptera	Chironomidae	Conchapelopia/Helopelopia

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
3	3	Diptera	Chironomidae	Constempellina
4	4	Diptera	Chironomidae	Corynoneura
5	5	Diptera	Chironomidae	Cricotopus
x	x	Diptera	Chironomidae	Cricotopus annulator
5	x	Diptera	Chironomidae	Cricotopus bicinctus
5	x	Diptera	Chironomidae	Cricotopus bicinctus Gr.
5	x	Diptera	Chironomidae	Cricotopus festivellus Gr.
5	x	Diptera	Chironomidae	Cricotopus infuscatus
5	x	Diptera	Chironomidae	Cricotopus infuscatus/triannula
5	x	Diptera	Chironomidae	Cricotopus intersectus Gp.
5	x	Diptera	Chironomidae	Cricotopus luciae
5	x	Diptera	Chironomidae	Cricotopus sylvestris Gr.
5	x	Diptera	Chironomidae	Cricotopus tremulus Gp.
5	x	Diptera	Chironomidae	Cricotopus trifascia
5	x	Diptera	Chironomidae	Cricotopus trifascia Gr.
5	x	Diptera	Chironomidae	Cricotopus/Orthocladius
4	4	Diptera	Chironomidae	Cryptochironomus
x	x	Diptera	Chironomidae	Cryptochironomus fulvus
4	4	Diptera	Chironomidae	Cryptotendipes
3	3	Diptera	Chironomidae	Demicryptochironomus
3	3	Diptera	Chironomidae	Diamesa
3	3	Diptera	Chironomidae	Diamesinae sp.2
5	5	Diptera	Chironomidae	Dicrotendipes
x	5	Diptera	Chironomidae	Dicrotendipes fumidus
4	4	Diptera	Chironomidae	Diplocladius

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	x	Diptera	Chironomidae	Einfeldia
5	5	Diptera	Chironomidae	Endochironomus
4	4	Diptera	Chironomidae	Endotribelos
4	4	Diptera	Chironomidae	Epoicocladius
x	4	Diptera	Chironomidae	Epoicocladius flavens
x	4	Diptera	Chironomidae	EPOICOCLADIUS SP.3
3	3	Diptera	Chironomidae	Eukiefferiella
x	3	Diptera	Chironomidae	Eukiefferiella brehmi Gr.
x	3	Diptera	Chironomidae	Eukiefferiella brevicalcar Gr.
x	3	Diptera	Chironomidae	Eukiefferiella claripennis Gr.
3	3	Diptera	Chironomidae	Eukiefferiella devonica Gr.
x	3	Diptera	Chironomidae	Eukiefferiella gracei Gr.
x	3	Diptera	Chironomidae	Eukiefferiella rectangularis Gp.
5	5	Diptera	Chironomidae	Glyptotendipes
x	5	Diptera	Chironomidae	Glyptotendipes (Glyptotendipes) SP. G
x	5	Diptera	Chironomidae	GLYPTOTENDIPES SP.G
x	x	Diptera	Chironomidae	Hayesomyia
2	2	Diptera	Chironomidae	Heleniella
2	2	Diptera	Chironomidae	Heterotrissocladius
4	4	Diptera	Chironomidae	Hydrobaenus
5	5	Diptera	Chironomidae	Kiefferulus
4	4	Diptera	Chironomidae	Labrundinia
4	4	Diptera	Chironomidae	Larsia
4	4	Diptera	Chironomidae	Lauterborniella
x	4	Diptera	Chironomidae	Lauterborniella agrayloides

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
4	4	Diptera	Chironomidae	Limnophyes
2	2	Diptera	Chironomidae	Lopescladius
x	x	Diptera	Chironomidae	Meropelopia
4	4	Diptera	Chironomidae	Microchironomus
x	x	Diptera	Chironomidae	Microcricotopus
4	4	Diptera	Chironomidae	Micropsectra
3	3	Diptera	Chironomidae	Microtendipes
4	3	Diptera	Chironomidae	Microtendipes pedellus
4	3	Diptera	Chironomidae	Microtendipes pedellus Gr.
3	3	Diptera	Chironomidae	Microtendipes rydalensis Gr.
4	4	Diptera	Chironomidae	Nanocladius
x	4	Diptera	Chironomidae	Nanocladius branchicolus
x	4	Diptera	Chironomidae	Nanocladius crassicornus
x	4	Diptera	Chironomidae	Nanocladius downesi
x	4	Diptera	Chironomidae	Nanocladius rectinervis
x	4	Diptera	Chironomidae	Nanocladius SP.5
4	4	Diptera	Chironomidae	Natarsia
x	4	Diptera	Chironomidae	Natarsia baltimoreus
x	x	Diptera	Chironomidae	Neostempellina
4	4	Diptera	Chironomidae	Nilotanypus
x	4	Diptera	Chironomidae	Nilotanypus fimbriatus
2	2	Diptera	Chironomidae	Nilothauma
3	3	Diptera	Chironomidae	Odontomesa
x	x	Diptera	Chironomidae	Omisus
x	x	Diptera	Chironomidae	Orthocladiinae

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	x	Diptera	Chironomidae	Orthocladiinae sp.1
4	4	Diptera	Chironomidae	Orthocladius
4	4	Diptera	Chironomidae	Orthocladius (Euortho.) rivulorum
4	4	Diptera	Chironomidae	Orthocladius (Euorthocladius)
3	4	Diptera	Chironomidae	Orthocladius frigidus
3	3	Diptera	Chironomidae	Pagastia
3	3	Diptera	Chironomidae	Pagastia sp.A
3	3	Diptera	Chironomidae	Pagastiella
2	2	Diptera	Chironomidae	Parachaetocladius
4	4	Diptera	Chironomidae	Parachironomus
x	4	Diptera	Chironomidae	Parachironomus tenuicaudatus
4	4	Diptera	Chironomidae	Paracladopelma
4	4	Diptera	Chironomidae	Parakiefferiella
4	4	Diptera	Chironomidae	Paralauterborniella
4	4	Diptera	Chironomidae	Paramerina
3	3	Diptera	Chironomidae	Parametriocnemus
4	4	Diptera	Chironomidae	Paraphaenocladius
5	5	Diptera	Chironomidae	Paratanytarsus
5	5	Diptera	Chironomidae	Paratanytarsus sp.A
5	5	Diptera	Chironomidae	PARATANYTARSUS SP.B
4	4	Diptera	Chironomidae	Paratendipes
4	4	Diptera	Chironomidae	Pentaneura
4	4	Diptera	Chironomidae	Pentaneura inconspicua
4	4	Diptera	Chironomidae	Phaenopsectra
x	4	Diptera	Chironomidae	Phaenopsectra obediens

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	4	Diptera	Chironomidae	Phaenopsectra obediens Gp.
4	4	Diptera	Chironomidae	Polypedilum
4	4	Diptera	Chironomidae	Polypedilum (Uresipedilum)
3	3	Diptera	Chironomidae	Polypedilum aviceps
4	4	Diptera	Chironomidae	Polypedilum fallax Gr.
4	4	Diptera	Chironomidae	Polypedilum flavum
5	5	Diptera	Chironomidae	Polypedilum illinoense Gr.
3	4	Diptera	Chironomidae	Polypedilum laetum
4	4	Diptera	Chironomidae	Polypedilum scalaenum Gr.
4	4	Diptera	Chironomidae	Polypedilum tritum
3	3	Diptera	Chironomidae	Potthastia
x	3	Diptera	Chironomidae	Potthastia longimana Gr.
4	4	Diptera	Chironomidae	Procladius
x	4	Diptera	Chironomidae	Procladius (Holotanypus)
3	3	Diptera	Chironomidae	Prodiamesa
x	3	Diptera	Chironomidae	Prodiamesa olivacea
4	4	Diptera	Chironomidae	Psectrocladius
x	x	Diptera	Chironomidae	Psectrotanypus
4	4	Diptera	Chironomidae	Pseudochironomus
2	2	Diptera	Chironomidae	Pseudodiamesa
4	4	Diptera	Chironomidae	Pseudorthocladius
x	x	Diptera	Chironomidae	Pseudosmittia
4	4	Diptera	Chironomidae	Psilometriocnemus
4	4	Diptera	Chironomidae	Rheocricotopus
x	4	Diptera	Chironomidae	Rheocricotopus robacki

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	4	Diptera	Chironomidae	Rheocricotopus unidentatus
3	3	Diptera	Chironomidae	Rheopelopia
2	2	Diptera	Chironomidae	Rheosmittia
4	4	Diptera	Chironomidae	Rheotanytarsus
x	4	Diptera	Chironomidae	Rheotanytarsus exiguus Gr.
x	4	Diptera	Chironomidae	Rheotanytarsus pellucidus Gr.
3	3	Diptera	Chironomidae	Robackia
4	4	Diptera	Chironomidae	Saetheria
2	2	Diptera	Chironomidae	Stempellina
x	2	Diptera	Chironomidae	Stempellina sp.C
3	3	Diptera	Chironomidae	Stempellinella
4	4	Diptera	Chironomidae	Stenochironomus
4	4	Diptera	Chironomidae	Stictochironomus
3	3	Diptera	Chironomidae	Stilocladius
3	3	Diptera	Chironomidae	Sublettea
3	3	Diptera	Chironomidae	Symposiocladius
x	x	Diptera	Chironomidae	Sympotthastia
2	2	Diptera	Chironomidae	Synorthocladius
x	x	Diptera	Chironomidae	Tanypodinae
5	5	Diptera	Chironomidae	Tanypus
4	4	Diptera	Chironomidae	Tanytarsini
4	4	Diptera	Chironomidae	Tanytarsini sp.4
4	4	Diptera	Chironomidae	Tanytarsus
4	4	Diptera	Chironomidae	Thienemanniella
x	4	Diptera	Chironomidae	Thienemanniella taurocapita

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	4	Diptera	Chironomidae	Thienemanniella xena
x	4	Diptera	Chironomidae	Thienemannimyia
4	4	Diptera	Chironomidae	Thienemannimyia Gr.
4	4	Diptera	Chironomidae	Tribelos
3	3	Diptera	Chironomidae	Trissopelopia
3	3	Diptera	Chironomidae	Tvetenia
3	3	Diptera	Chironomidae	Tvetenia bavarica Gr.
3	3	Diptera	Chironomidae	Tvetenia paucunca
3	3	Diptera	Chironomidae	Tvetenia sp.A
3	3	Diptera	Chironomidae	Tvetenia vitracies
x	x	Diptera	Chironomidae	Unniella
3	3	Diptera	Chironomidae	Xenochironomus
3	3	Diptera	Chironomidae	Xylotopus
x	x	Diptera	Chironomidae	Zalutschia
3	3	Diptera	Chironomidae	Zavrelimyia
x	3	Diptera	Chironomidae	Zavrelimyia sinuosa
x	3	Diptera	Chironomidae	Zavrelimyia thryptica
5	5	Diptera	Culicidae	Aedes
5	5	Diptera	Culicidae	Anopheles
5	5	Diptera	Culicidae	Culex
5	5	Diptera	Culicidae	Culicidae
4	4	Diptera	Dixidae	Dixa
x	4	Diptera	Dixidae	Dixa modesta
4	4	Diptera	Dixidae	Dixella
4	4	Diptera	Dolichopodidae	Dolichopodidae

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
4	4	Diptera	Empididae	Chelifera
4	4	Diptera	Empididae	Clinocera
4	4	Diptera	Empididae	Dolichocephala
4	4	Diptera	Empididae	Empididae
4	4	Diptera	Empididae	Hemerodromia
4	4	Diptera	Empididae	Neoplasta
5	5	Diptera	Ephydridae	Ephydridae
5	5	Diptera	Muscidae	Muscidae
4	4	Diptera	Psychodidae	Pericoma
5	5	Diptera	Psychodidae	Psychoda
4	4	Diptera	Psychodidae	Psychodidae
x	x	Diptera	Ptychopteridae	Ptychoptera
5	5	Diptera	Sciomyzidae	Sciomyzidae
x	x	Diptera	Simuliidae	Cnephia ornithophilia
3	3	Diptera	Simuliidae	Prosimulium
x	3	Diptera	Simuliidae	Prosimulium mixtum
x	3	Diptera	Simuliidae	Prosimulium mysticum
4	4	Diptera	Simuliidae	Simuliidae
4	4	Diptera	Simuliidae	Simulium
x	x	Diptera	Simuliidae	Simulium aureum
x	x	Diptera	Simuliidae	Simulium corbis
x	x	Diptera	Simuliidae	Simulium fibrinflatum
x	x	Diptera	Simuliidae	Simulium longistylatum
x	x	Diptera	Simuliidae	Simulium pictipes
x	x	Diptera	Simuliidae	Simulium tuberosum

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	x	Diptera	Simuliidae	Simulium venustum
x	x	Diptera	Simuliidae	Simulium verecundum
4	4	Diptera	Simuliidae	Simulium vittatum
x	x	Diptera	Simuliidae	Stegopterna
4	4	Diptera	Stratiomyidae	Caloparyphus
4	4	Diptera	Stratiomyidae	Euparyphus
4	4	Diptera	Stratiomyidae	Nemotelus
4	4	Diptera	Stratiomyidae	Odontomyia
4	4	Diptera	Stratiomyidae	Oxycera
4	4	Diptera	Stratiomyidae	Stratiomyidae
4	4	Diptera	Stratiomyidae	Stratiomys
x	x	Diptera	Syrphidae	Helophilus
3	3	Diptera	Tabanidae	Chrysops
3	3	Diptera	Tabanidae	Hybomitra
x	x	Diptera	Tabanidae	Silvius
4	4	Diptera	Tabanidae	Tabanidae
4	4	Diptera	Tabanidae	Tabanus
3	3	Diptera	Tipulidae	Antocha
3	3	Diptera	Tipulidae	Dicranota
4	4	Diptera	Tipulidae	Erioptera
4	4	Diptera	Tipulidae	Helius
2	2	Diptera	Tipulidae	Hesperoconopa
x	2	Diptera	Tipulidae	Hesperoconopa dolichophallus
3	3	Diptera	Tipulidae	Hexatoma
4	4	Diptera	Tipulidae	Limnophila

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
4	4	Diptera	Tipulidae	Limonia
3	3	Diptera	Tipulidae	Pedicia
4	4	Diptera	Tipulidae	Pilaria
3	3	Diptera	Tipulidae	Pseudolimnophila
4	4	Diptera	Tipulidae	Tipula
4	4	Diptera	Tipulidae	Tipulidae
x	x	Dorylaimida	Dorylaimidae	Nematoda
x	x	Ephemeroptera		Ephemeroptera
x	x	Ephemeroptera	Ameletidae	Ameletus
3	3	Ephemeroptera	Baetidae	Acentrella
x	3	Ephemeroptera	Baetidae	Acentrella ampla
x	3	Ephemeroptera	Baetidae	Acentrella parvula
x	3	Ephemeroptera	Baetidae	Acentrella turbida
3	3	Ephemeroptera	Baetidae	Acerpenna
x	3	Ephemeroptera	Baetidae	Acerpenna macdunnoughi
x	3	Ephemeroptera	Baetidae	Acerpenna pygmaea
x	x	Ephemeroptera	Baetidae	Baetidae
4	4	Ephemeroptera	Baetidae	Baetis
3	3	Ephemeroptera	Baetidae	Baetis brunneicolor
4	4	Ephemeroptera	Baetidae	Baetis flavistriga
4	4	Ephemeroptera	Baetidae	Baetis intercalaris
3	3	Ephemeroptera	Baetidae	Baetis tricaudatus
x	x	Ephemeroptera	Baetidae	Barbaetis
5	5	Ephemeroptera	Baetidae	Callibaetis
4	4	Ephemeroptera	Baetidae	Centroptilum

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	x	Ephemeroptera	Baetidae	Cloeon
x	x	Ephemeroptera	Baetidae	Diphetor
x	x	Ephemeroptera	Baetidae	Diphetor hageni
x	x	Ephemeroptera	Baetidae	Fallceon
3	3	Ephemeroptera	Baetidae	Plauditus
3	3	Ephemeroptera	Baetidae	Plauditus dubius
3	3	Ephemeroptera	Baetidae	Plauditus punctiventris
3	3	Ephemeroptera	Baetidae	Procloeon
4	4	Ephemeroptera	Baetidae	Pseudocloeon
x	4	Ephemeroptera	Baetidae	Pseudocloeon frondale
x	4	Ephemeroptera	Baetidae	Pseudocloeon propinquum
3	3	Ephemeroptera	Baetiscidae	Baetisca
4	4	Ephemeroptera	Caenidae	Caenis
3	3	Ephemeroptera	Ephemerellidae	Attenella
x	x	Ephemeroptera	Ephemerellidae	Dannella
2	2	Ephemeroptera	Ephemerellidae	Drunella
2	2	Ephemeroptera	Ephemerellidae	Ephemerella
2	3	Ephemeroptera	Ephemerellidae	Ephemerella aurivillii
x	3	Ephemeroptera	Ephemerellidae	Ephemerella catawba
3	3	Ephemeroptera	Ephemerellidae	Ephemerella dorothea dorothea
3	3	Ephemeroptera	Ephemerellidae	Ephemerella excrucians
3	3	Ephemeroptera	Ephemerellidae	Ephemerella invaria
2	2	Ephemeroptera	Ephemerellidae	Ephemerella subvaria
3	3	Ephemeroptera	Ephemerellidae	Ephemerellidae
3	3	Ephemeroptera	Ephemerellidae	Eurylophella

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	3	Ephemeroptera	Ephemerellidae	Eurylophella bicolor
x	3	Ephemeroptera	Ephemerellidae	Eurylophella temporalis
3	3	Ephemeroptera	Ephemerellidae	Serratella
x	3	Ephemeroptera	Ephemerellidae	Serratella deficiens
x	3	Ephemeroptera	Ephemerellidae	Serratella frisoni
3	3	Ephemeroptera	Ephemeridae	Ephemera
3	3	Ephemeroptera	Ephemeridae	Ephemera simulans
x	x	Ephemeroptera	Ephemeridae	Ephemeridae
4	4	Ephemeroptera	Ephemeridae	Hexagenia
x	4	Ephemeroptera	Ephemeridae	Hexagenia limbata
2	2	Ephemeroptera	Heptageniidae	Epeorus
2	2	Ephemeroptera	Heptageniidae	Epeorus vitreus
3	3	Ephemeroptera	Heptageniidae	Heptagenia
x	3	Ephemeroptera	Heptageniidae	Heptagenia diabasia
x	2	Ephemeroptera	Heptageniidae	Heptagenia pulla
4	4	Ephemeroptera	Heptageniidae	Heptageniidae
4	4	Ephemeroptera	Heptageniidae	Leucrocuta
4	4	Ephemeroptera	Heptageniidae	Leucrocuta hebe
4	4	Ephemeroptera	Heptageniidae	Maccaffertium
x	4	Ephemeroptera	Heptageniidae	Maccaffertium luteum
x	4	Ephemeroptera	Heptageniidae	Maccaffertium mediopunctatum
x	2	Ephemeroptera	Heptageniidae	Maccaffertium modestum
x	4	Ephemeroptera	Heptageniidae	Maccaffertium terminatum
x	4	Ephemeroptera	Heptageniidae	Maccaffertium vicarium
x	4	Ephemeroptera	Heptageniidae	Maccaffertium vicarium/luteum

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
2	2	Ephemeroptera	Heptageniidae	Rhithrogena
5	5	Ephemeroptera	Heptageniidae	Stenacron
x	5	Ephemeroptera	Heptageniidae	Stenacron interpunctatum
4	4	Ephemeroptera	Heptageniidae	Stenonema
x	4	Ephemeroptera	Heptageniidae	Stenonema femoratum
3	3	Ephemeroptera	Isonychiidae	Isonychia
4	4	Ephemeroptera	Leptohyphidae	Tricorythodes
4	4	Ephemeroptera	Leptophlebiidae	Leptophlebia
4	4	Ephemeroptera	Leptophlebiidae	Leptophlebia cupida
4	4	Ephemeroptera	Leptophlebiidae	Leptophlebiidae
3	3	Ephemeroptera	Leptophlebiidae	Paraleptophlebia
3	3	Ephemeroptera	Leptophlebiidae	Paraleptophlebia mollis
3	3	Ephemeroptera	Leptophlebiidae	Paraleptophlebia praepedita
3	3	Ephemeroptera	Metretopodidae	Siphloplecton
x	x	Ephemeroptera	Palingeniidae	Pentagenia
x	x	Ephemeroptera	Polymitarcyidae	Ephoron
3	3	Ephemeroptera	Siphlonuridae	Siphlonuridae
3	3	Ephemeroptera	Siphlonuridae	Siphlonurus
x	x	Haplotaxida		Haplotaxida
5	5	Haplotaxida		Oligochaeta
x	x	Haplotaxida	Enchytraeidae	Enchytraeidae
x	x	Haplotaxida	Lumbricidae	Lumbricidae
4	4	Haplotaxida	Naididae	Naididae
x	x	Haplotaxida	Naididae	Nais
x	x	Haplotaxida	Naididae	Nais behningi

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	x	Haplotaxida	Naididae	Nais bretscheri
x	x	Haplotaxida	Naididae	Nais communis
x	x	Haplotaxida	Naididae	Nais pardalis
x	x	Haplotaxida	Naididae	Nais simplex
x	x	Haplotaxida	Naididae	Ophidonais serpentina
x	x	Haplotaxida	Naididae	Pristina
x	x	Haplotaxida	Tubificidae	Aulodrilus pluriseta
x	5	Haplotaxida	Tubificidae	Ilyodrilus templetoni
x	5	Haplotaxida	Tubificidae	Limnodrilus hoffmeisteri
x	5	Haplotaxida	Tubificidae	Tubifex
x	5	Haplotaxida	Tubificidae	Tubifex tubifex
x	5	Haplotaxida	Tubificidae	Tubificidae
x	x	Hemiptera		Hemiptera
4	4	Hemiptera	Belostomatidae	Belostoma
4	4	Hemiptera	Belostomatidae	Belostoma flumineum
4	4	Hemiptera	Belostomatidae	Lethocerus
5	5	Hemiptera	Corixidae	Corixidae
5	5	Hemiptera	Corixidae	Cymatia
5	5	Hemiptera	Corixidae	Hesperocorixa
5	5	Hemiptera	Corixidae	Palmacorixa
5	5	Hemiptera	Corixidae	Sigara
5	5	Hemiptera	Corixidae	Sigara compressoidea
5	5	Hemiptera	Corixidae	Sigara mathesoni
5	5	Hemiptera	Corixidae	Sigara signata
5	5	Hemiptera	Corixidae	Sigara trilineata

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
5	5	Hemiptera	Corixidae	Trichocorixa
x	5	Hemiptera	Corixidae	Trichocorixa calva
x	5	Hemiptera	Corixidae	Trichocorixa naias
x	x	Hemiptera	Gerridae	Gerridae
x	x	Hemiptera	Gerridae	Gerris
x	x	Hemiptera	Gerridae	Limnoporus
x	x	Hemiptera	Macroveliidae	Macroveliidae
4	4	Hemiptera	Mesoveliidae	Mesovelia
4	4	Hemiptera	Nepidae	Ranatra
4	4	Hemiptera	Notonectidae	Notonectidae
4	4	Hemiptera	Pleidae	Neoplea
4	4	Hemiptera	Veliidae	Microvelia
x	4	Hemiptera	Veliidae	Microvelia americana
x	x	Hemiptera	Veliidae	Rhagovelia
x	x	Hemiptera	Veliidae	Rhagovelia obesa
x	x	Hemiptera	Veliidae	Veliidae
x	x	Heterostropha	Valvatidae	Valvata
x	x	Heterostropha	Valvatidae	Valvatidae
x	x	Hydroida	Hydridae	Hydra
x	x	Hydroida	Hydridae	Hydridae
x	x	Isopoda	Asellidae	Asellidae
x	4	Isopoda	Asellidae	Asellus
4	4	Isopoda	Asellidae	Caecidotea
2	2	Isopoda	Asellidae	Caecidotea brevicauda brevicauda
5	5	Isopoda	Asellidae	Caecidotea intermedia

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
4	4	Isopoda	Asellidae	Caecidotea racovitzai racovitzai
x	x	Lepidoptera		Lepidoptera
x	x	Lepidoptera	Crambidae	Crambidae
x	x	Lepidoptera	Crambidae	Elophila
x	x	Lepidoptera	Crambidae	Munroessa
x	x	Lepidoptera	Noctuidae	Noctuidae
x	x	Lepidoptera	Pyralidae	Acentria
3	3	Lepidoptera	Pyralidae	Paraponyx
x	x	Lepidoptera	Pyralidae	Pyralidae
x	x	Lumbriculida	Lumbriculidae	Lumbriculidae
4	4	Megaloptera	Corydalidae	Chauliodes
4	4	Megaloptera	Corydalidae	Corydalus
x	4	Megaloptera	Corydalidae	Corydalus cornutus
3	3	Megaloptera	Corydalidae	Nigronia
x	3	Megaloptera	Corydalidae	Nigronia serricornis
4	4	Megaloptera	Sialidae	Sialis
x	x	Mermithida	Mermithidae	Mermithidae
x	x	Mesogastropoda		Viviparoidea
4	4	Mesogastropoda	Hydrobiidae	Amnicola
4	4	Mesogastropoda	Hydrobiidae	Hydrobiidae
x	x	Mesogastropoda	Pomatiopsidae	Pomatiopsis
4	4	Mesogastropoda	Viviparidae	Campeloma
4	4	Mesogastropoda	Viviparidae	Viviparidae
x	x	Neotaenioglossa	Bithyniidae	Bithyniidae
4	4	Neotaenioglossa	Hydrobiidae	Fontigens

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	x	Odonata		Libellulinae
4	4	Odonata	Aeshnidae	Aeshna
x	x	Odonata	Aeshnidae	Aeshnidae
x	x	Odonata	Aeshnidae	Anax
x	x	Odonata	Aeshnidae	Basiaeschna
x	x	Odonata	Aeshnidae	Basiaeschna janata
3	3	Odonata	Aeshnidae	Boyeria
3	3	Odonata	Aeshnidae	Boyeria vinosa
x	4	Odonata	Calopterygidae	Calopterygidae
4	4	Odonata	Calopterygidae	Calopteryx
4	4	Odonata	Calopterygidae	Calopteryx maculata
4	4	Odonata	Calopterygidae	Hetaerina
4	4	Odonata	Calopterygidae	Hetaerina americana
4	4	Odonata	Coenagrionidae	Argia
x	4	Odonata	Coenagrionidae	Argia moesta
2	2	Odonata	Coenagrionidae	Chromagrion
2	2	Odonata	Coenagrionidae	Chromagrion conditum
4	4	Odonata	Coenagrionidae	Coenagrionidae
5	5	Odonata	Coenagrionidae	Enallagma
2	2	Odonata	Cordulegastridae	Cordulegaster
2	2	Odonata	Cordulegastridae	Cordulegaster maculata
x	x	Odonata	Cordulegastridae	Epitheca
x	x	Odonata	Corduliidae	Corduliidae
4	4	Odonata	Corduliidae	Neurocordulia
3	3	Odonata	Corduliidae	Somatochlora

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	x	Odonata	Corduliidae/Libellulidae	Odonata
3	3	Odonata	Gomphidae	Gomphidae
3	3	Odonata	Gomphidae	Gomphus
3	3	Odonata	Gomphidae	Hagenius
x	3	Odonata	Gomphidae	Hagenius brevistylus
2	2	Odonata	Gomphidae	Ophiogomphus
2	2	Odonata	Gomphidae	Ophiogomphus rupinsulensis
x	x	Odonata	Libellulidae	Libellulidae
x	x	Odonata	Libellulidae	Pantala
x	x	Odonata	Libellulidae	Perithemis
x	x	Odonata	Libellulidae	Sympetrum
x	x	Pharyngodellida		Gastropoda
3	3	Plecoptera		Plecoptera
4	4	Plecoptera	Capniidae	Allocapnia
3	3	Plecoptera	Capniidae	Capniidae
3	3	Plecoptera	Capniidae	Paracapnia
x	3	Plecoptera	Capniidae	Paracapnia angulata
3	3	Plecoptera	Chloroperlidae	Chloroperlidae
3	3	Plecoptera	Chloroperlidae	Haploperla orpha
2	2	Plecoptera	Leuctridae	Leuctra
2	2	Plecoptera	Leuctridae	Leuctridae
2	2	Plecoptera	Leuctridae	Paraleuctra
2	2	Plecoptera	Nemouridae	Amphinemura
x	2	Plecoptera	Nemouridae	Amphinemura delosa
x	2	Plecoptera	Nemouridae	Amphinemura linda

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	2	Plecoptera	Nemouridae	Nemoura trispinosa
2	2	Plecoptera	Nemouridae	Nemouridae
3	3	Plecoptera	Nemouridae	Prostoia
2	2	Plecoptera	Nemouridae	Soyedina
3	3	Plecoptera	Perlidae	Acroneuria
3	3	Plecoptera	Perlidae	Acroneuria lycorias
2	2	Plecoptera	Perlidae	Agnetina
3	3	Plecoptera	Perlidae	Agnetina capitata
x	x	Plecoptera	Perlidae	Claassenia
x	x	Plecoptera	Perlidae	Eccoptura
3	3	Plecoptera	Perlidae	Paragnetina
3	3	Plecoptera	Perlidae	Paragnetina media
4	4	Plecoptera	Perlidae	Perlesta
4	4	Plecoptera	Perlidae	Perlesta decipiens
3	3	Plecoptera	Perlidae	Perlidae
3	3	Plecoptera	Perlidae	Perlinella
2	2	Plecoptera	Perlodidae	Isogenoides
x	2	Plecoptera	Perlodidae	Isogenoides frontalis
x	2	Plecoptera	Perlodidae	Isogenoides olivaceus
3	3	Plecoptera	Perlodidae	Isoperla
3	3	Plecoptera	Perlodidae	Isoperla dicala
2	3	Plecoptera	Perlodidae	Isoperla frisoni
4	3	Plecoptera	Perlodidae	Isoperla nana
3	3	Plecoptera	Perlodidae	Isoperla signata
3	3	Plecoptera	Perlodidae	Isoperla slossonae

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
3	3	Plecoptera	Perlodidae	Isoperla transmarina
3	3	Plecoptera	Perlodidae	Perlodidae
3	3	Plecoptera	Pteronarcyidae	Pteronarcys
x	3	Plecoptera	Taeniopterygidae	Strophopteryx fasciata
4	4	Plecoptera	Taeniopterygidae	Taeniopterygidae
4	4	Plecoptera	Taeniopterygidae	Taeniopteryx
x	4	Plecoptera	Taeniopterygidae	Taeniopteryx burksi
x	4	Plecoptera	Taeniopterygidae	Taeniopteryx nivalis
5	5	Rhynchobdellida	Glossiphoniidae	Glossiphoniidae
5	5	Rhynchobdellida	Glossiphoniidae	Helobdella
5	5	Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis
5	5	Rhynchobdellida	Glossiphoniidae	Placobdella ornata
5	5	Rhynchobdellida	Piscicolidae	Piscicolidae
x	x	Trichoptera		Trichoptera
1	1	Trichoptera	Apataniidae	Apatania
3	3	Trichoptera	Brachycentridae	Brachycentridae
3	3	Trichoptera	Brachycentridae	Brachycentrus
3	3	Trichoptera	Brachycentridae	Brachycentrus americanus
3	3	Trichoptera	Brachycentridae	Brachycentrus numerosus
3	3	Trichoptera	Brachycentridae	Brachycentrus occidentalis
3	3	Trichoptera	Brachycentridae	Micrasema
x	3	Trichoptera	Brachycentridae	Micrasema gelidum
x	3	Trichoptera	Brachycentridae	Micrasema rusticum
x	3	Trichoptera	Brachycentridae	Micrasema wataga
2	2	Trichoptera	Dipseudopsidae	Phylocentropus

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
2	2	Trichoptera	Glossosomatidae	Agapetus
2	2	Trichoptera	Glossosomatidae	Glossosoma
x	2	Trichoptera	Glossosomatidae	Glossosoma intermedium
2	2	Trichoptera	Glossosomatidae	Glossosomatidae
3	3	Trichoptera	Glossosomatidae	Protoptila
1	1	Trichoptera	Goeridae	Goera
1	1	Trichoptera	Goeridae	Goera stylata
4	4	Trichoptera	Helicopsychidae	Helicopsyche
4	4	Trichoptera	Helicopsychidae	Helicopsyche borealis
4	4	Trichoptera	Helicopsychidae	Helicopsychidae
3	3	Trichoptera	Hydropsychidae	Ceratopsyche
3	3	Trichoptera	Hydropsychidae	Ceratopsyche alhedra
3	3	Trichoptera	Hydropsychidae	Ceratopsyche alternans
x	3	Trichoptera	Hydropsychidae	Ceratopsyche bifida Gr.
4	4	Trichoptera	Hydropsychidae	Ceratopsyche bronta
3	3	Trichoptera	Hydropsychidae	Ceratopsyche morosa
4	3	Trichoptera	Hydropsychidae	Ceratopsyche morosa bifida
x	3	Trichoptera	Hydropsychidae	Ceratopsyche morosa morosa
4	4	Trichoptera	Hydropsychidae	Ceratopsyche slossonae
3	3	Trichoptera	Hydropsychidae	Ceratopsyche sparna
3	3	Trichoptera	Hydropsychidae	Ceratopsyche vexa
2	2	Trichoptera	Hydropsychidae	Ceratopsyche walkeri
4	4	Trichoptera	Hydropsychidae	Cheumatopsyche
x	x	Trichoptera	Hydropsychidae	Cheumatopsyche minuscula
2	2	Trichoptera	Hydropsychidae	Diplectrona

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
2	2	Trichoptera	Hydropsychidae	Diplectrona modesta
4	4	Trichoptera	Hydropsychidae	Hydropsyche
4	4	Trichoptera	Hydropsychidae	Hydropsyche betteni
3	3	Trichoptera	Hydropsychidae	Hydropsyche dicantha
3	3	Trichoptera	Hydropsychidae	Hydropsyche scalaris
x	x	Trichoptera	Hydropsychidae	Hydropsychidae
2	2	Trichoptera	Hydropsychidae	Parapsyche
2	2	Trichoptera	Hydropsychidae	Parapsyche apicalis
4	4	Trichoptera	Hydropsychidae	Potamyia
4	4	Trichoptera	Hydroptilidae	Hydroptila
4	4	Trichoptera	Hydroptilidae	Hydroptilidae
3	3	Trichoptera	Hydroptilidae	Leucotrichia pictipes
4	4	Trichoptera	Hydroptilidae	Ochrotrichia
x	4	Trichoptera	Hydroptilidae	Ochrotrichia riesi
4	4	Trichoptera	Hydroptilidae	Oxyethira
x	x	Trichoptera	Hydroptilidae	Stactobiella
2	2	Trichoptera	Lepidostomatidae	Lepidostoma
4	4	Trichoptera	Leptoceridae	Ceraclea
4	4	Trichoptera	Leptoceridae	Leptoceridae
4	x	Trichoptera	Leptoceridae	Leptocerus americanus
4	4	Trichoptera	Leptoceridae	Mystacides
4	4	Trichoptera	Leptoceridae	Nectopsyche
4	4	Trichoptera	Leptoceridae	Oecetis
3	3	Trichoptera	Leptoceridae	Setodes
4	4	Trichoptera	Leptoceridae	Triaenodes

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
4	4	Trichoptera	Limnephilidae	Anabolia
3	3	Trichoptera	Limnephilidae	Glyphopsyche
2	2	Trichoptera	Limnephilidae	Hesperophylax
x	2	Trichoptera	Limnephilidae	Hesperophylax designatus
3	3	Trichoptera	Limnephilidae	Hydatophylax
3	3	Trichoptera	Limnephilidae	Hydatophylax argus
3	3	Trichoptera	Limnephilidae	Limnephilidae
4	4	Trichoptera	Limnephilidae	Limnephilus
4	4	Trichoptera	Limnephilidae	Limnephilus rhombicus
3	3	Trichoptera	Limnephilidae	Nemotaulius
x	3	Trichoptera	Limnephilidae	Neophylax concinnus
4	4	Trichoptera	Limnephilidae	Platycentropus
3	3	Trichoptera	Limnephilidae	Pseudostenophylax
3	3	Trichoptera	Limnephilidae	Pycnopsyche
x	3	Trichoptera	Limnephilidae	Pycnopsyche lepida
x	3	Trichoptera	Limnephilidae	Pycnopsyche scabripennis
3	3	Trichoptera	Molannidae	Molanna
3	3	Trichoptera	Philopotamidae	Chimarra
3	3	Trichoptera	Philopotamidae	Chimarra aterrima
2	2	Trichoptera	Philopotamidae	Chimarra feria
3	3	Trichoptera	Philopotamidae	Chimarra obscura
2	2	Trichoptera	Philopotamidae	Dolophilodes
2	2	Trichoptera	Philopotamidae	Dolophilodes distinctus
3	3	Trichoptera	Philopotamidae	Philopotamidae
2	x	Trichoptera	Phryganeidae	Oligostomis ocelligera

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
4	4	Trichoptera	Phryganeidae	Phryganea
4	4	Trichoptera	Phryganeidae	Phryganeidae
4	4	Trichoptera	Phryganeidae	Ptilostomis
4	4	Trichoptera	Polycentropodidae	Cernotina
4	4	Trichoptera	Polycentropodidae	Cyrnellus
4	4	Trichoptera	Polycentropodidae	Neureclipsis
4	4	Trichoptera	Polycentropodidae	Nyctiophylax
4	4	Trichoptera	Polycentropodidae	Nyctiophylax (Paranyctiophylax)
4	4	Trichoptera	Polycentropodidae	Polycentropodidae
4	4	Trichoptera	Polycentropodidae	Polycentropus
3	3	Trichoptera	Psychomyiidae	Lype
3	3	Trichoptera	Psychomyiidae	Lype diversa
3	3	Trichoptera	Psychomyiidae	Psychomyia
3	3	Trichoptera	Psychomyiidae	Psychomyia flavida
3	3	Trichoptera	Psychomyiidae	Psychomyiidae
2	2	Trichoptera	Rhyacophilidae	Rhyacophila
x	2	Trichoptera	Rhyacophilidae	Rhyacophila brunnea
2	2	Trichoptera	Sericostomatidae	Agarodes
3	3	Trichoptera	Uenoidae	Neophylax
x	3	Trichoptera	Uenoidae	Neophylax fuscus
3	3	Trichoptera	Uenoidae	Uenoidae
x	x	Tricladida		Tricladida
x	x	Trombidiformes		Trombidiformes
x	x	Trombidiformes	Hydrachnidae	Hydrachnidae
x	x	Trombidiformes	Hygrobatidae	Hygrobates

Table D1. continued…

BCG Attribute - COLD	BCG Attribute - COOL	Order	Family	Final ID
x	x	Trombidiformes	Lebertiidae	Lebertia
x	x	Trombidiformes	Limnesiidae	Limnesia
x	x	Trombidiformes	Sperchontidae	Sperchonopsis
x	x	Trombidiformes	Unionicolidae	Unionicola
4	4	Veneroida	Pisidiidae	Pisidiidae
4	4	Veneroida	Pisidiidae	Pisidium
4	4	Veneroida	Pisidiidae	Pisidium dubium
4	4	Veneroida	Pisidiidae	Sphaerium
x	4	Veneroida	Pisidiidae	Sphaerium striatinum

APPENDIX E

List of Warmwater Fish Species

Appendix E. Table E -1. List of warmwater fish species, based on participant input. The ‘x’ denotes which taxa were selected by each participant.

Family	Scientific Name	Common Name	Chris Yoder (MBI)	MPCA	MDNRE	WDNR (based on Lyons et al. 2009)
Acipenseridae	*Scaphirhynchus platorynchus*	shovelnose sturgeon	x	x		x
Amiidae	*Amia calva*	bowfin		x	x	x
Anguillidae	*Anguilla rostrata*	American eel		x		x
Aphredoderidae	*Aphredoderus sayanus*	pirate perch	x		x	x
Atherinopsidae	*Labidesthes sicculus*	brook silverside		x	x	x
Catostomidae	*Ictiobus cyprinellus*	bigmouth buffalo	x	x	x	x
Catostomidae	*Ictiobus niger*	black buffalo	x	x		x
Catostomidae	*Moxostoma duquesnei*	black redhorse	x		x	x
Catostomidae	*Cycleptus elongatus*	blue sucker	x	x		x
Catostomidae	*Erimyzon oblongus*	creek chubsucker			x	x
Catostomidae	*Ictiobus*	Gen: buffalos		x	x	
Catostomidae	*Carpiodes*	Gen: carpsuckers		x		
Catostomidae	*Moxostoma*	Gen: redhorses			x	
Catostomidae	*Moxostoma erythrurum*	golden redhorse	x		x	x
Catostomidae	*Moxostoma valenciennesi*	greater redhorse	x	x	x	x
Catostomidae	*Carpiodes velifer*	highfin carpsucker	x	x		x
Catostomidae	*Carpiodes cyprinus*	quillback	x	x	x	x
Catostomidae	*Carpiodes carpio*	river carpsucker	x	x		x
Catostomidae	*Moxostoma carinatum*	river redhorse	x	x	x	x
Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	x	x	x	x
Catostomidae	*Moxostoma anisurum*	silver redhorse	x	x	x	x
Catostomidae	*Ictiobus bubalus*	smallmouth buffalo	x	x	x	x
Catostomidae	*Minytrema melanops*	spotted sucker	x	x		x
Catostomidae	*Ictiobinae*	SubFam: buffalo/carpsuckers		x		
Catostomidae	*Catostomus commersoni*	white sucker			x	

Table E -1. continued…

Family	Scientific Name	Common Name	Chris Yoder (MBI)	MPCA	MDNRE	WDNR (based on Lyons et al. 2009)
Centrarchidae	*Pomoxis nigromaculatus*	black crappie	x	x	x	x
Centrarchidae	*Lepomis macrochirus*	bluegill	x		x	x
Centrarchidae	*Lepomis*	Gen: common sunfishes			x	
Centrarchidae	*Pomoxis*	Gen: crappies			x	
Centrarchidae	*Micropterus*	Gen: Micropterus			x	
Centrarchidae	*Lepomis cyanellus*	green sunfish	x		x	x
Centrarchidae	*Lepomis hybrid*	hybrid sunfish			x	
Centrarchidae	*Micropterus salmoides*	largemouth bass	x		x	x
Centrarchidae	*Lepomis megalotis*	longear sunfish	x	x	x	x
Centrarchidae	*Lepomis humilis*	orangespotted sunfish	x	x	x	x
Centrarchidae	*Lepomis gibbosus*	pumpkinseed			x	x
Centrarchidae	*Ambloplites rupestris*	rock bass		x	x	x
Centrarchidae	*Micropterus dolomieu*	smallmouth bass	x?		x	x
Centrarchidae	*Lepomis gulosus*	warmouth	x		x	x
Centrarchidae	*Pomoxis annularis*	white crappie	x		x	x
Clupeidae	*Alosa pseudoharengus*	alewife				
Clupeidae	*Dorosoma cepedianum*	gizzard shad	x	x	x	x
Clupeidae	*Alosa chrysochloris*	skipjack herring	x			x
Cyprinidae	*Hypophthalmichthys nobilis*	bighead carp		x	x	
Cyprinidae	*Hybopsis dorsalis*	bigmouth shiner	x	x	x	x
Cyprinidae	*Etheostoma chlorosomum*	bluntnose darter				x
Cyprinidae	*Pimephales notatus*	bluntnose minnow	x		x	x
Cyprinidae	*Hybognathus hankinsoni*	brassy minnow		x		
Cyprinidae	*Pimephales vigilax*	bullhead minnow	x			x
Cyprinidae	*Notropis percobromus*	carmine shiner			x	x

Table E -1. continued…

Family	Scientific Name	Common Name	Chris Yoder (MBI)	MPCA	MDNRE	WDNR (based on Lyons et al. 2009)
Cyprinidae	*Campostoma anomalum*	central stoneroller		x	x	x
Cyprinidae	*Notropis wickliffi*	channel shiner	x			x
Cyprinidae	*Cyrpinus carpio*	common carp	x	x	x	x
Cyprinidae	*Luxilus cornutus*	common shiner			x	x
Cyprinidae	*Notropis atherinoides*	emerald shiner	x		x	x
Cyprinidae	*Pimephales promelas*	fathead minnow			x	x
Cyprinidae	*Campostoma*	Gen: stonerollers		x		
Cyprinidae	*Notropis buchanani*	ghost shiner	x			x
Cyprinidae	*Notemigonus crysoleucas*	golden shiner			x	x
Cyprinidae	*Carassius auratus*	goldfish	x	x	x	x
Cyprinidae	*Ctenopharyngodon idella*	grass carp		x	x	
Cyprinidae	*Erimystax x-punctatus*	gravel chub	x		x	x
Cyprinidae	*Nocomis biguttatus*	hornyhead chub	x		x	x
Cyprinidae	*Leuciscus idus*	ide		x		
Cyprinidae	*Campostoma oligolepis*	largescale stoneroller		x	x	x
Cyprinidae	*Rhinichthys cataractae*	longnose dace				
Cyprinidae	*Notropis volucellus*	mimic shiner	x	x	x	x
Cyprinidae	*Hybognathus nuchalis*	Mississippi silvery minnow	x			x
Cyprinidae	*Notropis nubilus*	Ozark minnow				x
Cyprinidae	*Hybopsis amnis*	pallid shiner				x
Cyprinidae	*Opsopoeodus emiliae*	pugnose minnow	x			x
Cyprinidae	*Notropis anogenus*	pugnose shiner	x			
Cyprinidae	*Cyprinella lutrensis*	red shiner	x	x	x	
Cyprinidae	*Lythrurus umbratilis*	redfin shiner	x	x	x	x
Cyprinidae	*Nocomis micropogon*	river chub	x			

Table E -1. continued…

Family	Scientific Name	Common Name	Chris Yoder (MBI)	MPCA	MDNRE	WDNR (based on Lyons et al. 2009)
Cyprinidae	*Notropis blennius*	river shiner	x			x
Cyprinidae	*Notropis rubellus*	rosyface shiner	x		x	x
Cyprinidae	*Notropis stramineus*	sand shiner	x	x	x	x
Cyprinidae	*Macrhybopsis hyostoma*	shoal chub	x			
Cyprinidae	*Hypophthalmichthys molitrix*	silver carp		x		
Cyprinidae	*Macrhybopsis storeriana*	silver chub	x	x		x
Cyprinidae	*Phoxinus erythrogaster*	southern redbelly dace	x		x	x
Cyprinidae	*Cyprinella spiloptera*	spotfin shiner	x	x	x	x
Cyprinidae	*Notropis hudsonius*	spottail shiner		x	x	x
Cyprinidae	*Phenacobius mirabilis*	suckermouth minnow	x		x	x
Cyprinidae	*Notropis topeka*	Topeka shiner	x			
Cyprinidae	*Notropis texanus*	weed shiner				x
Esocidae	*Esox americanus*	grass pickerel			x	x
Esocidae	*Esox masquinongy*	muskellunge		x		
Esocidae	*Esox lucius*	northern pike			x	
Esocidae	*Esox hybrid*	tiger musky		x		
Fundulidae	*Fundulus diaphanus*	banded killifish		x		x
Fundulidae	*Fundulus notatus*	blackstripe topminnow	x		x	x
Fundulidae	*Fundulus sciadicus*	plains topminnow	x			
Fundulidae	*Fundulus dispar*	starhead topminnow	x			x
Gobiidae	*Neogobius melanostomus*	round goby				x
Gobiidae	*Proterorhinus marmoratus*	tubenose goby				x
Hiodontidae	*Hiodon alosoides*	goldeye	x			x
Hiodontidae	*Hiodon tergisus*	mooneye	x			x
Ictaluridae	*Ameiurus melas*	black bullhead	x	x	x	x

Table E -1. continued…

Family	Scientific Name	Common Name	Chris Yoder (MBI)	MPCA	MDNRE	WDNR (based on Lyons et al. 2009)
Ictaluridae	*Ictalurus furcatus*	blue catfish	x	x		
Ictaluridae	*Ameiurus nebulosus*	brown bullhead		x	x	x
Ictaluridae	*Ictalurus punctatus*	channel catfish	x	x	x	x
Ictaluridae	*Ictaluridae*	Fam: catfishes		x		
Ictaluridae	*Pylodictis olivaris*	flathead catfish	x	x	x	x
Ictaluridae	*Ameiurus*	Gen: bullheads		x	x	
Ictaluridae	*Noturus stigmosus*	northern madtom	x		x	
Ictaluridae	*Noturus exilis*	slender madtom	x			x
Ictaluridae	*Noturus flavus*	stonecat			x	x
Ictaluridae	*Noturus gyrinus*	tadpole madtom	x		x	x
Ictaluridae	*Ameiurus natalis*	yellow bullhead	x	x	x	x
Lepisosteidae	*Lepisosteidae*	Fam: gars		x		
Lepisosteidae	*Lepisosteus osseus*	longnose gar	x	x	x	x
Lepisosteidae	*Lepisosteus platostomus*	shortnose gar	x	x		x
Moronidae	*Morone chrysops*	white bass	x	x	x	x
Moronidae	*Morone americana*	white perch	x	x		x
Moronidae	*Morone mississippiensis*	yellow bass	x	x		x
Percidae	*Etheostoma zonale*	banded darter	x		x	x
Percidae	*Percina maculata*	blackside darter	x		x	x
Percidae	*Crystallaria asprella*	crystal darter	x	x		x
Percidae	*Etheostoma flabellare*	fantail darter			x	x
Percidae	*Percina evides*	gilt darter		x		x
Percidae	*Etheostoma blennioides*	greenside darter	x		x	
Percidae	*Etheostoma exile*	Iowa darter			x	x
Percidae	*Etheostoma microperca*	least darter	x	x	x	x

Table E -1. continued…

Family	Scientific Name	Common Name	Chris Yoder (MBI)	MPCA	MDNRE	WDNR (based on Lyons et al. 2009)
Percidae	*Percina caprodes*	logperch	x	x	x	x
Percidae	*Etheostoma asprigene*	mud darter		x		x
Percidae	*Etheostoma caeruleum*	rainbow darter			x	x
Percidae	*Percina shumardi*	river darter	x	x		x
Percidae	*Sander canadensis*	sauger	x			x
Percidae	*Percina phoxocephala*	slenderhead darter	x		x	x
Percidae	*Ammocrypta clara*	western sand darter	x	x		x
Petromyzontidae	*Ichthyomyzon castaneus*	chestnut lamprey				x
Petromyzontidae	*Ichthyomyzon unicuspis*	silver lamprey				x
Polyodontidae	*Polyodon spathula*	paddlefish	x	x		x
Sciaenidae	*Aplodinotus grunniens*	freshwater drum	x	x	x	x

APPENDIX F

Sample worksheets

Appendix F. Figure F1. Example of a fish worksheet that was used when making BCG level assignments.

ExerciseID	Samp002	Assigned Tier	Range of BCG calls	
CollMethod	Fish_01	3	2-, 3+, 3, 4+	
CollDate	08-01-1983			
BCG Att	**# Taxa**	**# Individ**	**Pct Taxa**	**Pct Ind**
1	0	0	0	0
2	2	10	0.17	0.07
3	2	32	0.17	0.23
4	5	85	0.42	0.61
5	2	7	0.17	0.05
5a	0	0	0.00	0.00
6	1	6	0.08	0.04
6a	0	0	0.00	0.00
x	0	0	0.00	0.00
Total	**12**	**140**		

SiteID	grand291_1467
StreamName	1467
Stream Class	Cold
WatershedArea_mi2	36.31916287
Size Class	Stream
AvgJulyTemp	NA
pctForest	26.12181634
Human Disturbance	NA
Comments	

BCG Att	Common Name	Scientific Name	# Individs
2	American brook lamprey	*Lampetra appendix*	3
4	blackside darter	*Percina maculata*	5
2	brook trout	*Salvelinus fontinalis*	7
6	brown trout	*Salmo trutta*	6
5	central mudminnow	*Umbra limi*	5
4	creek chub	*Semotilus atromaculatus*	15
4	golden shiner	*Notemigonus crysoleucas*	2
4	johnny darter	*Etheostoma nigrum*	5
3	northern hog sucker	*Hypentelium nigricans*	5
5	northern pike	*Esox lucius*	2
3	sculpin	*Cottus*	27
4	white sucker	*Catostomus commersonii*	58

Expert	BCG Call	Reason
js	2-	2 att 2 species
mf	3	
sn	3+	trout numbers not great, good assemblage
lw	3	
kg	3	good diversity, good distribution, reduced #'s of 2/3's but still present
mm	4+	associates white sucker with degraded conditions, also very ubiquitous in midwest
bn	4+	brk trout, lamp, white suckers; nice mix, exotics present, some more tolerant taxa, moderate change in community (looking at BCG table) - not sure about pure cold though

Appendix F. Figure F2. Example of a macroinvertebrate worksheet that was used when making BCG level assignments.

ExerciseID	Samp004	Assigned Tier	Reasoning	
CollMethod	Ben_MN	3	2-, 3+, 3, 3-, 4+	
CollDate	08-07-2008			
BCG Att	**#Taxa**	**#Individ**	**Pct Taxa**	**Pct Ind**
1	0	0	0.00	0.00
2	3	11	0.13	0.03
3	6	70	0.25	0.21
4	8	181	0.33	0.55
5	3	28	0.13	0.09
6	0	0	0.00	0.00
x	4	37	0.17	0.11
Total	**24**	**327**		

SiteID	08LM066
StreamName	Daley Creek
Stream Class	Cold
WatershedArea_mi2	4.6
Size Class	Headwater
AvgJulyTemp	11.3
pctForest	41.2
Human Disturbance	66.2
Comments	

BCG Att	FinalID	#Individs	Order	Family (Tribe)
x	Acari	6		
x	Amphipoda	22	Amphipoda	
4	Gammarus	81	Amphipoda	Gammaridae
5	Physa	25	Basommatophora	Physidae
4	Optioservus	1	Coleoptera	Elmidae
3	Pagastia	3	Diptera	Chironomidae (Diamesini)
5	Cricotopus	1	Diptera	Chironomidae (Orthocladiini)
3	Eukiefferiella	4	Diptera	Chironomidae (Orthocladiini)
3	Parametriocnemus	1	Diptera	Chironomidae (Orthocladiini)
3	Tvetenia	3	Diptera	Chironomidae (Orthocladiini)
4	Micropsectra	8	Diptera	Chironomidae (Tanytarsini)
4	Simuliidae	3	Diptera	Simuliidae
4	Simulium	21	Diptera	Simuliidae (Simuliini)
x	Baetidae	8	Ephemeroptera	Baetidae
4	Baetis	64	Ephemeroptera	Baetidae
5	Oligochaeta	2	Haplotaxida	
x	Hydra	1	Hydroida	Hydridae
3	Brachycentrus	57	Trichoptera	Brachycentridae
2	Glossosoma	4	Trichoptera	Glossosomatidae
2	Glossosomatidae	6	Trichoptera	Glossosomatidae
2	Hesperophylax	1	Trichoptera	Limnephilidae
3	Limnephilidae	2	Trichoptera	Limnephilidae
4	Limnephilus	1	Trichoptera	Limnephilidae
4	Pisidiidae	2	Veneroida	Pisidiidae

Expert	BCG Call	Reason
wb	3+	lots of coldwater taxa; perhaps not a 2 because #s of 2-3s loo low; otherwise looks pretty good
jc	2-	coldwater taxa domination! Nice 2s and 3s taxa and ind, could have a few more mayflies, but nice.
ks_univ	3-	
ks_mpca	3	not enough 2 indivs, Physa #
so	3-	
bn	4	
js	4+	
jg	3-	low spp. richness, probably closer to 20
bl	2-	

APPENDIX G

Coldwater BCG Level Assignments - Fish

Appendix G. Participants made BCG level assignments on coldwater fish samples during a workshop in LaCrosse, WI (May 26-27, 2010) and a webinar (November 18, 2010). Samples were assessed using the scoring scale shown in Table G1. Participants that made BCG level assignments during each exercise are listed in Table G2.

Table G1. Scoring scale that was used for making BCG level assignments.

best	1
	1-
	2+
	2
	2-
	3+
	3
	3-
	4+
	4
	4-
	5+
	5
	5-
	6+
	6
worst	6-

Table G2. List of participants that made BCG level assignments during each exercise.

Name	**Affiliation**	**LaCrosse workshop**	**Nov. 18 Webinar**	**Follow up calls**
John Sandberg	MPCA	x	x	x
Mike Feist	MPCA	x	x	x
Scott Niemela	MPCA	x	x	x
Daniel Helwig	MPCA		x	
Kevin Goodwin	MDRNE	x	x	x
Lizhu Wang	MDRNE	x	x	
Michael Miller	WDNR	x	x	x
Nancy Schuldt	Fond du Lac	x		
Ed Hammer	EPA Region 5	x		x
Betsy Nightingale	EPA Region 5	x	x	
Chris Yoder	MBI		x	
Stephanie Ogren	LRBOI			x
James Snitgen	Oneida Nation			x

Table G-3. BCG level assignments and sample information for ***coldwater fish calibration*** samples that were analyzed. BCG level assignments are as follows: Final=consensus BCG level (=the assignment made by the majority of participants), without the + or - (2+ and 2- were assigned to level 2, etc.); Final (+/-) = consensus BCG level using the scoring scale shown in Table G1; Worst=the worst BCG level assignment (based on the Table G1 scoring scale) given by a participant; Best= the best BCG level assignment given by a participant. Samples are highlighted in yellow if the consensus call from the panelists is different from the primary call from the model.

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	Notes
MI	deadr349	Yellow D	7/4/2009	4	4	4-	3+	4	4		this site appears to be impacted by unique site-specific factors. Assignment made at LaCrosse workshop.
MI	ausab304	AuSable	7/4/2009	3	3	3-	2-	3	3		Assignment made at LaCrosse workshop.
MI	deadr138	1056	9/1/1998	1	1-	2+	1-	1	2	tie 1/2	Assignment made at LaCrosse workshop.
MI	grand2363	Pratt La	7/4/2009	**5**	5+	5	5+	**4**	4		Assignment made at LaCrosse workshop.
MI	grand2479	Duck Cre	7/4/2009	3	3-	4+	3	3	4	tie 3/4	Assignment made at LaCrosse workshop.
MI	kalam801	Spring B	7/4/2009	4	4	4	3	4	4		Assignment made at LaCrosse workshop.
MI	kewee926	West Bra	7/4/2009	2	2	3+	2	2	2		Assignment made at LaCrosse workshop.
MI	muske1118	Butler C	7/4/2009	2	2	2	2+	2	3	close	Assignment made at LaCrosse workshop.
MI	sagin1690	546	11/1/1996	2	2+	2	1-	2	2		Assignment made at LaCrosse workshop.
MI	sturg131	North Br	7/4/2009	3	3	3	2-	3	3		original panelist call = 2, was revised to a 3 during Feb 10 webinar due to rainbow trout. Assignment made at LaCrosse workshop.
MI	sturg203	Beaver C	7/4/2009	1	1-	1-	1-	1	1		Assignment made at LaCrosse workshop.
MI	waisk44	1632	9/1/1998	1	1-	1-	1-	1	1		Assignment made at LaCrosse workshop.
MN	03UM110	Little Rock Creek	7/30/2008	5	5	5	5+	5	5		Assignment made at LaCrosse workshop.

Table G-3. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	04LM058	Spring Valley Creek	6/24/2004	4	4-	5+	4	4	4		Assignment made at LaCrosse workshop.
MN	04LM077	Rice Creek	7/12/2004	2	2+	2	1-	2	2		Assignment made at LaCrosse workshop.
MN	04LM089	Hay Creek	8/17/2004	**3**	3	4	2	**4**	4		panelist calls ranged across 2 BCG levels. Assignment made at LaCrosse workshop.
MN	04LM092	Big Trout Creek (a.k.a. Pickwick Creek)	6/22/2004	4	4-	5+	4	4	3		Assignment made at LaCrosse workshop.
MN	04LM101	Trout Run	6/23/2004	3	3	3	1-	3	3		original panelist call = 2 (assignment made at LaCrosse workshop), was revised to a 3 during Feb 10 webinar
MN	04LM102	South Fork Whitewater River	8/2/2004	3	3+	3	2	3	3		looks like coolwater assemblage. Assignment made at LaCrosse workshop.
MN	04LM134	Trout Brook	7/7/2004	4	4	4-	3-	4	4		Assignment made at LaCrosse workshop.
MN	08LM029	Root River, South Branch	7/29/2008	3	3-	4	3-	3	3		Assignment made at LaCrosse workshop.
MN	08LM091	Butterfield Creek	7/14/2008	3	3	4+	2	3	3		panelist calls ranged across 2 BCG levels. Assignment made at LaCrosse workshop.
MN	08LM095	Storer Creek	7/23/2008	1	1-	2+	1-	1	2	tie 1/2	Assignment made at LaCrosse workshop.
WI	10008034	Lee Creek	10/2/2000	2	2+	2+	1-	2	3		Assignment made at LaCrosse workshop.
WI	10008092	Genesee Creek	5/24/2002	3	3	4	2-	3	4		panelist calls ranged across 2 BCG levels. Assignment made at LaCrosse workshop.

Table G-3. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MI	ausab240	AuSable	7/4/2009	3	3	4	2-	3	4		panelist calls ranged across 2 BCG levels. Assignment made at Nov 18 webinar.
MI	chebo105	Mullett	7/4/2009	2	2+	2+	1-	2	2		initially classified as cool, changed to cold per feedback at Nov 18 webinar
MI	grand2362	1418	8/1/1989	**4**	4-	5+	4+	**5**	5		Assignment made at Nov 18 webinar.
MI	grand291	1467	8/1/1983	3	3	4+	2-	3	3		panelist calls ranged across 2 BCG levels. Assignment made at Nov 18 webinar.
MI	manis530	Spalding	7/4/2009	5	5	5-	5+	5	5		Assignment made at Nov 18 webinar.
MI	menom999	Iron Riv	7/4/2009	2	2-	3	2+	2	2		Assignment made at Nov 18 webinar.
MI	muske1166	Brooks C	7/4/2009	**5**	5	5	4-	**4**	4		Assignment made at Nov 18 webinar.
MI	muske1215	1597	7/1/2004	5	5+	5	4-	5	4		Assignment made at Nov 18 webinar.
MI	muske566	Hersey R	7/4/2009	**4**	4+	4-	3	**3**	4		Assignment made at Nov 18 webinar.
MI	platt53	Victoria	7/4/2009	3	3-	4-	3-	3	5		Assignment made at Nov 18 webinar.
MI	sagin1226	Indian C	7/4/2009	2	2-	3-	2	2	3		Assignment made at Nov 18 webinar.
MI	sagin844	North Br	7/4/2009	5	5+	5	4	5	5		Assignment made at Nov 18 webinar.
MI	stjom1424	McKinzie	7/4/2009	5	5+	5	4+	5	4	tie 4/5	Assignment made at Nov 18 webinar.
MI	sturg79	North Br	7/4/2009	3	3	3	2+	3	3		Assignment made at Nov 18 webinar.
MI	waisk21	1625	9/1/1998	3	3+	3-	2	3	3		Assignment made at Nov 18 webinar.
MN	00UM043	Briggs Creek	7/8/2009	5	5-	6	5+	5	4		based on DNR review, appears to be an impaired coldwater stream. Assignment made at Nov 18 webinar.
MN	04LM007	Wells Creek	7/7/2004	4	4	4-	4	4	5	close	Assignment made at Nov 18 webinar.
MN	04LM029	South Branch Vermillion River	7/8/2004	4	4	4-	4	4	5		Assignment made at Nov 18 webinar.

Table G-3. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	04LM090	Belle Creek	7/26/2004	4	4+	4-	3	4	3		Assignment made at Nov 18 webinar.
MN	04LM095	Pine Creek	6/23/2008	3	3	3-	3+	3	3		Assignment made at Nov 18 webinar.
MN	04LM095	Pine Creek	8/11/2008	3	3	3-	3+	3	3		Assignment made at Nov 18 webinar.
MN	04LM129	Mill Creek	6/30/2008	4	4	4-	3-	4	4		assessed twice - consensus calls from Nov 18 webinar & LaCrosse were the same
MN	07UM092	Snake River	7/31/2007	4	4-	5+	4	4	4		Assignment made at Nov 18 webinar.
MN	08LM053	Root River, South Branch	7/23/2008	3	3+	3	2-	3	3		Assignment made at Nov 18 webinar.
WI	10008018	Harker Creek	10/3/2000	2	2	2-	1-	2	1		Assignment made at Nov 18 webinar.
WI	10011185	West Branch Baraboo River	8/5/2003	5	5	5	3	5	4		panelist original call = 4 (assignment was made at Nov 18 webinar), was revised to a 5 during Feb 10 webinar
WI	10011186	West Branch Baraboo River	8/5/2003	5	5	5-	4-	5	5		looks like a warmwater community. Assignment made at Nov 18 webinar.

Table G-4. Site information for coldwater fish samples that were analyzed during the BCG ***calibration*** exercise. Original class refers to the original classification information provided by each entity (for more information see Section 2.1). Area refers to the upstream watershed area. Land use (% Agr=% agricultural, % For= % forest, % Urb= % urban, % Wet= % wetland) is for the upstream catchment area. Mean July Temp (temperature) is based either on instantaneous measurements taken at the time of the biological sampling event or on continuous measurements from temperature loggers. The human disturbance score is calculated by MPCA based on upstream land use (higher score=less disturbance). Additional information (i.e. nutrient and habitat data) may available for some of the sites.

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cold	MI	waisk44	-84.89973	46.46268	Cold stream	3.49	Stream		Northern Lakes and Forests		95.75	0.88	1.90	
Cold	MI	sturg203	-88.79639	46.80619	Cold stream	0.55	Stream		Northern Lakes and Forests		99.18		0.56	
Cold	MI	deadr138	-87.80631	46.81774	Cold stream	0.22	Stream		Northern Lakes and Forests		93.33		1.90	
Cold	MN	08LM095	-91.48408	43.79345	Southern Coldwater	6.44	Headwater	15.9	Driftless Area	38.60	59.80	1.60		71.4
Cold	MI	muske1118	-85.98344	43.37893	Cold stream	40.10	Stream		Southern Michigan/Northern Indiana Drift Plains	47.70	20.65	6.11	9.29	
Cold	WI	10008034	-90.23980	42.99999	Cold Mainstem	3.26			Driftless Area	3.69	44.14	0.01		
Cold	MI	chebo105	-84.59494	45.53462	Cold transitional stream	11.31	Stream		Northern Lakes and Forests	33.65	32.59	5.17	15.97	
Cold	MI	sagin1690	-84.90112	43.56234	Cold stream	5.96	Stream		Southern Michigan/Northern Indiana Drift Plains	65.52	15.40	4.92	9.54	
Cold	MN	04LM077	-93.21064	44.44602	Southern Coldwater	5.89	Headwater	16.3	North Central Hardwoods	90.60	3.60	5.70	0.10	44.9
Cold	MI	kewee926	-88.98399	46.74965	Cold stream	6.27	Stream		Northern Lakes and Forests		86.62	0.95	8.65	
Cold	MI	sturg131	-88.69916	46.88318	Cold stream	6.98	Stream		Northern Lakes and Forests		91.21		6.99	
Cold	WI	10008018	-90.23950	43.01354	Cold Mainstem	8.56			Driftless Area	4.85	57.00			
Cold	MI	menom999	-88.62293	46.06507	Cold small river	82.85	Small		Northern Lakes and Forests	7.23	63.45	5.73	14.96	
Cold	MI	sturg79	-88.65509	46.93057	Cold stream	50.46	Stream		Northern Lakes and Forests	1.24	77.69	1.47	15.83	

Table G-4. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cold	MI	sagin1226	-85.02688	43.63298	Cold stream	10.01	Stream		Southern Michigan/Northern Indiana Drift Plains	15.38	62.42	1.70	7.09	
Cold	MN	04LM101	-92.04809	44.04722	Southern Coldwater	7.54	Wadeable	11.3	Driftless Area	83.40	11.70	4.90		58.9
Cold	MN	04LM095	-91.80546	43.85259	Southern Coldwater	49.41	River	16.7	Driftless Area	79.00	17.20	3.60	0.10	53.4
Cold	MN	04LM095	-91.80546	43.85259	Southern Coldwater	49.41	River	16.7	Driftless Area	79.00	17.20	3.60	0.10	53.4
Cold	MN	08LM053	-92.15253	43.66201	Southern Coldwater	133.91	River	16.1	Driftless Area	82.20	11.90	5.20	0.40	56.5
Cold	MI	grand2479	-85.33646	42.77477	Cold stream	29.08	Stream		Southern Michigan/Northern Indiana Drift Plains	78.40	10.53	3.63	5.18	
Cold	MN	08LM029	-92.23369	43.62054	Southern Coldwater	69.13	River	17.5	Driftless Area	86.00	7.70	5.70	0.30	44.9
Cold	MN	04LM102	-91.98075	44.06884	Southern Coldwater	78.02	River	17.8	Driftless Area	78.20	12.20	9.40	0.10	50.7
Cold	MI	ausab304	-84.52087	44.66743	Cold stream	240.42	Stream		Northern Lakes and Forests	0.91	65.48	2.98	7.49	
Cold	MI	platt53	-85.76142	44.84334	Cold stream	24.55	Stream		North Central Hardwoods	25.29	36.23	3.78	18.80	
Cold	MI	waisk21	-84.97010	46.47586	Cold stream	5.42	Stream		Northern Lakes and Forests		70.12	1.16	28.00	
Cold	MI	grand291	-84.97993	43.24597	Cold stream	36.32	Stream		Southern Michigan/Northern Indiana Drift Plains	50.08	26.12	2.85	14.27	
Cold	MN	08LM091	-91.35433	43.74440	Southern Coldwater	5.99	Headwater	15.2	Driftless Area	43.50	53.90	2.60		68.6
Cold	WI	10008092	-88.36368	42.96469	Cold Mainstem	13.71			Southeastern Wisconsin Till Plains	32.77	23.67	5.06		
Cold	MI	ausab240	-84.74616	44.68210	Cold stream	85.57	Stream		Northern Lakes and Forests	0.65	72.90	2.74	6.49	

Table G-4. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cold	MN	04LM089	-92.59826	44.47133	Southern Coldwater	16.36	Wadeable	13.2	Driftless Area	88.50	6.90	4.50		57.8
Cold	MN	04LM007	-92.36173	44.49556	Southern Coldwater	64.68	River		Driftless Area	74.60	21.90	3.30	0.10	61.1
Cold	MN	04LM029	-93.02948	44.63628	Southern Coldwater	27.57	Wadeable		Western Corn Belt Plains	86.20	6.60	5.30	1.60	54.4
Cold	MN	04LM058	-92.35264	43.70084	Southern Coldwater	18.57	Wadeable		Driftless Area	86.10	2.60	11.10	0.10	30.1
Cold	MN	04LM092	-91.47575	43.99201	Southern Coldwater	20.04	Wadeable	17.9	Driftless Area	41.20	54.00	4.50	0.20	67.8
Cold	MN	07UM092	-93.79551	45.40923	Southern Coldwater	28.26	Wadeable		North Central Hardwoods	41.20	38.70	3.20	14.30	48.1
Cold	MI	kalam801	-85.52516	42.37527	Cold stream	14.98	Stream		Southern Michigan/Northern Indiana Drift Plains	57.02	25.26	3.20	7.71	
Cold	MN	04LM134	-92.53420	44.29863	Southern Coldwater	49.13	River	14.3	Driftless Area	93.30	1.90	4.60		41.9
Cold	MN	04LM129	-92.19545	43.84975	Southern Coldwater	31.31	Wadeable	17.1	Driftless Area	82.60	10.40	6.90	0.10	39.3
Cold	MI	grand2362	-85.33188	42.80420	Cold stream	23.48	Stream		Southern Michigan/Northern Indiana Drift Plains	76.57	9.77	3.86	6.60	
Cold	MI	muske566	-85.47732	43.86588	Cold stream	104.50	Stream		Southern Michigan/Northern Indiana Drift Plains	21.04	46.08	4.00	13.86	
Cold	MN	04LM090	-92.74896	44.50383	Southern Coldwater	69.57	River		Driftless Area	86.60	8.40	4.60		57.7
Cold	WI	10011185	-90.28675	43.67099	Cool (Cold Transition) Ma	60.78			Driftless Area	47.18	30.54	5.32		
Cold	MI	grand2363	-85.33188	42.80420	Cold stream	17.19	Stream		Southern Michigan/Northern Indiana Drift Plains	72.20	9.77	5.17	9.08	

Table G-4. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cold	MN	03UM110	-94.19247	45.85335	Southern Coldwater	20.80	Wadeable	17.4	North Central Hardwoods	75.30	8.40	3.10	13.00	
Cold	MI	manis530	-85.48463	44.18134	Cold stream	5.76	Stream		Southern Michigan/Northern Indiana Drift Plains	15.57	39.66	3.73	28.36	
Cold	MI	muske1215	-86.11548	43.30506	Cold stream	12.24	Stream		Southern Michigan/Northern Indiana Drift Plains	13.28	54.49	2.02	16.80	
Cold	MI	muske1166	-86.02199	43.35011	Cold stream	55.33	Stream		Southern Michigan/Northern Indiana Drift Plains	45.36	23.43	5.14	8.46	
Cold	MI	sagin844	-84.84436	43.74637	Cold stream	23.55	Stream		Southern Michigan/Northern Indiana Drift Plains	18.25	44.96	2.38	22.61	
Cold	WI	10011186	-90.33150	43.65668	Cool (Cold Transition) Ma	39.51			Driftless Area	46.35	32.02	5.73		
Cold	MI	stjom1424	-86.22472	41.88503	Cold stream	18.54	Stream		Southern Michigan/Northern Indiana Drift Plains	49.92	22.58	4.46	13.21	
Cold	MN	00UM043	-93.92420	45.51623	Southern Coldwater	8.66	Wadeable		North Central Hardwoods	49.90	34.60	4.50	10.00	64.3

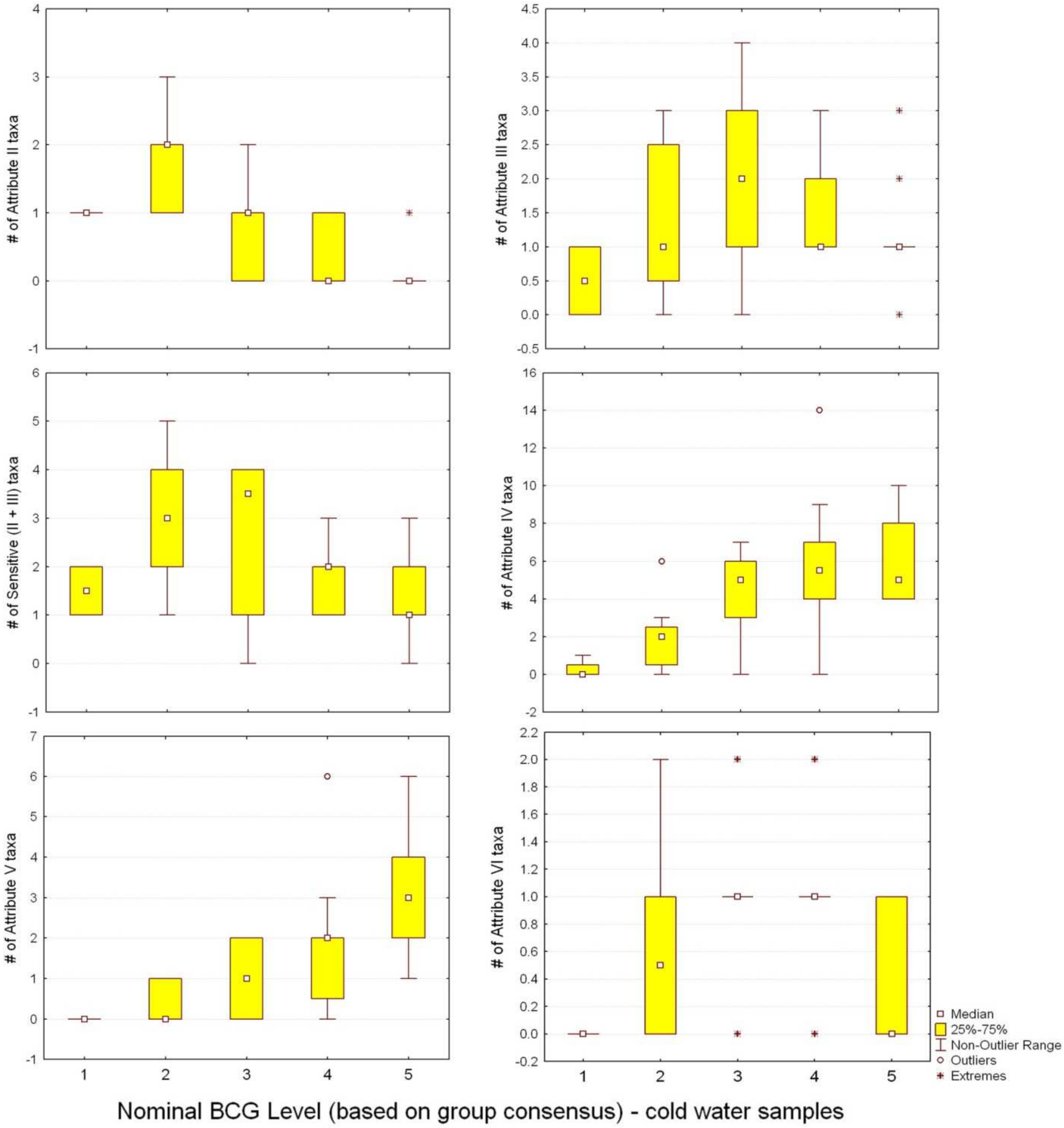

Figure G-1. Box plots of BCG attribute II-VI richness metrics for 51 coldwater fish samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 1 = 4, level 2 = 12, level 3 = 14, level 4 = 12, and level 5 = 9.

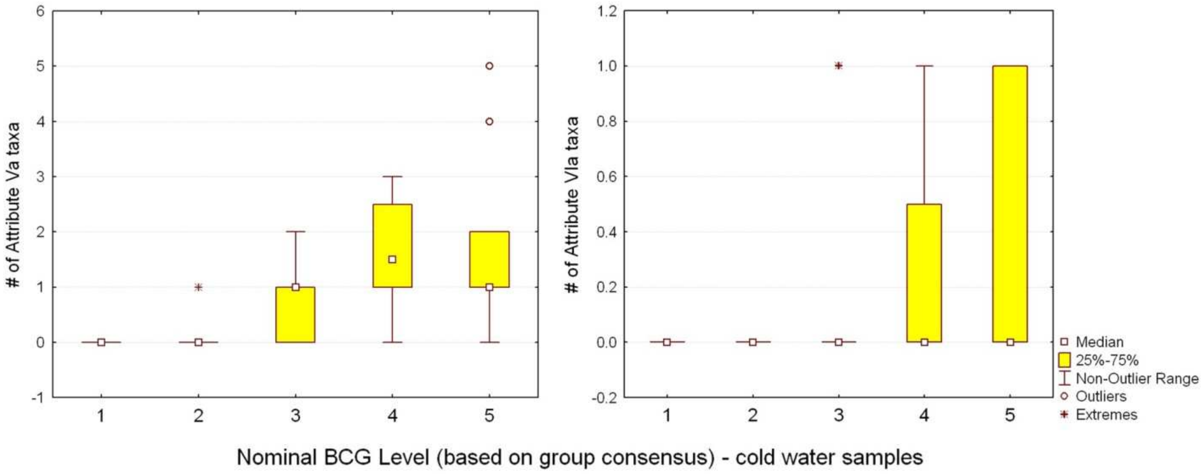

Figure G-2. Box plots of BCG attribute Va-VIa richness metrics for 51 coldwater fish samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 1 = 4, level 2 = 12, level 3 = 14, level 4 = 12, and level 5 = 9.

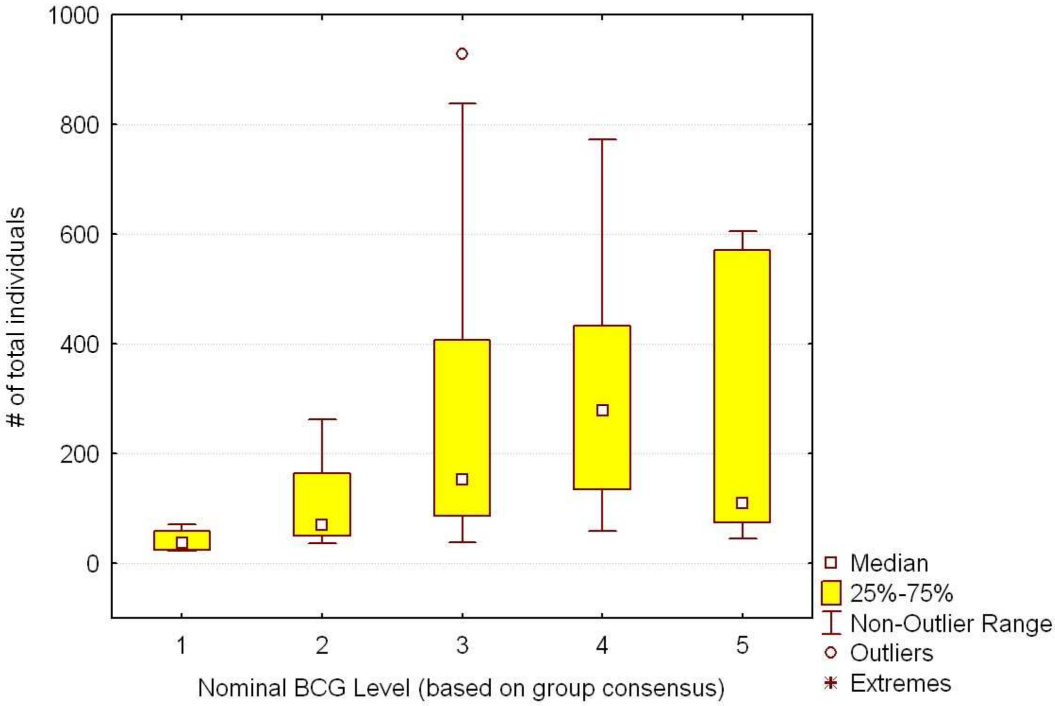

Figure G-3. Box plots of total number of individual metric values for coldwater fish samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 1 = 4, level 2 = 12, level 3 = 14, level 4 = 12, and level 5 = 9.

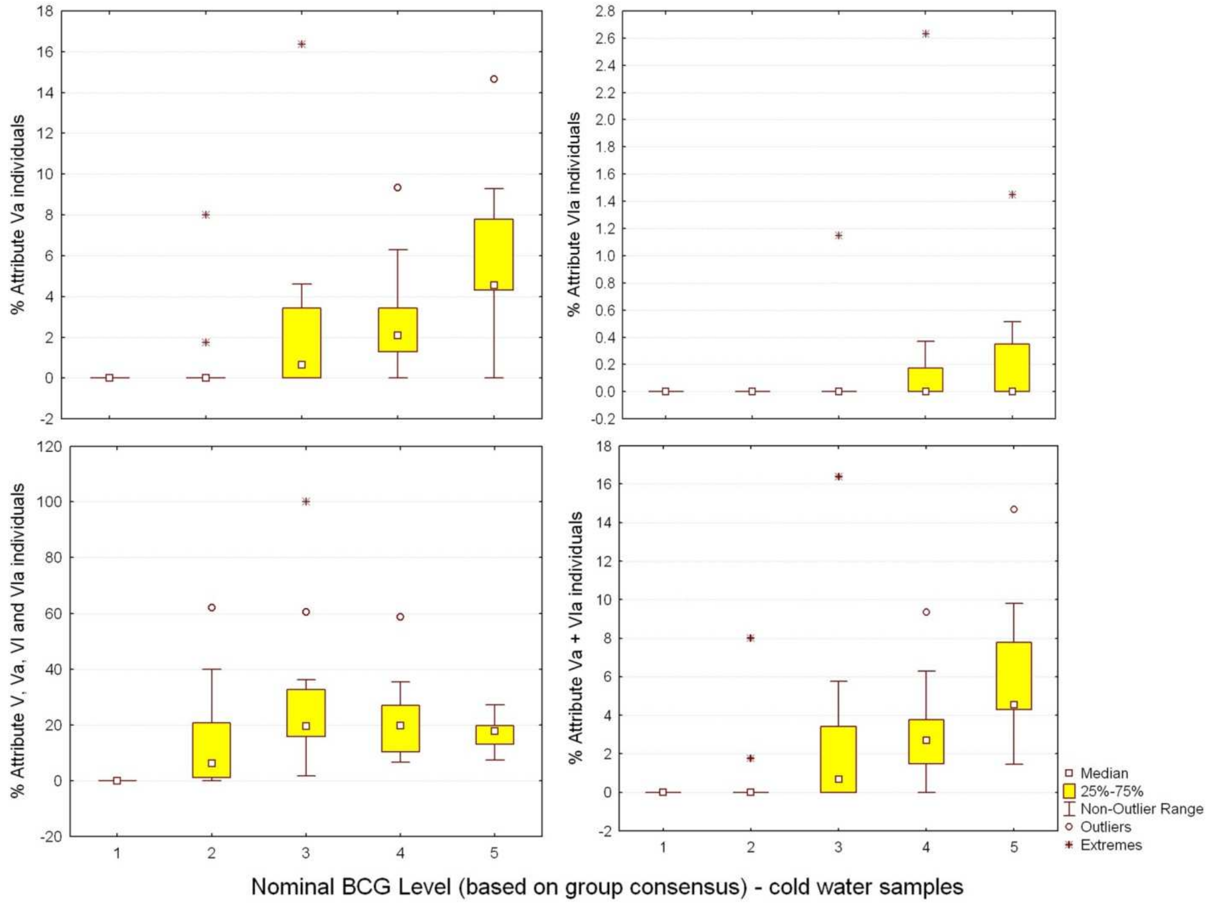

Figure G-4. Box plots of BCG attribute Va and VIa percent individual metrics for 51 coldwater fish samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 1 = 4, level 2 = 12, level 3 = 14, level 4 = 12, and level 5 = 9.

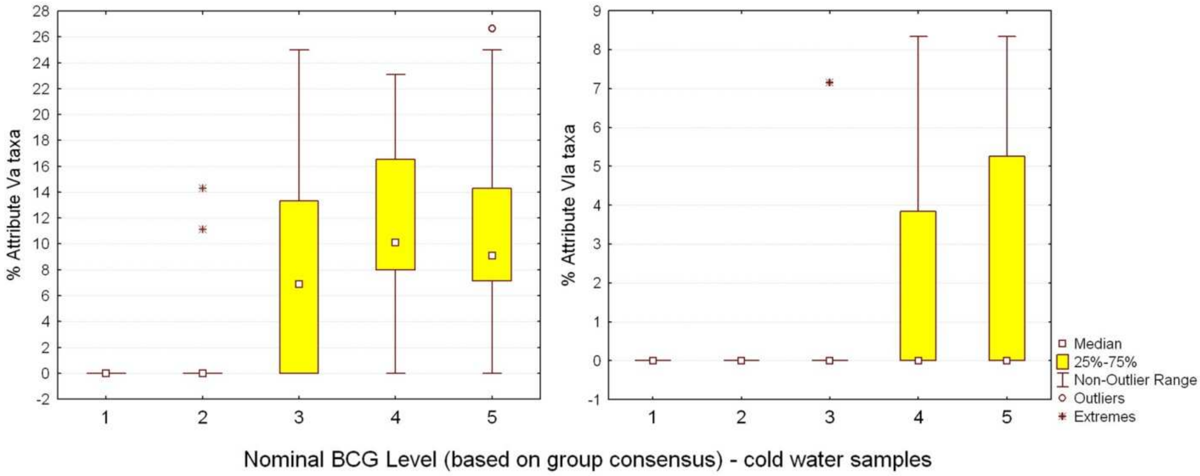

Figure G-5. Box plots of BCG attribute Va and VIa percent taxa metrics for 51 coldwater fish samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 1 = 4, level 2 = 12, level 3 = 14, level 4 = 12, and level 5 = 9.

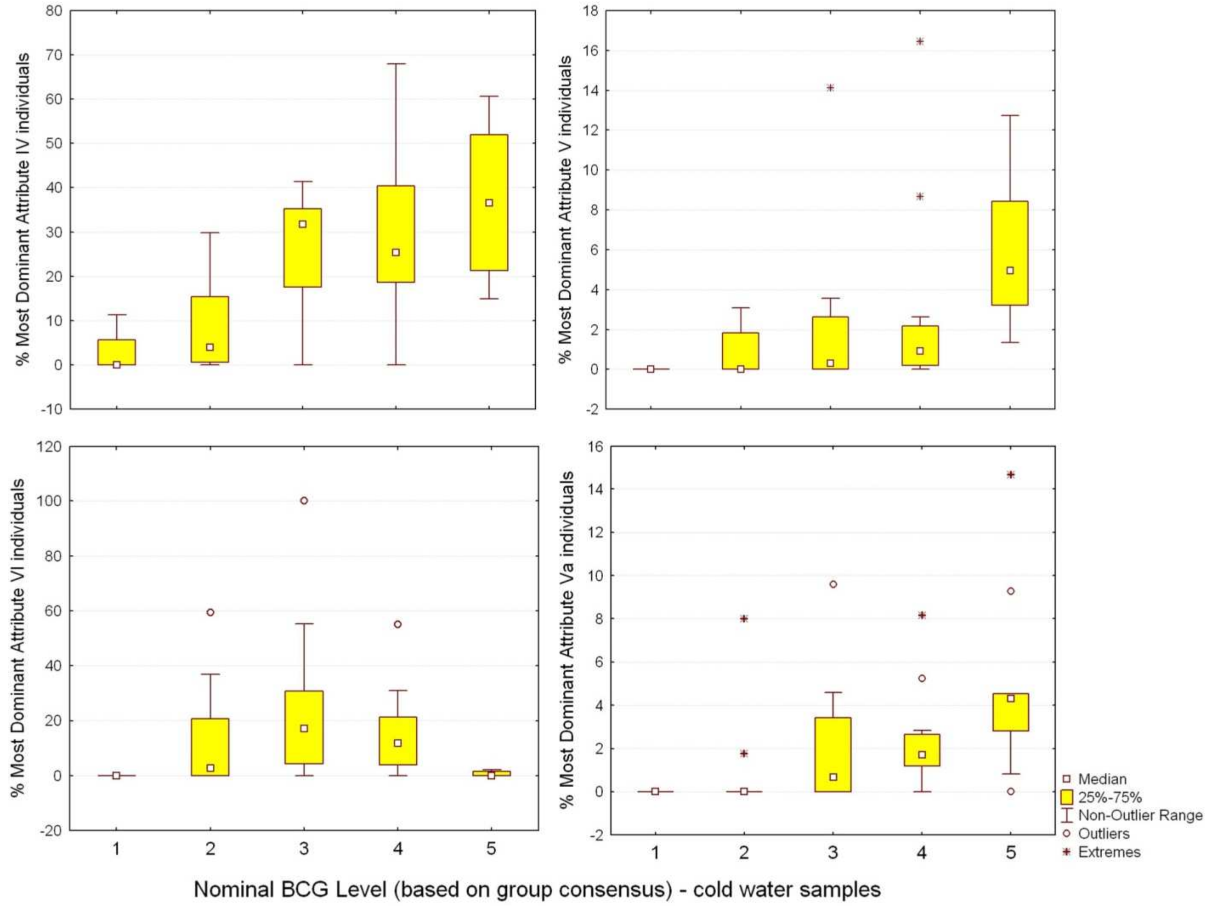

Figure G-6. Box plots of % dominant BCG attribute IV, V, Va and VI individual metrics for 51 coldwater fish samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 1 = 4, level 2 = 12, level 3 = 14, level 4 = 12, and level 5 = 9.

Table G-5. BCG level assignments and sample information for ***coldwater fish validation*** samples that were analyzed. BCG level assignments are as follows: Final=consensus BCG level (=the assignment made by the majority of participants), without the + or - (2+ and 2- were assigned to level 2, etc.); Final (+/-) = consensus BCG level using the scoring scale shown in Table G1; Worst=the worst BCG level assignment (based on the Table G1 scoring scale) given by a participant; Best= the best BCG level assignment given by a participant. Samples are highlighted in yellow if the consensus call from the panelists is different from the primary call from the model.

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
WI	10008092	Genesee Creek	9/18/2002	**4**	4-	5+	4+	**5**	3		strange assemblage
WI	10013489	Friday Creek	7/19/2005	4	4	4-	4	4	4		Panelists changed their consensus call to a 4 during the Nov 14 call
WI	10014187	Dody Brook	6/13/2006	4	4	5	3	4	4		small headwater wetland stream, or very small stream with flow issues? No predators.
WI	10015347	King Creek	6/6/2006	4	4	4-	3+	4	4		low numbers of individuals - sampling issue?
WI	10015553	Sidney Creek	5/28/2008	2	2	2-	2+	2	4		
WI	10021137	Waumandee Creek	6/20/2005	4	4	5	3	4	4		
MN	04LM104	Beaver Creek	6/28/2004	3	3	4	2-	3	3		strong presence of brown trout
MN	08LM030	Wisel Creek	8/19/2008	¾ (tie)	3-	4	3	3	3		During the Nov 14 call, panelists gave this a consensus call of 3/4
MN	08LM102	Root River, South Fork	8/12/2008	4	4	5+	3	4	3		questionable classification - could be transitional cold/cool
MN	08LM117	Unnamed creek	6/17/2008	**5**	5+	5	4	**4**	4		strange assemblage for a small cold stream
MN	08LM142	Trib. To Root River	7/28/2008	2	2+	2	2+	2	2		
MN	98SC007	Hay Creek	6/16/1998	**5**	5+	5	4-	**4**	4		Panelist call was confirmed during Nov 14 call; several called it a 5+/4-
MN	99MN007	Assumption Creek	7/2/1999	5	5+	5	3	5	5		strange assemblage -could be a wetland stream
MI	board226	Deer Cre	7/4/2009	3	3-	5	3+	3	3		

Table G-5. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MI	board660	1319	7/1/1995	1	1-	2	1	1	1		Confirmed during the Nov 14 call
MI	escan122	Warner C	7/4/2009	2	2	4	2	2	2		
MI	kalam745	36	4/1/1996	4	4	5	3-	4	3		strange assemblage for a small coldwater stream
MI	maniq67	886	8/1/1997	2	2	2	2+	2	4		Confirmed during the Nov 14 call
MI	muske1020	1384	6/1/1990	4	4	5	3	4	4		score bumped down by presence of non-native trout, creek chub and mud minnows
MI	muske1212	1404	7/1/1985	2	2	3+	2	2	2		
MI	muske1214	1401	7/1/1985	**5**	5	6	4-	**4**	5		questionable sample - low numbers for a stream this size
MI	rifle30	703	7/1/2000	3	3-	4	3	3	4	close	score bumped down by presence of brown trout, creek chub and green sunfish
MI	sagin12	595	8/1/2000	3	3+	3	2-	3	4		high number of brown trout
MI	sagin244	549	8/1/2001	3	3-	4	3-	3	4		Panelist call was confirmed during Nov 14 call; most called it a 3- , two people called it a 4
MI	tahqu164	1111	8/1/1998	2	2	2-	2+	2	3		numeric dominance of BCG-2 taxa

Table G-6. Site information for coldwater fish samples that were analyzed during the BCG ***validation*** exercise. Original class refers to the original classification information provided by each entity (for more information see Section 2.1). Area refers to the upstream watershed area. Land use (% Agr=% agricultural, % For= % forest, % Urb= % urban, % Wet= % wetland) is for the upstream catchment area. Mean July Temp (temperature) is based either on instantaneous measurements taken at the time of the biological sampling event or on continuous measurements from temperature loggers. The human disturbance score is calculated by MPCA based on upstream land use (higher score=less disturbance). Additional information (i.e. nutrient and habitat data) may available for some of the sites.

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cold	MN	08LM030	-91.81286	43.59915	Southern Coldwater	40.33	Wadeable	15.3	Driftless Area	84.50	10.20	5.00	0.10	55.6
Cold	MN	08LM142	-91.82080	43.76518	Southern Coldwater	4.72	Headwater		Driftless Area	57.70	39.40	2.90	0.10	62.9
Cold	MI	sagin244	-84.66562	44.03881	Cold stream	10.39	Stream		Northern Lakes and Forests	6.17	66.76	3.65	9.40	
Cold	MI	board660	-85.56466	44.62329	Cold stream	8.93	Stream		Northern Lakes and Forests	37.85	34.39	2.55	8.74	
Cold	MI	muske1214	-86.11548	43.30506	Cold stream	39.22	Stream		Southern Michigan/Northern Indiana Drift Plains	16.48	54.54	3.77	8.62	
Cold	MI	sagin12	-84.25189	44.21250	Cold stream	2.56	Stream		Northern Lakes and Forests	43.96	29.45	3.39	8.43	
Cold	MN	08LM102	-91.79265	43.66030	Southern Coldwater	95.98	River		Driftless Area	79.10	16.40	4.40	0.10	50.1
Cold	MI	maniq67	-85.94075	46.44795	Cold stream	21.46	Stream		Northern Lakes and Forests		80.31	0.84	12.95	
Cold	MI	kalam745	-85.58991	42.40686	Cold stream	3.04	Stream		Southern Michigan/Northern Indiana Drift Plains	43.00	41.72	3.81	3.46	
Cold	WI	10015553	-88.31880	45.66700	Cold Mainstem	14.66			Northern Lakes and Forests					
Cold	MI	rifle30_703	-84.05325	44.42006	Cold stream	3.10	Stream		Northern Lakes and Forests	3.69	76.77	0.75	10.81	

Table G-6. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cold	MI	escan122	-87.56423	46.41182	Cold stream	11.56	Stream		Northern Lakes and Forests		39.74	6.20	7.76	
Cold	WI	10015347	-91.26090	44.56130	Cool (Cold Transition) Ma	12.81			Driftless Area					
Cold	MN	98SC007	-92.87723	45.53085	Southern Coldwater	13.99	Wadeable		North Central Hardwoods	73.00	19.20	4.80	3.00	53.3
Cold	MN	99MN007	-93.55155	44.80883	Southern Coldwater	1.48	Headwater		North Central Hardwoods	31.50	32.10	30.90	5.00	66.4
Cold	WI	10021137	-91.68273	44.33338	Cool (Cold Transition) Ma	36.09			Driftless Area					
Cold	MI	muske1212	-86.11463	43.30650	Cold stream	35.90	Stream		Southern Michigan/Northern Indiana Drift Plains	17.93	52.87	3.80	8.75	
Cold	MI	board226	-85.02678	45.13726	Cold stream	28.53	Stream		Northern Lakes and Forests	14.39	53.30	3.28	17.84	
Cold	MN	04LM104	-92.05579	44.14454	Southern Coldwater	9.77	Wadeable	15.1	Driftless Area	70.20	26.50	3.00	0.30	64.2
Cold	WI	10008092	-88.36368	42.96469	Cold Mainstem	13.71			Southeastern Wisconsin Till Plains	32.77	23.67	5.06		
Cold	MN	08LM117	-93.05571	44.61522	Southern Coldwater	8.81	Wadeable		Western Corn Belt Plains	89.10	2.90	7.80		39.8
Cold	MI	muske1020	-85.74529	43.44981	Cold stream	16.26	Stream		Southern Michigan/Northern Indiana Drift Plains	7.86	66.19	1.35	14.14	
Cold	MI	tahqu164	-85.78007	46.37278	Cold stream	28.85	Stream		Northern Lakes and Forests		82.85	0.57	4.96	

Table G-6. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cold	WI	10013489	-92.41720	45.33903	Cold Mainstem	12.62			North Central Hardwoods					
Cold	WI	10014187	-92.49810	45.91450	Cold Mainstem	7.49			Northern Lakes and Forests					

APPENDIX H

Coldwater BCG Level Assignments - Macroinvertebrates

Appendix H. Participants made BCG level assignments on coldwater macroinvertebrate samples during a workshop in LaCrosse, WI (May 26-27, 2010) and a webinar (November 19, 2010). Samples were assessed using the scoring scale shown in Table H1. Participants that made BCG level assignments during each exercise are listed in Table H2.

Table H1. Scoring scale that was used for making BCG level assignments.

best	1
	1-
	2+
	2
	2-
	3+
	3
	3-
	4+
	4
	4-
	5+
	5
	5-
	6+
	6
worst	6-

Table H2. List of participants that made BCG level assignments during each exercise.

Name	**Affiliation**	**LaCrosse workshop**	**Nov. 19 Webinar**
Will Bouchard	MPCA	x	x
Joel Chirhart	MPCA	x	x
John Genet	MPCA		x
Kevin Stroom	MPCA		x
Benjamin Lundeen	MPCA		x
Kari Hedin	Fond du Lac	x	
Stephanie Ogren	LRBOI		x
James Snitgen	Oneida Nation		x
Jeffrey Dimick	University of Wisconsin - Stevens Point	x	
Kurt Schmude	University of Wisconsin - Superior	x	x
Betsy Nightingale	EPA Region 5		x
Kayla Bowe	RLDNR	x	

Table H-3. BCG level assignments and sample information for ***coldwater macroinvertebrate calibration*** samples that were analyzed. BCG level assignments are as follows: Final=consensus BCG level (=the assignment made by the majority of participants), without the + or - (2+ and 2- were assigned to level 2, etc.); Final (+/-) = consensus BCG level using the scoring scale shown in Table H1; Worst=the worst BCG level assignment (based on the Table H1 scoring scale) given by a participant; Best= the best BCG level assignment given by a participant. Samples are highlighted in yellow if the consensus call from the panelists is different from the primary call from the model.

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	04LM021	Willow Creek	8/23/2004	5	5+	5+	4-	5	5		
MN	04LM030	trib. to Winnebago Creek	8/31/2004	3	3	4	2-	3	3		Very high gradient (61 m/km) (outlier)
MN	04LM058	Spring Valley Creek	8/24/2004	4	4	4-	4	4	3		
MN	04LM068	South Fork White Water River	8/17/2004	4	4	4	4+	4	3		
MN	04LM069	South Fork Root River	8/23/2004	4	4	4-	4+	4	3		
MN	04LM092	Big Trout Creek (a.k.a. Pickwick Creek)	9/21/2004	3	3	4+	2-	3	3		
MN	04LM094	Pleasant Valley Creek	8/19/2004	4	4	4-	3-	4	5		
MN	04LM095	Pine Creek	9/1/2004	4	4	4	3-	4	4		
MN	04LM098	Trout Run	8/17/2004	5	5	5	4	5	5		

Table H-3. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	04LM099	Garvin Brook	8/23/2004	3	3+	3-	2	3	4		High gradient outlier (42.8 m/km); sample from same site/different collection date also assessed.
MN	04LM099	Garvin Brook	9/9/2004	3	3+	3-	2	3	4		High gradient outlier (42.8 m/km); sample from same site/different collection date also assessed.
MN	04LM104	Beaver Creek	8/18/2004	4	4	4-	3-	4	4		Higher gradient (26.4 m/km); sample from same site/different collection date also assessed.
MN	04LM104	Beaver Creek	9/21/2004	3	3-	4	3-	3	4	close	Higher gradient (26.4 m/km) (outlier); sample from same site/different collection date also assessed.
MN	04LM117	Riceford Creek	8/25/2004	4	4	4-	4+	4	4		
MN	04LM128	Crow Spring	8/16/2004	5	5+	5+	5+	5	5		
MN	04LM129	Mill Creek	8/4/2008	4	4-	5	4	4	5		appears marginally coldwater, probably a silty stream

Table H-3. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	04LM138	Handshaw Coulee	8/24/2004	4	4-	4-	4-	4	5	tie 4/5	Original panelist call=3 at LaCrosse; revised to 4- during Feb. 16 call.
MN	04LM144	Trout Brook	8/17/2004	4	4	5	4+	4	4		sample from same site/different collection date also assessed.
MN	04LM144	Trout Brook	9/7/2004	5	5+	5+	4	5	5		sample from same site/different collection date also assessed.
MN	08LM011	Money Creek	8/5/2008	4	4	4	3-	4	3	tie 4/3	
MN	08LM013	Deer Creek	8/18/2008	4	4	4+	3-	4	3	tie 3/4	Panelists ok with model call (per Feb 16 call)
MN	08LM016	Root River, South Fork	8/26/2008	3	3-	4	3	3	3		
MN	08LM020	Forestville Creek	8/18/2008	3	3	3	2-	3	2		Assessed twice - LaCrosse assignment = 3; Webinar assignment = 3+
MN	08LM020	Forestville Creek	8/18/2008	3	3	3-	2-	3	2		Assessed twice - LaCrosse assigment = 3; Webinar assignment = 3+
MN	08LM027	Upper Bear Creek	8/5/2008	4	4	4-	4+	4	4		
MN	08LM044	Gribben Creek	8/6/2008	3	3	3-	3+	3	4		
MN	08LM048	Duschee Creek	8/6/2008	4	4	4-	4+	4	4		
MN	08LM052	Diamond Creek	8/6/2008	3	3-	4	3	3	3		
MN	08LM063	Pine Creek	8/26/2008	4	4+	4	3	4	3		

Table H-3. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	08LM066	Daley Creek	8/7/2008	3	3	4+	2-	3	3		
MN	08LM091	Butterfield Creek	8/6/2008	3	3	4+	3+	3	4		
MN	08LM095	Storer Creek	8/5/2008	3	3	3-	3	3	4		
MN	08LM106	Beaver Creek, East Fork	8/7/2008	2	2	2-	2+	2	2		
MN	08LM124	Unnamed Creek	9/9/2008	5	5+	5	4-	5	5		
MN	08LM135	Wells Creek	8/27/2008	4	4	4-	3-	4	4		
WI	10008018	Harker Creek	11/3/2000	3	3	4	2-	3	4		sampled collected in November
WI	10009328	Black Earth Creek	5/24/1988	Excluded – spring sample							Panelists called this a BCG level 4, which was in agreement with the model
WI	10009920	West Fork White River	10/24/2002	4	4	4-	4+	4	4		stream likely has a high sediment load
WI	10009965	Halfway Creek	11/6/2002	5	5+	4-	3-	5	5		
WI	10010073	Pompey Pillar Creek	10/30/2003	4	4	5	3-	4	4		Formerly classified as cool water
WI	10011185	West Branch Baraboo River	10/13/2004	4	4	5	4	4	4		Formerly classified as cool water
WI	10012156	North Fish Creek	10/19/2004	**4**	4	5+	4+	**3**	3		Panelists decided to stick with their original call (per Feb 16 call)

Table H-3. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
WI	10015217	Otter Creek	10/4/2007	5	5+	5+	4	5	5		Looks like low gradient assemblage. no cold water taxa; heavy agricultural area, edge of driftless area
WI	10015410	Lenawee Creek	5/7/2004	Excluded – spring sample							Panelists called this a BCG level 5, which was in agreement with the model
WI	10015553	Sidney Creek	5/7/2004	Excluded – spring sample							Panelists called this a BCG level 4, the model called it a 5

Table H-4. Site information for ***coldwater macroinvertebrate calibration*** samples that were analyzed. Original class = the original classification information provided by each entity (per Section 2.1). Area = upstream watershed area. Land use (% Agr=% agricultural, % For= % forest, % Urb= % urban, % Wet= % wetland) is based on upstream catchment area. Mean July Temp (temperature) is based either on instantaneous measurements or on continuous measurements from temperature loggers. The MPCA human disturbance score is based on upstream land use (higher score=less disturbance).

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	Grad (m/km)	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cold	WI	10008018	-90.23950	43.01354	Cold Mainstem	8.6			Driftless Area	3.7	4.9	57.0			
Cold	WI	10009328	-89.66030	43.11297	Cold Mainstem	26.9			Driftless Area	1.4	29.1	25.2	1.9		
Cold	WI	10009920	-91.30936	46.47172	Cold Mainstem	20.4			Northern Lakes and Forests	1.9	0.0	93.6	1.2		
Cold	WI	10009965	-91.25661	43.96430	Cold Mainstem	29.9			Driftless Area	3.6	32.3	57.6	3.1		
Cold	WI	10010073	-90.27290	43.08550	Cool (Cold Transition) Ma	19.1			Driftless Area	1.0	5.6	39.7	0.1		
Cold	WI	10011185	-90.28675	43.67099	Cool (Cold Transition) Ma	60.8			Driftless Area	1.6	47.2	30.5	5.3		
Cold	WI	10012156	-91.12888	46.53457	Cold Mainstem	61.3			Northern Lakes and Forests	5.4					
Cold	WI	10015217	-89.79800	43.36220	Cold Mainstem	10.6			Driftless Area	2.2	10.3	70.1	0.3		
Cold	WI	10015410	-91.23763	46.75882	Cold Mainstem	9.0			Northern Lakes and Forests	12.3					
Cold	WI	10015553	-88.31880	45.66700	Cold Mainstem	14.7			Northern Lakes and Forests	4.5					
Cold	MN	04LM021	-92.10267	43.64877	Southern Coldwater	34.4	wadeable	16.3	Driftless Area	9.0	82.2	12.9	4.7	0.2	51.7
Cold	MN	04LM030	-91.39403	43.54944	Southern Coldwater	1.4	Headwater	10.4	Driftless Area	61.2	43.2	55.3	1.5		52.1

Table H-4. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	Grad (m/km)	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cold	MN	04LM058	-92.35264	43.70084	Southern Coldwater	18.6	wadeable		Driftless Area	10.1	86.1	2.6	11.1	0.1	30.1
Cold	MN	04LM068	-91.97659	44.00959	Southern Coldwater	52.2	River	18.9	Driftless Area	18.7	81.3	6.9	11.6		48.1
Cold	MN	04LM069	-91.86959	43.61076	Southern Coldwater	24.9	wadeable	14.1	Driftless Area	13.0	84.3	11.2	4.4	0.1	60.2
Cold	MN	04LM092	-91.47575	43.99201	Southern Coldwater	20.0	wadeable	17.9	Driftless Area	11.4	41.2	54.0	4.5	0.2	67.8
Cold	MN	04LM094	-91.60385	44.01932	Southern Coldwater	11.8	wadeable	15.5	Driftless Area	8.6	32.1	59.0	8.9		55.0
Cold	MN	04LM095	-91.80546	43.85259	Southern Coldwater	49.4	River	16.7	Driftless Area	6.6	79.0	17.2	3.6	0.1	53.4
Cold	MN	04LM098	-92.07231	43.89362	Southern Coldwater	8.9	wadeable	11.9	Driftless Area	8.8	76.7	16.6	6.6		59.5
Cold	MN	04LM099	-91.81293	43.99540	Southern Coldwater	4.0	Headwater	11.3	Driftless Area	42.8	75.7	19.3	5.0		62.7
Cold	MN	04LM104	-92.05579	44.14454	Southern Coldwater	9.8	wadeable	15.1	Driftless Area	26.4	70.2	26.5	3.0	0.3	64.2
Cold	MN	04LM117	-91.72749	43.58145	Southern Coldwater	32.9	wadeable	16.5	Driftless Area	10.0	84.4	9.3	6.2		44.4
Cold	MN	04LM128	-92.12069	44.00694	Southern Coldwater	5.5	Headwater	13.6	Driftless Area	9.4	91.1	3.7	5.0	0.2	42.5
Cold	MN	04LM129	-92.19545	43.84975	Southern Coldwater	31.3	wadeable	17.1	Driftless Area	7.3	82.6	10.4	6.9	0.1	39.3
Cold	MN	04LM138	-92.23971	44.42272	Southern Coldwater	5.1	Headwater	13.0	Driftless Area	16.4	62.8	34.1	3.2		68.0
Cold	MN	04LM144	-92.83290	44.56566	Southern Coldwater	15.1	wadeable	9.9	Driftless Area	20.5	92.2	2.1	5.6		49.8
Cold	MN	08LM011	-91.59352	43.79406	Southern Coldwater	73.6	River	18.9	Driftless Area	0.9	48.7	46.7	4.2	0.4	59.7
Cold	MN	08LM013	-92.29344	43.73835	Southern Coldwater	88.5	River	19.4	Driftless Area	3.0	83.8	9.1	6.9	0.1	42.2

Table H-4. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi²)	Size Class	Mean July Temp (°C)	L3 Ecoregion	Grad (m/km)	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cold	MN	08LM016	-91.85515	43.62052	Southern Coldwater	29.2	wadeable	15.2	Driftless Area	4.7	81.8	13.7	4.4	0.1	59.0
Cold	MN	08LM020	-92.22278	43.63574	Southern Coldwater	16.9	wadeable	14.1	Driftless Area	6.0	84.4	11.7	3.7	0.1	60.6
Cold	MN	08LM027	-92.19532	43.81013	Southern Coldwater	18.7	wadeable	16.8	Driftless Area	4.8	80.1	14.9	4.8	0.1	57.7
Cold	MN	08LM044	-91.91387	43.70737	Southern Coldwater	7.9	wadeable		Driftless Area	7.2	65.7	30.0	4.2		64.5
Cold	MN	08LM048	-91.98666	43.70384	Southern Coldwater	22.7	wadeable	13.1	Driftless Area	3.3	72.6	22.9	4.4	0.1	43.7
Cold	MN	08LM052	-91.88373	43.73711	Southern Coldwater	9.8	wadeable	13.8	Driftless Area	2.5	70.5	27.0	2.5		66.7
Cold	MN	08LM063	-91.88265	43.84090	Southern Coldwater	30.0	wadeable	16.0	Driftless Area	5.2	87.4	8.4	4.2		54.3
Cold	MN	08LM066	-91.68858	43.75241	Southern Coldwater	4.6	Headwater	11.3	Driftless Area	4.3	56.4	41.2	2.4		66.2
Cold	MN	08LM091	-91.35433	43.74440	Southern Coldwater	6.0	Headwater	15.2	Driftless Area	5.3	43.5	53.9	2.6		68.6
Cold	MN	08LM095	-91.48408	43.79345	Southern Coldwater	6.4	Headwater	15.9	Driftless Area	6.4	38.6	59.8	1.6		71.4
Cold	MN	08LM106	-91.57932	43.64167	Southern Coldwater	7.5	wadeable		Driftless Area	10.2	83.4	13.0	3.5		59.0
Cold	MN	08LM124	-93.19401	44.63278	Southern Coldwater	21.6	wadeable	14.7	Western Corn Belt Plains	1.7	50.5	13.3	30.7	1.6	54.7
Cold	MN	08LM135	-92.43277	44.48734	Southern Coldwater	45.9	River	17.5	Driftless Area	1.7	81.3	15.2	3.4	0.1	58.5

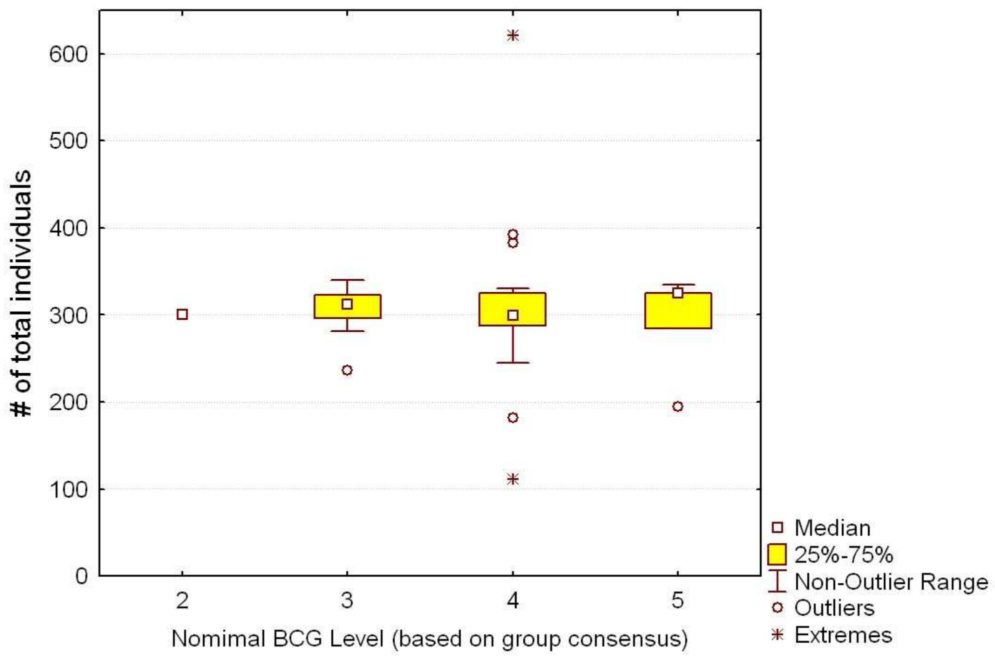

Figure H-1. Box plots of total number of individual metric values for coldwater macroinvertebrate samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 2 = 1, level 3 = 15, level 4 = 24, and level 5 = 5. One sample (extreme outlier – Station 10009328, Black Earth Creek, WI – 3151 total individuals) has been excluded from this plot.

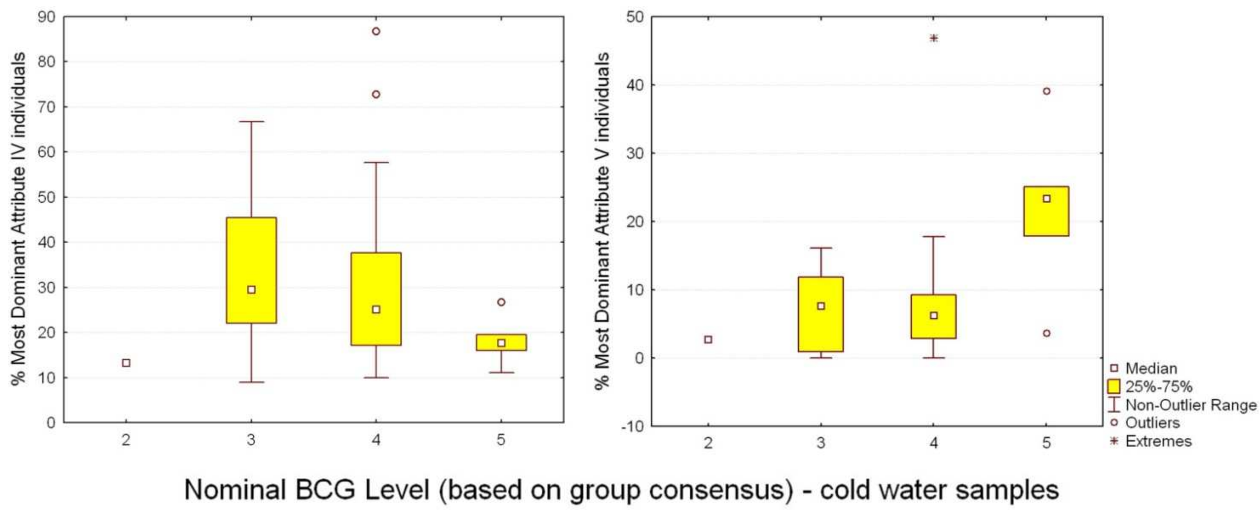

Figure H-2. Box plots of % dominant BCG attribute IV and V individual metrics for 45 coldwater macroinvertebrate samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 2 = 1, level 3 = 15, level 4 = 24, and level 5 = 5.

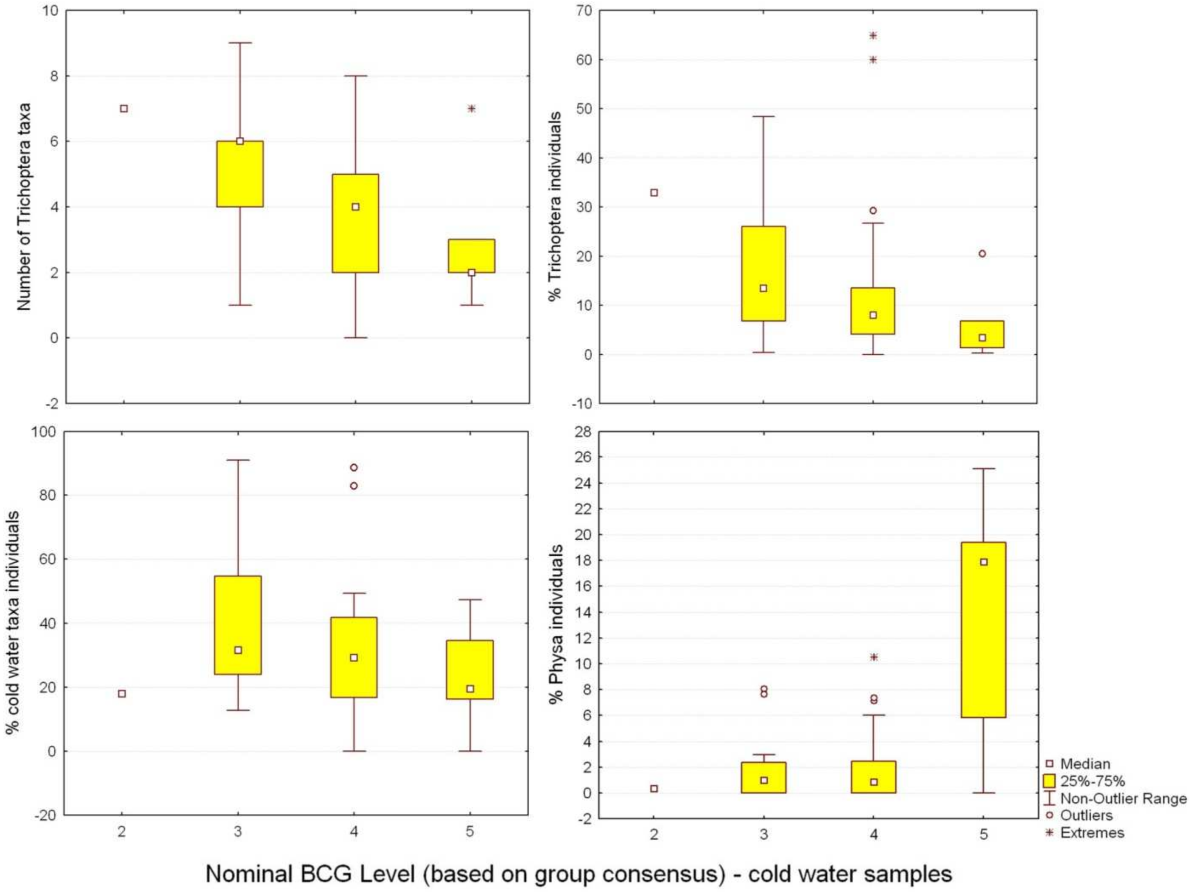

Figure H-3. Box plots of additional metrics for 45 coldwater macroinvertebrate samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 2 = 1, level 3 = 15, level 4 = 24, and level 5 = 5.

Table H-5. BCG level assignments and sample information for ***coldwater macroinvertebrate validation*** samples that were analyzed. BCG level assignments are as follows: Final=consensus BCG level (=the assignment made by the majority of participants), without the + or - (2+ and 2- were assigned to level 2, etc.); Final (+/-) = consensus BCG level using the scoring scale shown in Table G1; Worst=the worst BCG level assignment (based on the Table G1 scoring scale) given by a participant; Best= the best BCG level assignment given by a participant. Samples are highlighted in yellow if the consensus call from the panelists is different from the primary call from the model. Wisconsin samples with fewer than 100 individuals were excluded from the validation dataset.

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	04LM011	trib. to Forestville Creek	8/25/2004	4	4+	3+	4	4	4		Odd sample. Sand bottom? Lots of att 5 taxa (i.e. Physa). Hesperophylax seen as a positive.
MN	04LM097	Pine Creek	8/18/2004	4	4	4+	4-	4	4		Agreement with model was confirmed during Oct 31 call
MN	04LM132	Hay Creek	8/30/2004	3	3-	3	4	3	4		Bumped down due to high number of Att 4 individuals (i.e. Simulium)
MN	06SC055	Browns Creek	8/11/2006	3	3-	3+	4	3	3		Lots of Att 4 taxa
MN	07UM018	Sucker Creek	8/14/2007	4	4-	4	5	4	4		Warm? Low gradient?
MN	08LM027	Upper Bear Creek	8/20/2008	4	4	4+	4	4	4		High % Att 4 individs, lots of chiro individs
MN	08LM123	Vermillion River	8/28/2008	4	4	4+	4-	4	5		High number of Att 4 individuals
MN	08LM136	Wells Creek	8/19/2008	4	4+	3-	4	4	3		High number of Att 4 taxa, high number of Att 3 individuals
MN	99SC002	Browns Creek	9/23/2008	3	3	3+	3	3	2		Agreement with model was confirmed during Oct 31 call
MN	99SC006	Browns Creek	9/23/2008	3	3-	3+	4	3	4		High % of Att 4 taxa

Table H-5. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
WI	10007881	Big Spring Br	10/31/2001	**4**	4	4+	4	4	3	**tie 3/4**	Low velocity, sand and sedimentation. 50% dominance by G. pseudolimnaeus
WI	10008055	Lost Hollow Creek	11/17/2000	**2/3**	3+	2	3-	**2**	**2**		During the October 31 call, panelists gave this a consensus call of 2/3 (tie)
WI	10011918	Dodge Br	9/17/2004	**3**	3+	2-	3	**2**	2		Difference was confirmed during Oct 31 call. Could be marginally coldwater; good EPT
WI	10009029	North Branch Copper Creek	5/12/1994	Exclude – spring sample							Panelists called this a BCG level 3, so did the model
WI	10009512	Dougherty Creek	12/6/1988	5	5	5+	6	5	5		Strong stressor at work here. Very high numbers of Oligochaeta imply Tubificidae, and not the relatively intolerant ones.
WI	10009512	Dougherty Creek	4/7/1990	Exclude – spring sample							Panelists called this a BCG level 4, the model called it a 3
WI	10016703	Lawrence Creek	10/28/2003	4	4	3-	4	4	3	tie 3/4	Main consideration = number of Att 4 taxa and individuals
WI	223323	Sinsinawa River	10/26/1990	5	5	5	5+	5	4		Panelist call was revised to a 5 during the Oct 31 call

Table H-6. Site information for ***coldwater macroinvertebrate validation*** samples that were analyzed during the BCG ***validation*** exercise. Original class refers to the original classification information provided by each entity (for more information see Section 2.1). Area refers to the upstream watershed area. Land use (% Agr=% agricultural, % For= % forest, % Urb= % urban, % Wet= % wetland) is for the upstream catchment area. Mean July Temp (temperature) is based either on instantaneous measurements taken at the time of the biological sampling event or on continuous measurements from temperature loggers. The human disturbance score is calculated by MPCA based on upstream land use (higher score=less disturbance). Additional information (i.e. nutrient and habitat data) may available for some of the sites.

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cold	MN	04LM011	-92.24688	43.64185	Southern Coldwater	14.6	Wadable		Driftless Area	90.0	6.1	3.8		59.0
Cold	MN	04LM097	-91.86849	43.86318	Southern Coldwater	33.7	Wadable	17.8	Driftless Area	83.1	12.8	3.9	0.2	59.4
Cold	MN	04LM132	-92.56125	44.52187	Southern Coldwater	33.5	Wadable		Driftless Area	74.8	20.9	3.9	0.3	61.1
Cold	MN	06SC055	-92.84715	45.07331	Southern Coldwater	17.9	Wadable	19.0	North Central Hardwoods	55.5	23.5	7.0	6.0	62.8
Cold	MN	07UM018	-94.48056	45.05755	Southern Coldwater	13.3	Wadable	20.3	North Central Hardwoods	71.1	8.9	5.0	4.7	49.0
Cold	MN	08LM027	-92.19532	43.81013	Southern Coldwater	18.7	Wadable	16.8	Driftless Area	80.1	14.9	4.8	0.1	57.7
Cold	MN	08LM123	-93.16715	44.63009	Southern Coldwater	38.1	Wadable	19.9	Western Corn Belt Plains	74.4	14.9	5.9	3.9	46.0
Cold	MN	08LM136	-92.47359	44.46288	Southern Coldwater	33.4	Wadable		Driftless Area	82.8	13.7	3.4	0.1	58.5
Cold	MN	99SC002	-92.81014	45.07625	Southern Coldwater	28.5	Wadable		North Central Hardwoods	53.7	21.4	14.3	4.6	60.3
Cold	MN	99SC006	-92.84450	45.07106	Southern Coldwater	26.4	Wadable		North Central Hardwoods	53.7	21.7	13.5	4.7	59.8
Cold	WI	10007881	-90.46680	43.10070	Cool (Cold Transition) Ma	12.5			Driftless Area					

Table H-6. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cold	WI	10008055	-90.23572	43.40004	Cool (Cold Transition) Ma	3.3			Driftless Area					
Cold	WI	10011918	-89.97747	42.89609	Cool (Cold Transition) Ma	43.5			Driftless Area					
Cold	WI	10009029	-90.99881	43.31637	Cool (Cold Transition) Ma	14.2			Driftless Area					
Cold	WI	10009512	-89.79421	42.72181	Cool (Cold Transition) Ma	19.4			Driftless Area					
Cold	WI	10016703	-89.59862	43.89792	Cold Mainstem	16.8			North Central Hardwoods					
Cold	WI	223323	-90.47985	42.54723	Cool (Cold Transition) Ma	19.0			Driftless Area					

APPENDIX I

Cold-cool transitional BCG Level Assignments - Fish

Appendix I. Participants made BCG level assignments on cold-cool transitional fish samples during a workshop in LaCrosse, WI (May 26-27, 2010) and a webinar (November 18, 2010). Samples were assessed using the scoring scale shown in Table I1. Participants that made BCG level assignments during each exercise are listed in Table I2.

Table I1. Scoring scale that was used for making BCG level assignments.

best	1
	1-
	2+
	2
	2-
	3+
	3
	3-
	4+
	4
	4-
	5+
	5
	5-
	6+
	6
worst	6-

Table I2. List of participants that made BCG level assignments during each exercise.

Name	Affiliation	LaCrosse workshop	Nov. 18 Webinar	Follow up calls
John Sandberg	MPCA	x	x	x
Mike Feist	MPCA	x	x	x
Scott Niemela	MPCA	x	x	x
Daniel Helwig	MPCA		x	
Kevin Goodwin	MDRNE	x	x	x
Lizhu Wang	MDRNE	x	x	
Michael Miller	WDNR	x	x	x
Nancy Schuldt	Fond du Lac	x		
Ed Hammer	EPA Region 5	x		x
Betsy Nightingale	EPA Region 5	x	x	
Chris Yoder	MBI		x	
Stephanie Ogren	LRBOI			x
James Snitgen	Oneida Nation			x

Table I-3. BCG level assignments and sample information for ***cold-cool transitional fish calibration samples*** that were analyzed. BCG level assignments are as follows: Final=consensus BCG level (=the assignment made by the majority of participants), without the + or - (2+ and 2- were assigned to level 2, etc.); Final (+/-) = consensus BCG level using the scoring scale shown in Table I1; Worst=the worst BCG level assignment (based on the Table I1 scoring scale) given by a participant; Best= the best BCG level assignment given by a participant. Samples are highlighted in yellow if the consensus call from the panelists is different from the primary call from the model. The sample from StationID 10011836 – Sudan Br (WI) was excluded due to the oddness of the assemblage.

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
Fond du Lac	203B	Martin Branch (Stevens Rd.)	7/17/2009	2	2+	2+	2+	2	2		only brook trout present (and in good numbers).
Fond du Lac	204A	Otter Creek (Station 1)	6/10/1999	2	2-	3-	2	2	1		
Fond du Lac	204A	Otter Creek (Station 1)	7/16/2009	**3**	3+	3+	2-	**2**	3	tie 2/3	Panelists tied between 2 and 3
Fond du Lac	205	Simian Creek Station 1	7/3/2002	4	4+	4	3-	4	4		
Fond du Lac	207A	Stoney Brook Station 1	7/18/2000	4	4	4-	3-	4	3		
MI	carpr113	943	9/1/1999	3	3-	4+	3	3	3		
MI	carpr151	1243	8/1/1983	3	3-	3-	3	3	3		
MI	grand2578	336	7/1/1996	4	4-	5	3-	4	5		
MI	grand3018	1453	8/1/1990	5	5+	5	4	5	5		
MI	grand3199	1458	9/1/1991	4	4	4-	4	4	4		
MI	kalam837	1	8/1/1999	3	3	3-	3+	3	4		
MI	kalam986	81	8/1/1999	3	3-	4	3	3	3		
MI	manis618	431	7/1/2001	2	2	2	2+	2	2		
MI	perem568	396	10/1/1996	2	2	2-	2+	2	2		only one species (brook trout) present.
MI	sagin257	568	8/1/2001	**4**	3-	4	3+	**3**	3		Panelists split between 3 and 4. changed to 4 from 3 during Feb 10 call

Table I-3.continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MI	sagin257	571	8/1/1997	3	3-	4-	3+	3	3		
MI	thund289	1605	7/1/2004	4	4	4-	3-	4	5		
MI	carpr121	Carp Riv	7/4/2009	2	2	3	2+	2	2		
MI	grand2030	Rush Cre	7/4/2009	5	5	5	5	5	5		could be misclassified; looks like warmwater assemblage; known impairments though
MI	grand594	Cedar Cr	7/4/2009	2	2	2-	2	2	3		
MI	maniq318	Little I	7/4/2009	3	3	3-	3	3	3		
MI	choco322	1041	11/1/1988	**3**	3+	3	2+	**2**	2		panelists tied between 2 & 3, low numbers
WI	10010418	Pike River	9/9/2003	5	5	5-	5	5	5		
WI	10016775	Neenah Creek	9/11/2007	3	3	4-	3+	3	3		assessed twice (LaCrosse & Nov 18 webinar) - this is the consensus call from Nov 18
MN	05RN042	Dumbbell River	8/18/2005	**4**	4-	5	4	**5**	5		confirmed coldwater status - DNR said it had brook trout reproduction in the 1980's
MN	06LS002	East Branch Split Rock	7/27/2006	2	2	3	2+	2	3		could be misclassified; may be a better fit in MN as a coolwater (not sfc cold)? In-between
MN	07UM071	Little Rock Creek	8/12/2008	4	5	5	5+	4	4		changed from 5 to 4 during Feb 10 call
MN	07UM073	Little Rock Creek	7/24/2007	5	5	5-	3-	5	5		

Table I-3.continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	08RN021	Venning Creek	6/18/2008	3	3+	3	2-	3	2		could be misclassified; thermally impaired? Or warmwater?
MN	08RN042	Stony Brook	7/9/2008	3	3+	3	2	3	2		
MN	82UM001	Little Rock Creek	8/12/2008	5	5+	5+	4-	5	4		
MN	92UM001	Little Rock Creek	8/13/2008	5	5+	5	4	5	5		
MN	97LS056	Schoolhouse Creek	7/8/1997	2	2-	2-	2	2	2		
MN	97LS058	East Branch Beaver River	7/10/1997	3	3	3	3+	3	2	almost a tie	
MN	97LS074	Greenwood River	8/26/1997	2	1-	2-	1-	2	2		changed from 1 to 2 during Feb 10 call because brown trout are present; Brook nonnative: can it be a 1?
MN	97LS112	trib. to Midway River	7/1/2009	2	2	3+	1-	2	2		
MN	99LS002	Little Devil Track River	8/2/1999	2	2-	3+	2-	2	2		sample collected by DNR
MN	99LS003	Little Devil Track River	7/28/1999	2	2-	3	2	2	2		sample collected by DNR
MN	99LS007	Stewart River	8/27/1999	2	2-	3-	2	2	2		rainbows >> brooks but BOTH are non-native. rainbow > brook, brook not native. Sampled collected by DNR
MN	99NF094	Irish Creek	7/27/1999	2	2	3	1-	2	2		

Table I-3.continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	99NF120	Dark River	8/3/1999	4	4+	4+	3-	4	4		assessed twice (LaCrosse & Nov 18 webinar) - consensus calls were in agreement
MN	99NF120	Dark River	6/17/2008	3	3	3	2	3	2		

Table I-4. Site information for ***cold-cool transitional fish calibration samples*** that were analyzed. Original class = the original classification information provided by each entity (per Section 2.1). Area = upstream watershed area. Land use (% Agr=% agricultural, % For= % forest, % Urb= % urban, % Wet= % wetland) is based on upstream catchment area. Mean July Temp (temperature) is based either on instantaneous measurements or on continuous measurements from temperature loggers. The MPCA human disturbance score is based on upstream land use (higher score=less disturbance). The sample from StationID 10011836 – Sudan Br (WI) was excluded due to the oddness of the assemblage.

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	Fond du Lac	205	-92.51333	46.80417	Cool water	22		21.1	Northern Lakes and Forests	0.9	37.2	0.2	34.4	
Cool	WI	10010418	-87.82491	42.63918	Cool (Cold Transition) Ma				Central Corn Belt Plains					
Cool	WI	10016775	-89.57378	43.76367	Cool (Cold Transition) Ma	37.3			North Central Hardwoods	25.1	52.4	6.2		
Cool	MN	05RN042	-91.19887	47.71634	Northern Coldwater	31.9	Wadable		Northern Lakes and Forests	0.1	88.2	0.2	7.5	79.1
Cool	MN	06LS002	-91.55034	47.33197	Northern Coldwater	2.5	Headwater	18.9	Northern Lakes and Forests		92		7.7	80.8
Cool	MN	07UM071	-94.2016	45.82946	Northern Coldwater	35.1	Wadable	18.4	North Central Hardwoods	77.2	8	3.5	11.2	55.3
Cool	MN	07UM073	-94.19852	45.77411	Northern Coldwater	66.1	River		North Central Hardwoods	79.4	8	3.4	9.1	50.2
Cool	MN	08RN021	-93.23222	47.72166	Northern Coldwater	12.8	Wadable	18.8	Northern Lakes and Forests	1.8	86.9	1.6	9	78.7
Cool	MN	08RN042	-93.0772	47.77682	Northern Coldwater	12	Wadable	18.7	Northern Minnesota Wetlands	2.1	86	0.7	9.2	78.9

Table I-4. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	Fond du Lac	203B	-92.68056	46.83556	Cold water				Northern Lakes and Forests					
Cool	Fond du Lac	204A	-92.48139	46.66389	Cold water			20.6	Northern Lakes and Forests					
Cool	Fond du Lac	207A	-92.59417	46.86722	Cool water				Northern Lakes and Forests					
Cool	MN	82UM001	-94.20729	45.81859	Northern Coldwater	42.2	Wadable	18.5	North Central Hardwoods	77.6	7.8	3.4	11.2	
Cool	MN	92UM001	-94.1898	45.79921	Northern Coldwater	62.5	River	17	North Central Hardwoods	80.2	7.4	3.4	9	
Cool	MN	97LS056	-91.17221	47.46498	Northern Coldwater	2.5	Headwater		Northern Lakes and Forests	0.1	99.8		0.1	81
Cool	MN	97LS058	-91.39846	47.38202	Northern Coldwater	18.4	Wadable		Northern Lakes and Forests	0.2	91.7	0.1	7.7	80.6
Cool	MN	97LS074	-90.14322	47.93301	Northern Coldwater	21.2	Wadable		Northern Lakes and Forests	0.1	80.5	0.3	1.1	80.5
Cool	MN	97LS112	-92.296	46.76356	Northern Coldwater	8.9	Wadable	17.1	Northern Lakes and Forests	19.8	71.1	5.6	3.2	
Cool	MN	99LS002	-90.32835	47.78575	Northern Coldwater	7.3	Headwater	16.5	Northern Lakes and Forests	0.6	94.6	1.5	0.4	76.8

Table I-4. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	MN	99LS003	-90.38028	47.78765	Northern Coldwater	2	Headwater	18.9	Northern Lakes and Forests	0.2	97.6	0.1	0.2	78.6
Cool	MN	99LS007	-91.71064	47.07266	Northern Coldwater	21.5	Wadable	18.3	Northern Lakes and Forests	1.8	93	0.8	2.3	78.3
Cool	MN	99NF094	-89.98977	47.93486	Northern Coldwater	9.2	Wadable		Northern Lakes and Forests	0.3	97.1	0.3	1.8	78.6
Cool	MN	99NF120	-92.85007	47.7039	Northern Coldwater	57.7	River	18.2	Northern Minnesota Wetlands	0.6	67.1	1	4.4	70.3
Cool	MI	carpr113	-84.62334	46.11124	Cold transitional stream	5.9	Stream		Northern Lakes and Forests		57.4	1.5	34.6	
Cool	MI	carpr121	-84.98703	46.10103	Cold transitional stream	27.1	Stream		Northern Lakes and Forests	0.4	28.2	1.1	57.6	
Cool	MI	carpr151	-84.86141	46.06043	Cold transitional stream	73	Stream		Northern Lakes and Forests	0.8	30.2	0.8	60.9	
Cool	MI	choco322	-86.95252	46.39343	Cold transitional stream	8.7	Stream		Northern Lakes and Forests		76.7		22.4	
Cool	MI	grand2030	-85.79518	42.8973	Cold transitional stream	24.2	Stream		Southern Michigan/Northern Indiana Drift Plains	41.9	12.8	32.7	2.4	

Table I-4. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	MI	grand2578	-84.9685	42.80592	Cold transitional stream	28.7	Stream		Southern Michigan/Northern Indiana Drift Plains	74.6	11.2	4	7.3	
Cool	MI	grand3018	-85.39046	42.61724	Cold transitional stream	16.5	Stream		Southern Michigan/Northern Indiana Drift Plains	16.3	53.2	2.5	14.9	
Cool	MI	grand3199	-85.2761	42.54666	Cold transitional stream	23	Stream		Southern Michigan/Northern Indiana Drift Plains	37.9	29.4	3.6	16.7	
Cool	MI	grand594	-85.61488	43.16738	Cold transitional stream	25.5	Stream		Southern Michigan/Northern Indiana Drift Plains	51.3	20	9.8	11	
Cool	MI	kalam837	-85.29877	42.36008	Cold transitional stream	16.1	Stream		Southern Michigan/Northern Indiana Drift Plains	39	32.3	3.7	17.2	
Cool	MI	kalam986	-84.96021	42.26531	Cold transitional small r	96.3	Small		Southern Michigan/Northern Indiana Drift Plains	55.8	15.8	4.4	17.6	
Cool	MI	maniq318	-86.52104	46.19045	Cold transitional stream	22.4	Stream		Northern Lakes and Forests		79.7	1.3	13.6	

Table I-4. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	MI	manis618	-85.77558	44.05179	Cold transitional stream	1.8	Stream		Southern Michigan/Northern Indiana Drift Plains	0.1	84.5	1.7	7.6	
Cool	MI	perem568	-85.88073	43.67752	Cold transitional stream	3.3	Stream		Southern Michigan/Northern Indiana Drift Plains		87.5	0.3	10.7	
Cool	MI	sagin257	-84.5763	44.0275	Cold transitional stream	28.2	Stream		Northern Lakes and Forests	7.6	63.3	1.3	12.7	
Cool	MI	thund289	-83.90031	44.92663	Cold transitional stream	10.1	Stream		Northern Lakes and Forests	0.7	67.7	0.1	12.1	

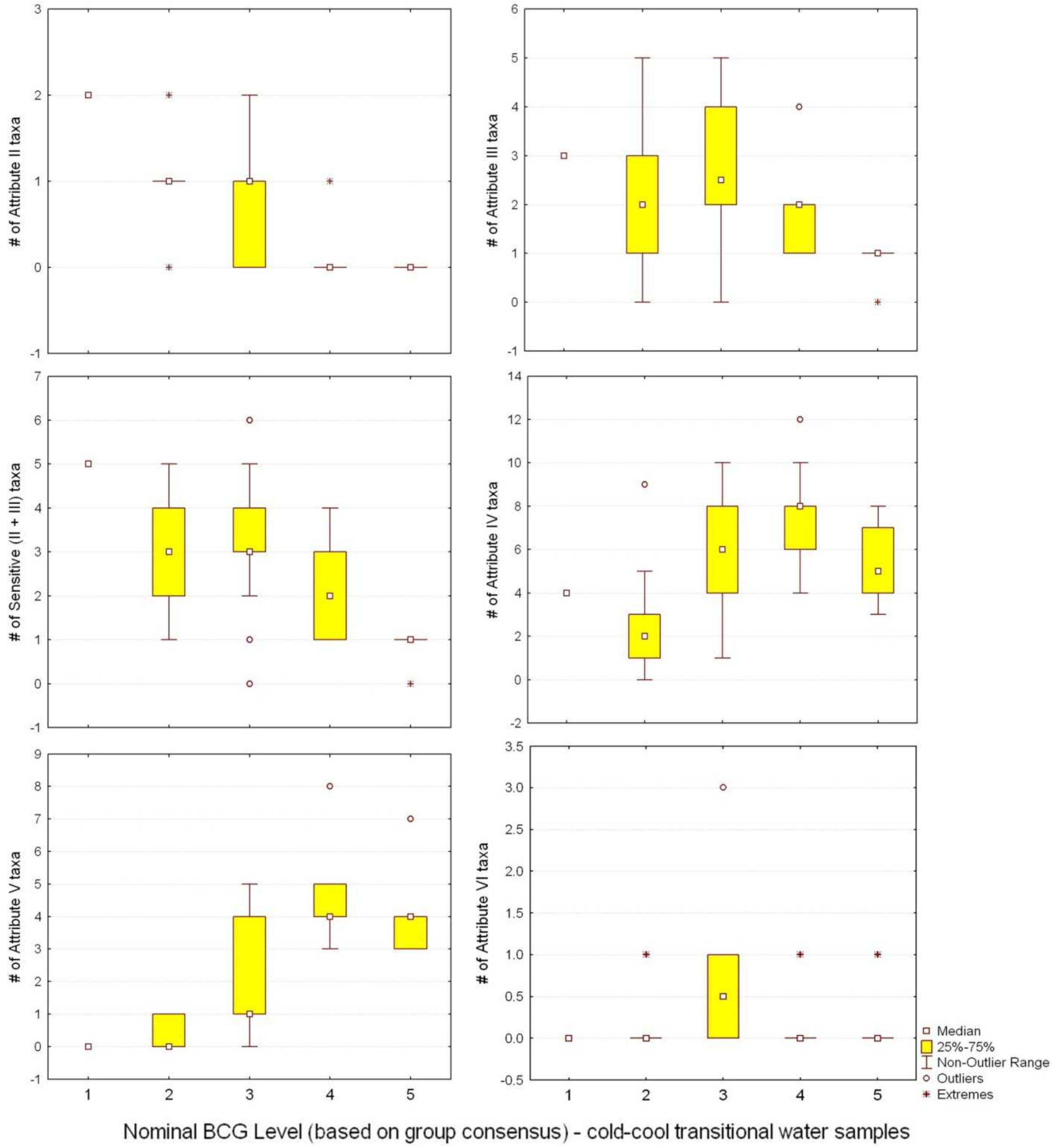

Figure I-1. Box plots of BCG attribute II-VI richness metrics for 44 cold-cool transitional fish samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 1 = 1, level 2 = 13, level 3 = 14, level 4 = 9, and level 5 = 7.

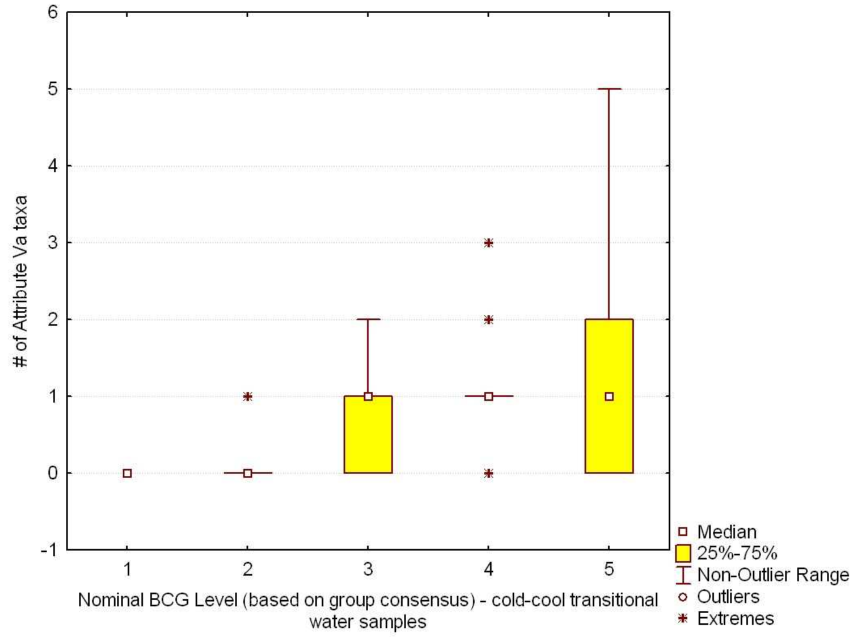

Figure I-2. Box plots of BCG attribute Va richness metric values for 44 cold-cool transitional fish samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 1 = 1, level 2 = 13, level 3 = 14, level 4 = 9, and level 5 = 7.

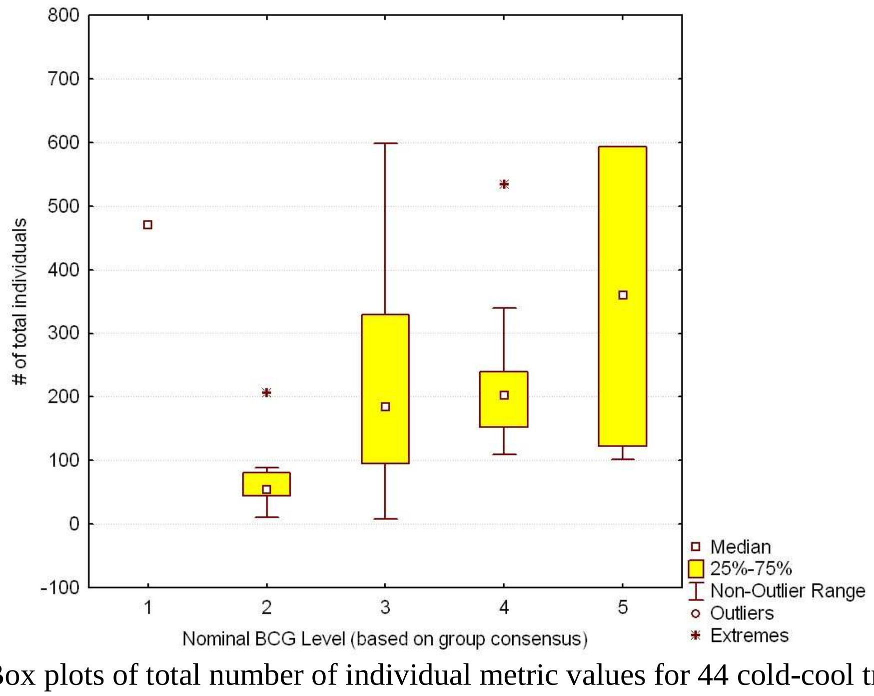

Figure I-3. Box plots of total number of individual metric values for 44 cold-cool transitional fish samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 1 = 1, level 2 = 13, level 3 = 14, level 4 = 9, and level 5 = 7.

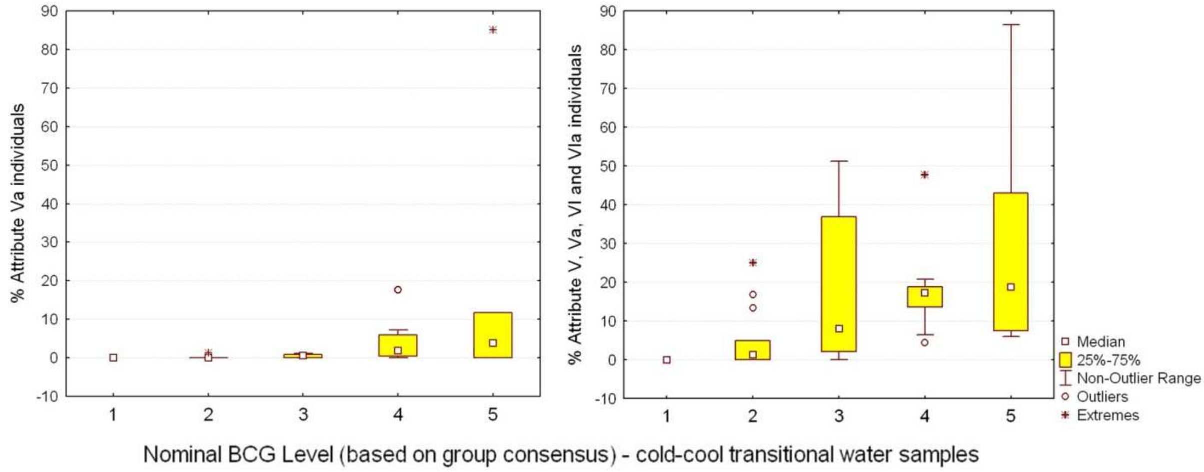

Figure I-4. Box plots of BCG attribute Va and V-VIa percent individual metric values for 44 cold-cool transitional fish samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 1 = 1, level 2 = 13, level 3 = 14, level 4 = 9, and level 5 = 7.

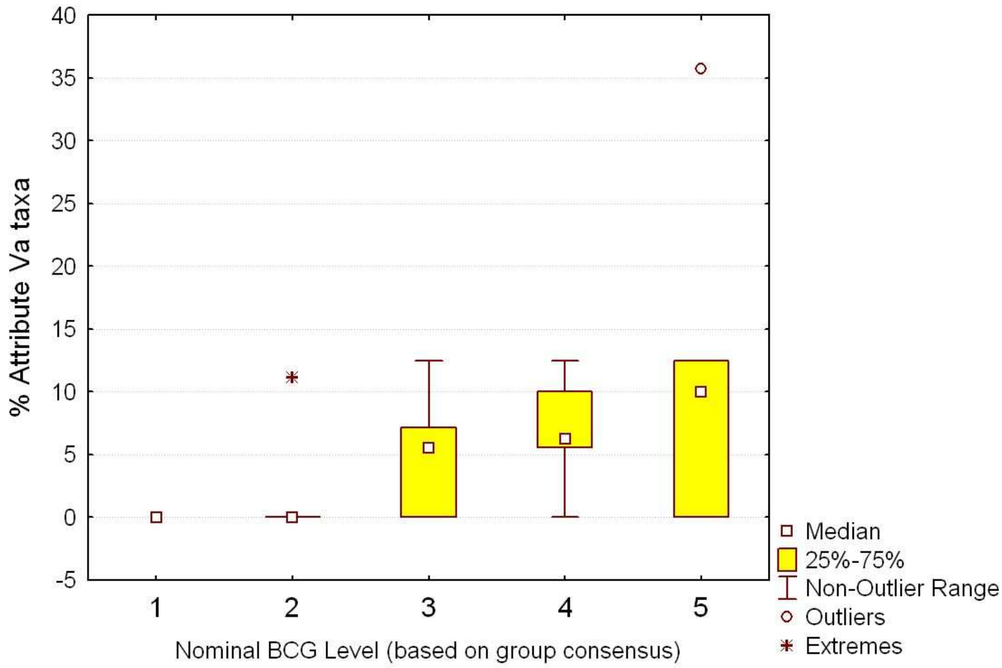

Figure I-5. Box plots of BCG attribute Va percent taxa metric values for 44 cold-cool transitional fish samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 1 = 1, level 2 = 13, level 3 = 14, level 4 = 9, and level 5 = 7.

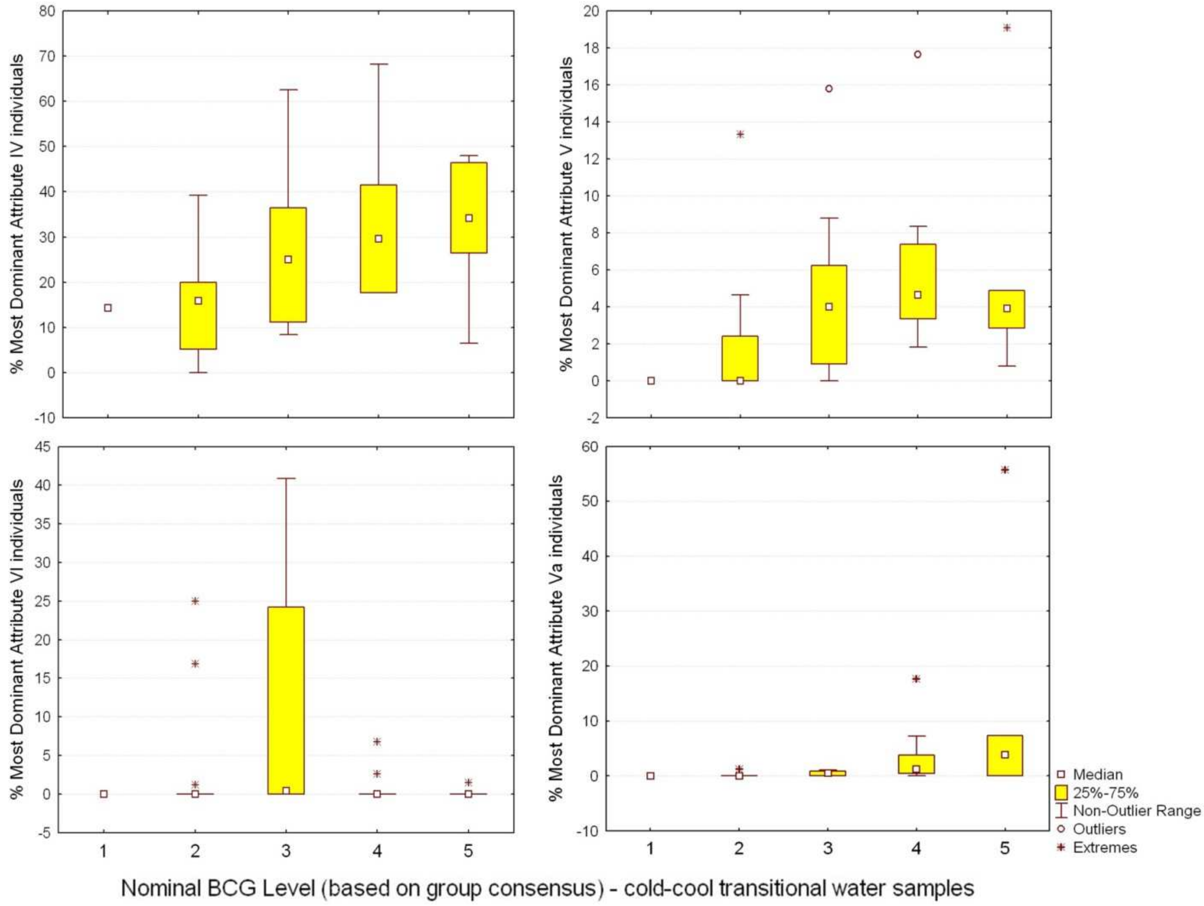

Figure I-6. Box plots of % dominant BCG attribute IV, V, Va and VI individual metrics for 44 cold-cool transitional fish samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 1 = 1, level 2 = 13, level 3 = 14, level 4 = 9, and level 5 = 7.

Table I-5. BCG level assignments and sample information for ***cold-cool transitional fish validation samples*** that were analyzed. BCG level assignments are as follows: Final=consensus BCG level (=the assignment made by the majority of participants), without the + or - (2+ and 2- were assigned to level 2, etc.); Final (+/-) = consensus BCG level using the scoring scale shown in Table G1; Worst=the worst BCG level assignment (based on the Table G1 scoring scale) given by a participant; Best= the best BCG level assignment given by a participant. Samples are highlighted in yellow if the consensus call from the panelists is different from the primary call from the model.

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
Fond du Lac	203A	Martin Branch (Marshall Rd.)	8/10/1999	5	5	5-	4-	5	5		
Fond du Lac	203A	Martin Branch (Marshall Rd.)	7/17/2009	**5**	5	5	5	**3**	**4**	3/4	Original consensus=3; changed to 5 during Nov 14 call
Fond du Lac	203B	Martin Branch (Stevens Rd.)	7/21/2004	2	2+	2-	1	2	2		missclassified? Could be coldwater stream
Fond du Lac	204A	Otter Creek (Station 1)	7/17/2003	**4**	4	5	3+	**3**	3		low numbers of fish; no trout
MI	choco381	955	8/1/1999	**4**	4	4	4	**4**	4		Original consensus=3; changed to 4 during Nov 14 call; this type of sample is unique to MI
MI	clint362	825	8/1/2001	3	3-	4	3	3	3		
MI	galie121	1405	7/1/1987	**5**	5+	5	4	**4**	4		abundance seems low for catchment size
MI	grand1142	1433	3/1/1991	5	5	5-	4-	5	5		
MI	stjom208	221	7/1/1999	3	3	4-	3+	3	3		
MI	tahqu172	1071	7/1/1998	**1**	1-	2	1	**2**	2		Confirmed panelist rating during Nov 14 call
MI	ausab749	Robinson	7/4/2009	2	2-	3	2-	2	3		
MI	chebo469	Black Ri	7/4/2009	3	3	3-	2	3	2		low numbers of fish for a stream this size
MI	grand1998	Unnamed	7/4/2009	2	2	2-	2	2	2		
MN	07SC007	Mission Creek	7/11/2007	5	5	5	4	5	5		wetland-influenced stream?
MN	97LS023	East Swan River	8/6/1997	4	4-	5+	3+	4	4		possibly misclassed - doesn't seem like a cold/cool water stream (i.e. large mouth bass are present)

Table I-5. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	97LS038	East Branch Amity Creek	7/2/1997	2	2	3+	2+	2	2		
MN	97LS057	Cross River	8/5/1997	**3**	3	3-	3	**2**	1		Confirmed panelist rating during Nov 14 call; some called it borderline 2/3
MN	98LS001	Miller Creek	6/29/1998	3	4+	4+	3	3	2		During Nov 14 call, panelists called this a ¾ (learning towards 3); previously they had called it a 4
MN	98LS036	Assinika Creek	8/4/1998	**2**	2	2-	2	**2**	2		During Nov 14 call, panelists called this a 2; previously they had called it a 3
MN	98LS041	Portage Brook	8/5/1998	**3**	3	4-	2-	**2**	3		
MN	99UM058	Little Rock Creek	7/15/1999	5	5	5-	4-	5	5		either nice wetland or degraded cool (assigned based on latter)
WI	10009265	Evergreen River	7/24/2001	**2**	2-	3+	2	**3**	2		Panelists confirmed this assignment during the Nov 14 call
WI	10010404	Pike River	8/26/2003	5	5	6+	5+	5	5		
WI	10028958	Tagatz Creek	6/26/2008	**2**	2-	4	2	**1**	1		
WI	243028	Belle Fountain Creek	7/7/2008	5	5-	6	5	5	5		very skewed assemblage - predators driving system

Table I-6. Site information for ***cold-cool transitional fish samples*** that were analyzed during the BCG ***validation*** exercise. Original class refers to the original classification information provided by each entity (for more information see Section 2.1). Area refers to the upstream watershed area. Land use (% Agr=% agricultural, % For= % forest, % Urb= % urban, % Wet= % wetland) is for the upstream catchment area. Mean July Temp (temperature) is based either on instantaneous measurements taken at the time of the biological sampling event or on continuous measurements from temperature loggers. The human disturbance score is calculated by MPCA based on upstream land use (higher score=less disturbance). Additional information (i.e. nutrient and habitat data) may available for some of the sites.

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	Fond du Lac	203A	-92.63944	46.83944	Cold water	7.38		20.6	Northern Lakes and Forests	0.0	48.8	0.1	10.2	
Cool	Fond du Lac	203A	-92.63944	46.83944	Cold water	7.38		20.6	Northern Lakes and Forests	0.0	48.8	0.1	10.2	
Cool	Fond du Lac	203B	-92.68056	46.83556	Cold water	2.26			Northern Lakes and Forests					
Cool	Fond du Lac	204A	-92.48139	46.66389	Cold water	18.53		20.6	Northern Lakes and Forests					
Cool	MI	choco381	-86.85025	46.38530	Cold transitional small r	85.30	Small		Northern Lakes and Forests	8.8	61.6	1.8	20.3	
Cool	MI	clint362	-83.14363	42.68976	Cold transitional stream	65.70	Stream		Southern Michigan/Northern Indiana Drift Plains	18.4	31.5	14.0	14.8	
Cool	MI	galie121	-86.65729	41.76230	Cold transitional stream	23.98	Stream			44.5	19.7	4.0	5.4	
Cool	MI	grand1142	-85.62912	43.06248	Cold transitional stream	3.65	Stream		Southern Michigan/Northern Indiana Drift Plains	27.0	26.7	20.8	9.5	
Cool	MI	stjom208	-86.24477	42.17508	Cold transitional stream	5.36	Stream		Southern Michigan/Northern Indiana Drift Plains	77.5	7.8	3.1	8.4	
Cool	MI	tahqu172	-85.67178	46.36447	Cold transitional stream	2.22	Stream		Northern Lakes and Forests		26.5		73.5	

Table I-6. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	MI	ausab749	-84.58657	44.45076	Cold transitional stream	18.22	Stream		Northern Lakes and Forests	0.3	42.5	2.3	45.5	
Cool	MI	chebo469	-84.35445	45.13433	Cold transitional stream	60.49	Stream		Northern Lakes and Forests	3.2	63.0	0.9	25.4	
Cool	MI	grand1998	-85.38509	42.92595	Cold transitional stream	4.68	Stream		Southern Michigan/Northern Indiana Drift Plains	28.7	46.1	6.7	6.9	
Cool	MN	07SC007	-92.92678	45.99222	Northern Coldwater	5.44	Headwater	18.0	North Central Hardwoods	49.1	19.5	16.1	15.3	60.7
Cool	MN	97LS023	-92.84359	47.29747	Northern Coldwater	113.64	River		Northern Lakes and Forests	11.2	48.1	9.8	18.1	53.5
Cool	MN	97LS038	-92.04736	46.86397	Northern Coldwater	7.55	Wadable		Northern Lakes and Forests	8.1	83.0	7.1	1.6	71.5
Cool	MN	97LS057	-90.97374	47.62242	Northern Coldwater	63.86	River		Northern Lakes and Forests	0.3	84.8	0.3	3.5	80.3
Cool	MN	98LS001	-92.16534	46.80852	Northern Coldwater	6.54	Headwater	19.5	Northern Lakes and Forests	3.8	53.5	40.8	1.6	37.1
Cool	MN	98LS036	-90.20363	47.94434	Northern Coldwater	13.41	Wadable		Northern Lakes and Forests	0.4	91.6	0.5	6.2	79.0
Cool	MN	98LS041	-90.02968	48.00337	Northern Coldwater	13.76	Wadable		Northern Lakes and Forests	0.2	91.2	0.5	1.7	78.5
Cool	MN	99UM058	-94.14607	45.87264	Northern Coldwater	12.08	Wadable		North Central Hardwoods	79.5	8.5	3.5	8.5	53.7
Cool	WI	10009265	-88.79552	45.12763	Cool (Cold Transition) Ma	29.00			North Central Hardwoods					
Cool	WI	10010404	-87.82421	42.65350	Cool (Cold Transition) Ma	41.42			Central Corn Belt Plains					

Table I-6. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	WI	10028958	-89.49373	43.95610	Cool (Cold Transition) Ma	16.77			North Central Hardwoods					
Cool	WI	243028	-89.21301	43.69927	Cool (Cold Transition) Ma	39.75			Southeastern Wisconsin Till Plains					

APPENDIX J

Cold-cool transitional BCG Level Assignments - Macroinvertebrates

Appendix J. Participants made BCG level assignments on cold-cool transitional macroinvertebrate samples during a workshop in LaCrosse, WI (May 26-27, 2010) and a webinar (November 19, 2010). Samples were assessed using the scoring scale shown in Table J1. Participants that made BCG level assignments during each exercise are listed in Table J2.

Table J1. Scoring scale that was used for making BCG level assignments.

best	1
	1-
	2+
	2
	2-
	3+
	3
	3-
	4+
	4
	4-
	5+
	5
	5-
	6+
	6
worst	6-

Table H2. List of participants that made BCG level assignments during each exercise.

Name	**Affiliation**	**LaCrosse workshop**	**Nov. 19 Webinar**
Will Bouchard	MPCA	x	x
Joel Chirhart	MPCA	x	x
John Genet	MPCA		x
Kevin Stroom	MPCA		x
Benjamin Lundeen	MPCA		x
Kari Hedin	Fond du Lac	x	
Stephanie Ogren	LRBOI		x
James Snitgen	Oneida Nation		x
Jeffrey Dimick	University of Wisconsin - Stevens Point	x	
Kurt Schmude	University of Wisconsin - Superior	x	x
Betsy Nightingale	EPA Region 5		x
Kayla Bowe	RLDNR	x	

Table J-3. BCG level assignments and sample information for ***cold-cool transitional macroinvertebrate calibration*** samples that were analyzed. BCG level assignments are as follows: Final=consensus BCG level (=the assignment made by the majority of participants), without the + or **-** (2+ and 2- were assigned to level 2, etc.); Final (+/-) = consensus BCG level using the scoring scale shown in Table J1; Worst=the worst BCG level assignment (based on the Table J1 scoring scale) given by a participant; Best= the best BCG level assignment given by a participant. Samples are highlighted in yellow if the consensus call from the panelists is different from the primary call from the model.

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
Fond du Lac	202B	Fond du Lac Creek Station 2	6/2/1999	2	2-	3	3	2	2	tie 2/3	sample from same site/different collection date also assessed.
Fond du Lac	202B	Fond du Lac Creek Station 2	10/23/2007	2	2-	3 +	3 +	2	2		sample from same site/different collection date also assessed.
Fond du Lac	205	Simian Creek Station 1	6/29/1999	3	3-	4 +	4 +	3	3		
Fond du Lac	204A	Otter Creek (Station 1)	10/30/2008	3	3-	3 -	3 -	3	4	almost a tie	
Fond du Lac	207B	Stoney Brook Station 2	5/29/2008	Excluded – spring sample							Panelist and model calls=3
Fond du Lac	207B	Stoney Brook Station 2	10/29/2008	3	3-	4 +	4 +	3	4		samples from same site/different collection date also assessed.
Fond du Lac	207B	Stoney Brook Station 2	5/14/2002	Excluded – spring sample							Panelist and model calls=3
WI	10028940	North Branch Pike River	9/10/2008	2	2	3	3	2	3		sample from same site/different collection date also assessed.

Table J-3. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
WI	10028940	North Branch Pike River	5/13/1992	Excluded – spring sample							Panelist and model calls=4
WI	10007964	Becky Creek	11/13/2008	3	3	4 +	2 -	3	3		Formerly classified as coldwater. Assessed twice - LaCrosse assigment = 3; Webinar assignment = 3
MN	05RN003	West Two River	8/8/2005	4	4	4 -	4 +	4	5		
MN	05RN042	Dumbbell River	8/9/2005	5	5	5 -	4 -	5	6	close	May be low gradient. Gradient = 0.7097 m/km.
MN	05RN072	Little Isabella River	8/10/2005	3	3	4	3 +	3	3		
MN	05RN073	Mitawan Creek	8/10/2005	3	3	3 -	4 +	3	3		
MN	07SC007	Mission Creek	8/2/2007	**4**	4-	5 +	4	**5**	6		Prior to Nov 2012 changes, model had been matching panelist call (level 4)
MN	07UM072	Little Rock Creek	8/7/2007	4	4	5	3 -	4	3	tie 4/3	
MN	08RN021	Venning Creek	8/5/2008	4	4	5	2	4	5		Asssessed twice - assigned to BCG level 4 both times
MN	97LS011	tributary to Lake Superior	9/5/1997	**2**	2-	3	3	**3**	2	close	
MN	97LS055	Beaver River	9/23/1997	3	3	3 -	3 -	3	2		
MN	97LS056	Schoolhouse Creek	9/9/1997	2	2	2 -	2 -	2	2		

Table J-3. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	97LS059	West Branch Baptism River	9/9/1997	3	3-	4	4	3	4		
MN	97LS060	Cascade River	9/15/1997	3	3	3 -	3 -	3	2	tie 3/2	
MN	97LS073	Little Devil Track River	9/4/1997	2	2	3	3	2	2		
MN	97LS075	Heartbreak Creek	9/2/1997	2	2-	3	3	2	2		samples from same site/different collection date also assessed.
MN	97LS075	Heartbreak Creek	9/16/2004	2	2	3	2	2	2		Assessed twice - assigned to BCG level 2+ in LaCrosse and level 2 during Nov19 webinar; samples from same site/different collection date also assessed.
MN	97LS078	Caribou River	9/9/1997	2	2	3	2 -	2	2		Assessed twice - assigned to BCG level 2 in LaCrosse and to level 2- during Nov19 webinar
MN	97LS087	Nemadji River	9/18/1997	3	3	3	3	3	3		
MN	97LS089	Big Sucker Creek	9/10/1997	2	2-	3	3	2	2		
MN	98LS003	Kingsbury Creek	9/14/1998	**5**	5+	5	5	**4**	5		

Table J-3. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	98LS004	Amity Creek	9/14/1998	2	2-	3	3	2	4		
MN	98LS023	Silver Creek	9/8/1998	2	2-	4	4	2	4		
MN	98LS025	Split Rock River	9/22/1998	2	2-	4	4	2	3		
MN	97LS101	Mistletoe Creek	9/23/1997	2	2	3 +	3 +	2	2		
MN	97LS102	Poplar River	9/23/1997	2	2	3	3	2	2		
MN	97LS104	French River	9/24/1997	2	2	3	3	2	2		
WI	10007891	Marsh Creek	10/26/2000	4	4	4 -	2 +	4	4		
WI	10008101	North Fork Clam River	11/2/2005	2	2-	3 +	2 +	2	2		

Table J-4. Site information for ***cold-cool transitional macroinvertebrate calibration*** samples that were analyzed. Original class = the original classification information provided by each entity (per Section 2.1). Area = upstream watershed area. Land use (% Agr=% agricultural, % For= % forest, % Urb= % urban, % Wet= % wetland) is based on upstream catchment area. Mean July Temp (temperature) is based either on instantaneous measurements or on continuous measurements from temperature loggers. The MPCA human disturbance score is based on upstream land use (higher score=less disturbance).

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	Grad (m/km)	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	MN	97LS075	-90.91839	47.61257	Northern Coldwater	14.3	wadeable		Northern Lakes and Forests	16.7		95.2	0.2	3.7	80.6
Cool	MN	97LS078	-91.05236	47.53013	Northern Coldwater	11.0	wadeable		Northern Lakes and Forests	8.0	0.4	98.0	0.3	1.2	79.3
Cool	MN	97LS056	-91.17221	47.46498	Northern Coldwater	2.5	headwater		Northern Lakes and Forests	4.2	0.1	99.8		0.1	81.0
Cool	WI	10008101	-92.12567	45.73953	Cool (Cold Transition) Ma	49.4			North Central Hardwoods	1.8					
Cool	Fond du Lac	202B	-92.49556	46.74833	Cold water	11.0		19.5	Northern Lakes and Forests		2.4	42.3	1.9	41.1	
Cool	MN	97LS101	-90.68942	47.71821	Northern Coldwater	16.2	wadeable		Northern Lakes and Forests	15.3	0.4	94.7	0.2	1.8	79.1
Cool	MN	97LS102	-90.77631	47.73664	Northern Coldwater	29.3	wadeable		Northern Lakes and Forests	9.5	0.1	84.4	0.1	4.9	80.3
Cool	MN	97LS104	-91.92205	46.91992	Northern Coldwater	18.2	wadeable		Northern Lakes and Forests	14.4	3.2	86.2	2.4	7.8	77.2
Cool	MN	97LS075	-90.91839	47.61257	Northern Coldwater	14.3	wadeable		Northern Lakes and Forests	16.7		95.2	0.2	3.7	80.6
Cool	WI	10028940	-88.19689	45.63782	Cool (Cold Transition) Ma	58.6			Northern Lakes and Forests	1.8	2.9	81.8	3.6		

Table J-4. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	Grad (m/km)	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	MN	97LS073	-90.33209	47.78533	Northern Coldwater	7.2	headwater		Northern Lakes and Forests	17.6	0.6	94.6	1.3	0.3	77.9
Cool	MN	97LS011	-91.36758	47.21089	Northern Coldwater	2.5	headwater		Northern Lakes and Forests	43.3	1.6	96.6		1.5	80.9
Cool	MN	97LS078	-91.05236	47.53013	Northern Coldwater	11.0	wadeable		Northern Lakes and Forests	8.0	0.4	98.0	0.3	1.2	79.3
Cool	MN	97LS075	-90.91839	47.61257	Northern Coldwater	14.3	wadeable		Northern Lakes and Forests	16.7		95.2	0.2	3.7	80.6
Cool	MN	97LS089	-91.92276	46.99246	Northern Coldwater	27.9	wadeable		Northern Lakes and Forests	5.3	0.5	94.6	0.8	3.4	80.4
Cool	MN	98LS004	-92.05123	46.84348	Northern Coldwater	4.1	headwater		Northern Lakes and Forests	14.3	8.5	79.1	10.5	0.6	67.9
Cool	MN	98LS025	-91.41454	47.18807	Northern Coldwater	40.7	wadeable		Northern Lakes and Forests	13.0	1.1	96.1	0.3	2.2	80.6
Cool	MN	98LS023	-91.62503	47.07077	Northern Coldwater	12.2	wadeable		Northern Lakes and Forests	15.1	1.1	93.3	2.3	3.0	77.4
Cool	MN	97LS087	-92.46696	46.49471	Northern Coldwater	56.6	River		Northern Lakes and Forests	1.3	13.8	57.7	2.1	25.8	74.4
Cool	MN	97LS055	-91.31752	47.27245	Northern Coldwater	121.7	River	23.5	Northern Lakes and Forests	1.7	0.8	92.1	1.1	2.4	65.9
Cool	MN	05RN073	-91.41194	47.72156	Northern Coldwater	9.0	wadeable	20.9	Northern Lakes and Forests	1.6	0.2	92.3	0.1	2.2	80.5
Cool	MN	97LS060	-90.53347	47.83371	Northern Coldwater	50.2	River		Northern Lakes and Forests	4.9	0.1	85.7	0.1	4.4	80.3

Table J-4. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	Grad (m/km)	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	WI	10007964	-91.28016	45.53667	Cold Mainstem	4.3			Northern Lakes and Forests	3.9	6.9	87.7	1.0		
Cool	Fond du Lac	204A	-92.48139	46.66389	Cold water	18.5		20.6	Northern Lakes and Forests						
Cool	Fond du Lac	207B	-92.60722	46.85417	Cool water	92.6		21.0	Northern Lakes and Forests		0.1	43.8	0.5	39.6	
Cool	Fond du Lac	205	-92.51333	46.80417	Cool water	22.0		21.1	Northern Lakes and Forests		0.9	37.2	0.2	34.4	
Cool	MN	05RN072	-91.50669	47.73836	Northern Coldwater	39.7	wadeable	21.7	Northern Lakes and Forests	3.2	0.3	87.9	1.1	8.4	79.8
Cool	MN	97LS059	-91.31521	47.53034	Northern Coldwater	5.0	headwater		Northern Lakes and Forests	1.7	0.1	85.3	1.0	13.2	78.9
Cool	WI	10028940	-88.19689	45.63782	Cool (Cold Transition) Ma	58.6			Northern Lakes and Forests	1.8	2.9	81.8	3.6		
Cool	MN	08RN021	-93.23222	47.72166	Northern Coldwater	12.8	wadeable	18.8	Northern Lakes and Forests	1.7	1.8	86.9	1.6	9.0	78.7
Cool	WI	10007891	-89.09182	42.71563	Cool (Cold Transition) Ma	34.2			Southeastern Wisconsin Till Plains	1.4					
Cool	MN	07SC007	-92.92678	45.99222	Northern Coldwater	5.4	headwater	18.0	North Central Hardwoods	0.3	49.1	19.5	16.1	15.3	60.7
Cool	MN	05RN003	-92.29073	47.78077	Northern Coldwater	14.1	wadeable		Northern Lakes and Forests	0.9	1.1	94.4	0.7	3.4	78.9
Cool	MN	07UM072	-94.19790	45.80997	Northern Coldwater	42.7	wadeable		North Central Hardwoods	1.3	77.3	8.1	3.4	11.1	55.2

Table J-4. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	Grad (m/km)	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	MN	08RN021	-93.23222	47.72166	Northern Coldwater	12.8	wadeable	18.8	Northern Lakes and Forests	1.7	1.8	86.9	1.6	9.0	78.7
Cool	MN	98LS003	-92.22698	46.74212	Northern Coldwater	7.1	headwater		Northern Lakes and Forests	4.8	6.7	68.0	20.4	4.6	52.7
Cool	MN	05RN042	-91.19887	47.71634	Northern Coldwater	31.9	wadeable		Northern Lakes and Forests	0.7	0.1	88.2	0.2	7.5	79.1
Cool	WI	433351	-88.68046	45.17814	Cool (Cold Transition) Ma	40.7			Northern Lakes and Forests	3.3					

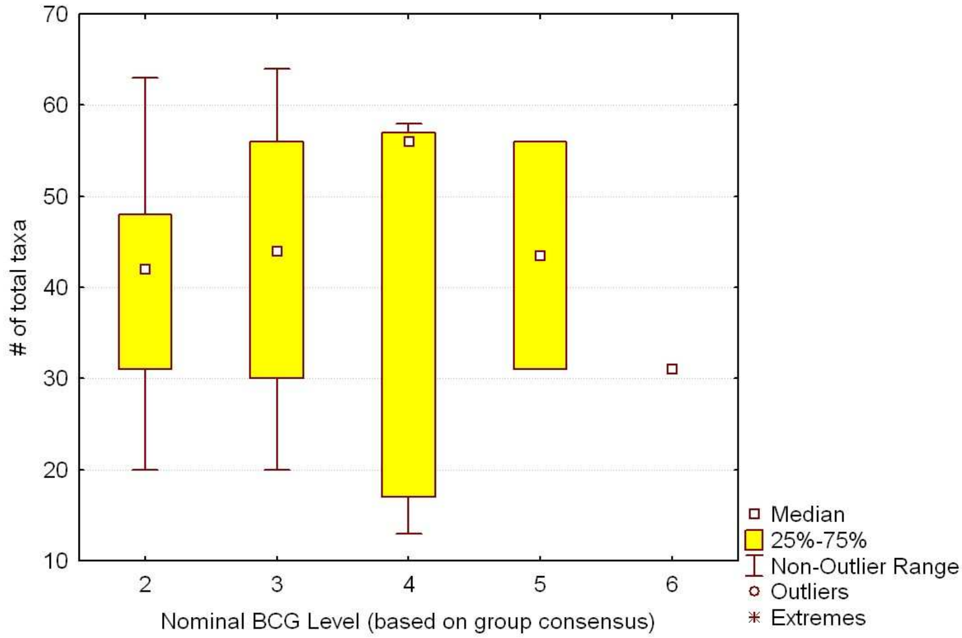

Figure J-1. Box plots of total taxa metric values for cold-cool transitional macroinvertebrate samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 2 = 19, level 3 = 13, level 4 = 7, level 5=2 and level 6 = 1.

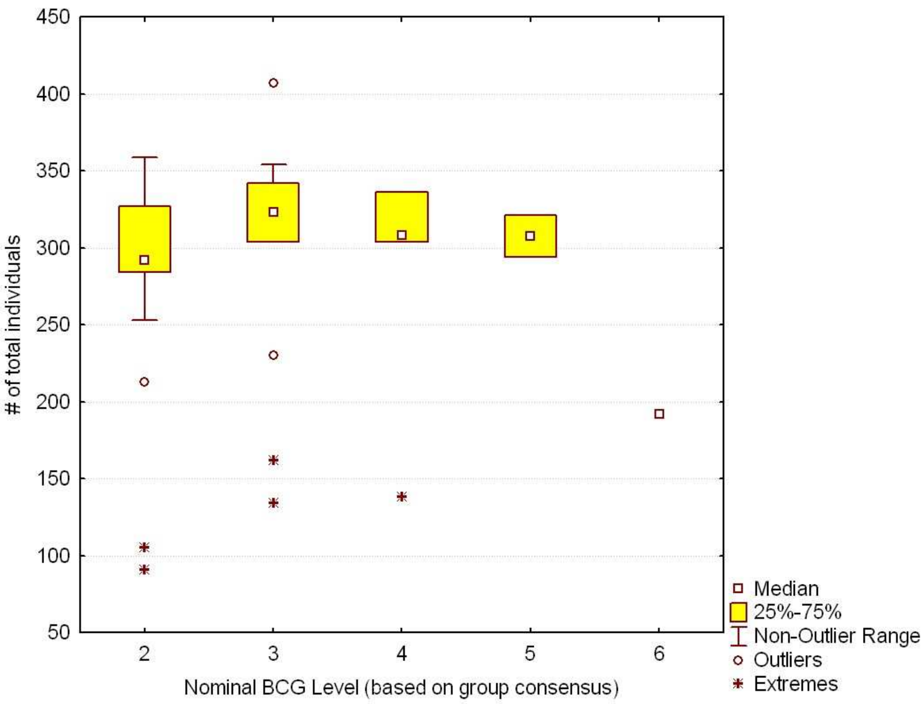

Figure J-2. Box plots of total number of individual metric values for cold-cool transitional macroinvertebrate samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 2 = 19, level 3 = 13, level 4 = 7, level 5=2 and level 6 = 1.

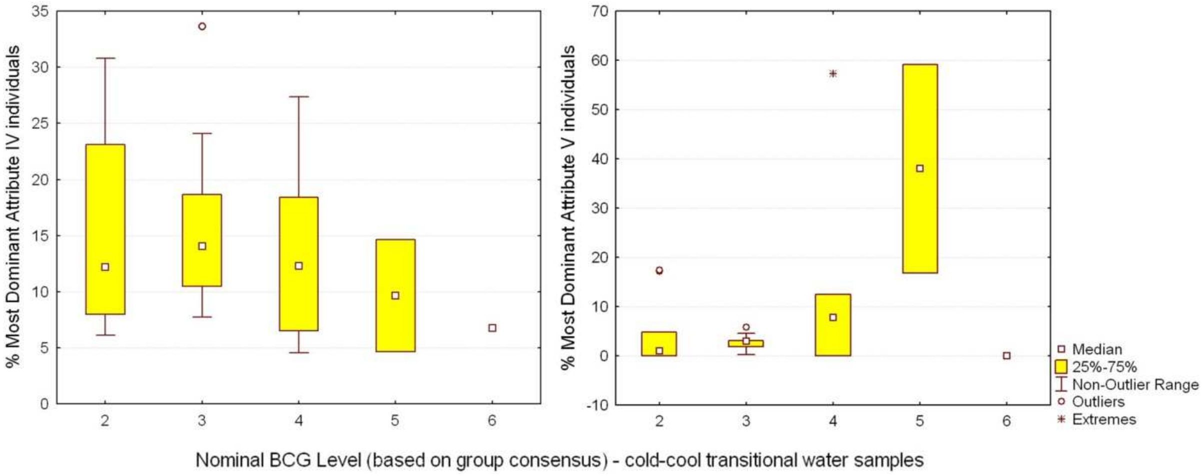

Figure J-3. Box plots of % dominant BCG attribute IV and V individual metrics for 42 cold-cool water transitional macroinvertebrate samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 2 = 19, level 3 = 13, level 4 = 7, level 5=2 and level 6 = 1.

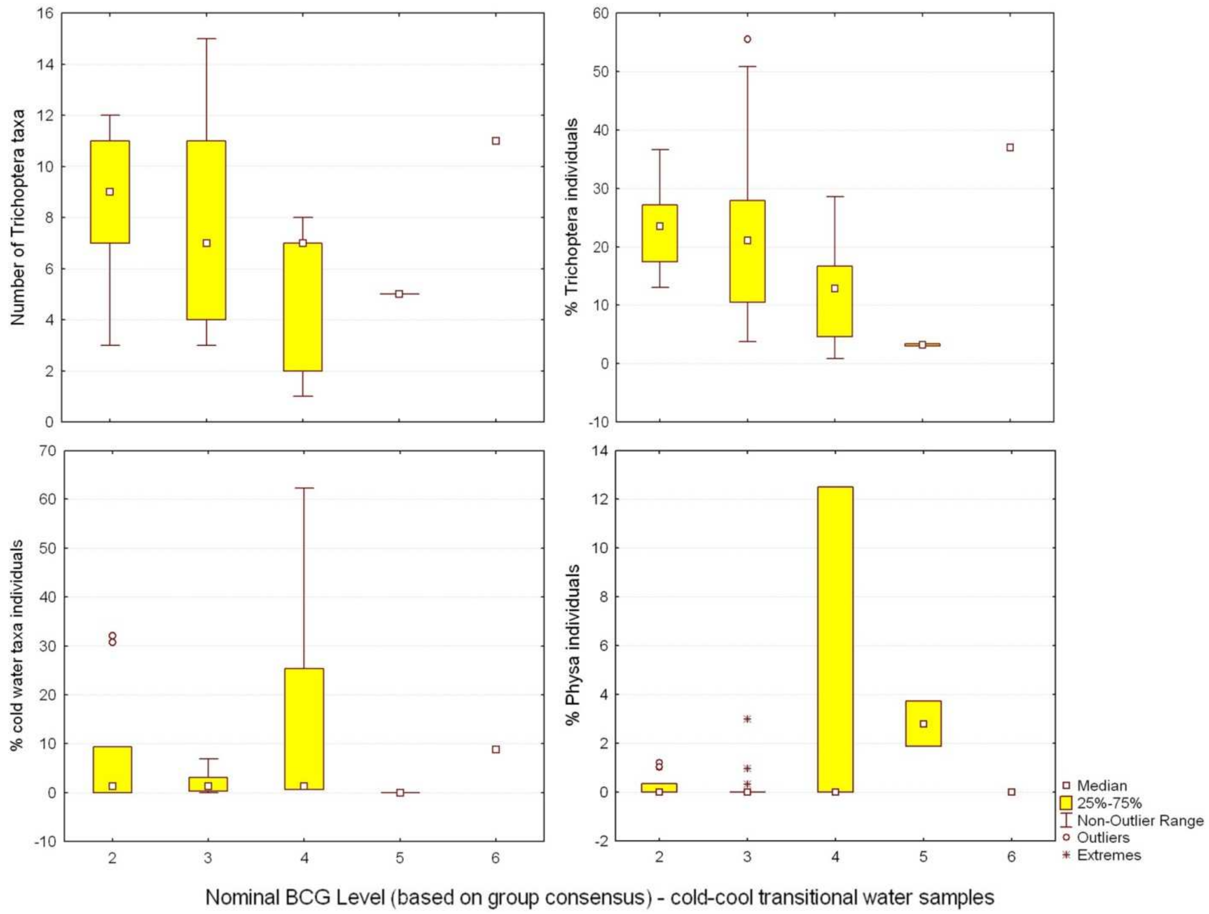

Figure J-4. Box plots of additional metrics for 42 cold-cool water transitional macroinvertebrate samples, grouped by nominal BCG level (group majority choice). Sample size for BCG level 2 = 19, level 3 = 13, level 4 = 7, level 5=2 and level 6 = 1.

Table J-5. BCG level assignments and sample information for ***cold-cool transitional macroinvertebrate validation*** samples that were analyzed. BCG level assignments are as follows: Final=consensus BCG level (=the assignment made by the majority of participants), without the + or - (2+ and 2- were assigned to level 2, etc.); Final (+/-) = consensus BCG level using the scoring scale shown in Table G1; Worst=the worst BCG level assignment (based on the Table G1 scoring scale) given by a participant; Best= the best BCG level assignment given by a participant. Samples are highlighted in yellow if the consensus call from the panelists is different from the primary call from the model. Wisconsin samples with fewer than 100 individuals were excluded from the validation dataset.

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
Fond du Lac	202B	Fond du Lac Creek Station 2	10/10/2002	3	3	4+	3	3	2		
Fond du Lac	202B	Fond du Lac Creek Station 2	10/25/2006	2	2-	3	2	2	2		
Fond du Lac	205	Simian Creek Station 1	10/25/2007	3	3-	4	3	3	2		
Fond du Lac	202B	Fond du Lac Creek Station 2	10/22/2003	**3**	3	3-	3	**2**	3	close	Exclude? < 100 ind.
Fond du Lac	203A	Martin Branch (Marshall Rd.)	10/26/2005	5	5	5	4	5	5		
MN	05RD089	Brandborg Creek	9/27/2005	4	4	4-	4	4	5		
MN	97LS009	Skunk Creek	9/8/1997	4	4	4-	4	4	4		
MN	97LS010	Beaver River	9/8/1997	2	2	2-	2	2	2		Panelist call was confirmed during Oct 31 call. Possible coldwater?
MN	97LS015	Berry Creek	9/10/1997	**3**	3+	4+	2	**2**	3	tie 2/3	
MN	97LS026	Us-Kab-Wan-Ka River	9/15/1997	3	3+	3-	2	3	3		
MN	98LS001	Miller Creek	9/14/1998	5	5+	5	4	5	5		Possible coldwater?
MN	98LS001	Miller Creek	10/1/1998	5	5+	5	4-	5	4		Panelist call was confirmed during Oct 31 call.
MN	98LS024	Crown Creek	9/15/1998	3	3-	4-	3+	3	4		

Table J-5. continued…

Entity	StationID	Waterbody Name	Coll Date	Panelist BCG Level Assignments				Model BCG Level Assignments			Notes
				Final	Final +/-	Worst	Best	Primary	Secondary	Tie	
MN	98LS028	Two Island River	9/16/1998	2	2	3+	2	2	2		Possible coldwater?
MN	98LS029	Plouff Creek	9/16/1998	**3**	3	3	3+	**2**	3	tie 2/3	Panelist call was confirmed during Oct 31 call.
MN	97LS103	Gooseberry River	9/24/1997	2	2	2-	2+	2	2		
WI	10010967	Six Mile Creek	5/21/1998	Excluded – spring sample							Panelist consensus call=4, model primary call=5
WI	10021290	Stevens Creek	9/30/2007	2	2	2	2+	2	2		Possible coldwater?
WI	10011273	Dalton Creek	5/7/1990	Excluded – spring sample							Panelist consensus call=4, model primary call=5
WI	10011949	Bears Grass Creek	11/3/2009	3	3	4+	3	3	4	close	Panelist call was confirmed during Oct 31 call. Possible coldwater?

Table J-6. Site information for ***cold-cool transitional*** samples that were analyzed during the BCG ***validation*** exercise. Original class refers to the original classification information provided by each entity (for more information see Section 2.1). Area refers to the upstream watershed area. Land use (% Agr=% agricultural, % For= % forest, % Urb= % urban, % Wet= % wetland) is for the upstream catchment area. Mean July Temp (temperature) is based either on instantaneous measurements taken at the time of the biological sampling event or on continuous measurements from temperature loggers. The human disturbance score is calculated by MPCA based on upstream land use (higher score=less disturbance). Additional information (i.e. nutrient and habitat data) may available for some of the sites.

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	Grad (m/km)	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	MN	05RD089	-95.49416	46.31169	Northern Coldwater	6.3	Headwater		North Central Hardwoods	2.4	67.7	18.6	9.5	4.0	58.1
Cool	WI	10010967	-89.46200	43.19576	Cool (Cold Transition) Ma	23.3			Southeastern Wisconsin Till Plains	1.4					
Cool	WI	10011273	-88.68820	45.18650	Cool (Cold Transition) Ma	11.6			Northern Lakes and Forests	3.8					
Cool	WI	10011949	-91.21090	44.71989	Cool (Cold Transition) Ma	15.9			North Central Hardwoods	1.9					
Cool	WI	10021290	-88.66396	45.92505	Cool (Cold Transition) Ma	19.3			Northern Lakes and Forests	1.6					
Cool	Fond du Lac	202B	-92.49556	46.74833	Cold water	11.0		19.5	Northern Lakes and Forests		2.4	42.3	1.9	41.1	
Cool	Fond du Lac	203A	-92.63944	46.83944	Cold water	7.4		20.6	Northern Lakes and Forests		0.0	48.8	0.1	10.2	
Cool	Fond du Lac	205	-92.51333	46.80417	Cool water	22.0		21.1	Northern Lakes and Forests		0.9	37.2	0.2	34.4	

Table J-6. continued…

Class	Entity	StationID	Long	Lat	Original Class	Area (mi^2)	Size Class	Mean July Temp (°C)	L3 Ecoregion	Grad (m/km)	% Agr	% For	% Urb	% Wet	Human Disturb Score
Cool	MN	97LS009	-91.53196	47.22773	Northern Coldwater	7.5	Headwater		Northern Lakes and Forests	3.1	0.8	96.3	0.6	2.2	80.6
Cool	MN	97LS010	-91.39485	47.27146	Northern Coldwater	48.6	River		Northern Lakes and Forests	11.4	0.2	97.3	0.5	1.5	79.5
Cool	MN	97LS015	-91.90053	47.29333	Northern Coldwater	24.4	Wadable		Northern Lakes and Forests	3.5	1.3	89.6	1.4	7.1	78.1
Cool	MN	97LS026	-92.34247	47.01323	Northern Coldwater	28.1	Wadable		Northern Lakes and Forests	2.1	4.0	90.8	0.2	3.3	78.8
Cool	MN	97LS103	-91.57518	47.17702	Northern Coldwater	31.3	Wadable		Northern Lakes and Forests	7.6	0.5	93.7	1.1	2.9	79.3
Cool	MN	98LS001	-92.16534	46.80852	Northern Coldwater	6.5	Headwater	19.5	Northern Lakes and Forests	5.5	3.8	53.5	40.8	1.6	37.1
Cool	MN	98LS024	-91.40773	47.52563	Northern Coldwater	4.4	Headwater		Northern Lakes and Forests	1.6	0.4	76.6	0.2	21.9	80.5
Cool	MN	98LS028	-90.97652	47.53938	Northern Coldwater	11.6	Wadable		Northern Lakes and Forests	9.8	0.2	96.0	0.6	1.7	77.2
Cool	MN	98LS029	-90.89380	47.77043	Northern Coldwater	13.5	Wadable		Northern Lakes and Forests	1.7		89.5	0.2	8.3	80.4

APPENDIX K

Comparison of Macroinvertebrate and Fish BCG Level Assignments

Appendix K. Table K -1. BCG level assignments were made independently by participants working in the fish and macroinvertebrate groups. There were 8 **coldwater** sites at which both fish and macroinvertebrate BCG level assignments were made (1 site had 2 fish samples from different dates). BCG level assignments between the two groups are compared in this table. Collection dates are highlighted in grey when fish and macroinvertebrates collection years differ. BCG level assignments are as follows: Final=consensus BCG level (=the assignment made by the majority of participants), without the + or - (2+ and 2- were assigned to level 2, etc.); Final (+/-) = consensus BCG level using the scoring scale shown in Table G1; Worst=the worst BCG level assignment (based on the Table G1 scoring scale) given by a participant; Best= the best BCG level assignment given by a participant.

Coldwater						**BCG Level Assignment**							
				Collection Date		**Fish**				**Macroinvertebrates**			
Class	**Entity**	**StationID**	**Waterbody Name**	**Fish**	**Macro**	**Final**	**Final +/-**	**Worst**	**Best**	**Final**	**Final +/-**	**Worst**	**Best**
Cold	WI	10008018	Harker Creek	10/3/2000	11/3/2000	**2**	2	2-	1-	**3**	3	4	2-
Cold	WI	10011185	West Branch Baraboo River	8/5/2003	10/13/2004	**4**	4-	5	3	**4**	4	5	4
Cold	MN	04LM058	Spring Valley Creek	6/24/2004	8/24/2004	**4**	4-	5+	4	**4**	4	4-	4
Cold	MN	04LM092	Big Trout Creek (a.k.a. Pickwick Creek)	6/22/2004	9/21/2004	**4**	4-	5+	4	**3**	3	4+	2-
Cold	MN	04LM095	Pine Creek	6/23/2008	9/1/2004	**3**	3	3-	3+	**4**	4	4	3-
Cold	MN	04LM095	Pine Creek	8/11/2008	9/1/2004	**3**	3	3-	3+	**4**	4	4	3-
Cold	MN	04LM129	Mill Creek	6/30/2008	8/4/2008	**4**	4	4-	3-	**4**	4-	5	4
Cold	MN	08LM091	Butterfield Creek	7/14/2008	8/6/2008	**3**	3	4+	2	**3**	3	4+	3+
Cold	MN	08LM095	Storer Creek	7/23/2008	8/5/2008	**1**	1-	2+	1-	**3**	3	3-	3

Table K -2. BCG level assignments were made independently by participants working in the fish and macroinvertebrate groups. There were 5 **cold-cool transitional** sites at which both fish and macroinvertebrate BCG level assignments were made (1 site had 2 fish samples from different dates). BCG level assignments between the two groups are compared in this table. Collection dates are highlighted in grey when fish and macroinvertebrates collection years differ. BCG level assignments are as follows: Final=consensus BCG level (=the assignment made by the majority of participants), without the + or - (2+ and 2- were assigned to level 2, etc.); Final (+/-) = consensus BCG level using the scoring scale shown in Table G1; Worst=the worst BCG level assignment (based on the Table G1 scoring scale) given by a participant; Best= the best BCG level assignment given by a participant.

Cold-cool transitional						BCG Level Assignment							
Class	Entity	StationID	Waterbody Name	Collection Date		Fish				Macroinvertebrates			
				Fish	Macro	Final	Final +/-	Worst	Best	Final	Final +/-	Worst	Best
Cool	Fond du Lac	204A	Otter Creek (Station 1)	6/10/1999	10/30/2008	**2**	2-	3-	2	**3**	3-	3-	3
Cool	Fond du Lac	204A	Otter Creek (Station 1)	7/16/2009	10/30/2008	**3**	3+	3+	2-	**3**	3-	3-	3
Cool	Fond du Lac	205	Simian Creek Station 1	7/3/2002	6/29/1999	**4**	4+	4	3-	**3**	3-	4+	3-
Cool	MN	97LS056	Schoolhouse Creek	7/8/1997	9/9/1997	**2**	2-	2-	2	**2**	2	2-	2
Cool	MN	08RN021	Venning Creek	6/18/2008	8/5/2008	**3**	3+	3	2-	**4**	4	4	3-
Cool	MN	05RN042	Dumbbell River	8/18/2005	8/9/2005	**4**	4-	5	4	**5**	5	5-	4-

APPENDIX L

Instructions for MS-Excel workbooks of BCG models

Instructions for MS-Excel workbooks of BCG models

Read This First

Before doing anything else, please make copies of the two spreadsheet models and save them in a safe place. Since they are in Excel, they are easy to modify and break!

Purpose

To calculate the Northern Tier Biological Condition Gradient model for fish or benthic macroinvertebrates (coldwater and coolwater). Two Excel workbooks are included as electronic attachments to this report, one each for fish and benthic macroinvertebrates. Each workbook calculates both the cold and coolwater models for all samples; it is up to the user to determine which samples are from coldwater sites and which are coolwater. These instructions are also included as a separate sheet in each workbook.

Requirements

MS-Excel 2010. Files are saved as ".xlsm" so that macros are enabled. If the file is saved as ".xls" it can be used in Excel 2007 but not earlier versions.
If features don't work then macros need to be enabled. In the spreadsheet, click the "Test macros" to test if macros are enabled.

Test macros.

Speed / Performance

The speed of the model calculation button depends on the number of records and speed of the computer. If the Workbook runs slow on your computer, turn off autocalculate while editing:.

> Go to the "Formulas" tab on the Ribbon. Under "Calculation", select the "Calculation Options" icon, and then the "Manual" option.
>
> Remember to turn it back on to get results (or calculate manually by typing <ctrl> =).

Sample Data

Data are added to the "TaxaSamples" worksheet, in columns identified by green or gray headers. The simplest way to enter data is to paste your data over the example data in "Taxa Samples". If you paste new data over old, then erase any remaining old data after you have pasted in the new data. You can also paste new data after the end of old data, up to the limit of Excel. Save and modify your data in copies of the "Bug test data.xlsx" and Fish test data.xlsx", and paste these into the model workbook when you want to calculate model values.

NOTE: Required data fields are "UniqueID", "TaxaName", "Count", and "Area_mi2" (watershed area ; columns A-C, and I). If watershed area is missing, the model assumes that it is less than 10 (headwater stream). The variables "StationID", "SampleID","CollectionDate", and "Class" are not required but can be useful in reporting results.
Data is in the long format. That is, the sample information is repeated for each taxon.

"Taxa Name" must match the "Taxa Name" entered in the master taxa list (scientific or common name). "Taxa Name Alternate" (the common name) is provided in the master taxa list to show the two names side by side. If your fish data are by common names, simply copy the common name column into "Taxa Name"

If any observations do not match the taxa names exactly, the model will return #VALUE! errors. The QC page will show how many observations do not match. Most often these will be due to spelling errors in either the TaxaSamples or TaxaMaster sheets. Find the taxa in the TaxaSamples sheet (using a filter: select the Data tab on the ribbon, then highlight the header row, and select "Filter") and correct either there or in the TaxaMaster sheet. New taxa need to be entered on the TaxaMaster sheet.

Additional fields required for some metrics are "Area_mi2", "Model Use" (only for checking calibration), "Grp Rating" (for comparing the panel's a priori designation to the model), and "BrookTroutNative" ("no" if brook trout are not native in the stream).

> If these fields are provided on the "TaxaSamples" worksheet they must be complete for every record.
> Alternatively these fields can be completed on the "Model" worksheet.

Master Taxa List

Each unique taxon needs to be added to the worksheet "TaxaMaster".
Required fields are "Taxa Name", "BCG Attribute COLD", and "BCG Attribute COOL".

QC

The QC worksheet shows number of taxa without a match in the master taxa list.

> Modify sample taxon or add new taxon to the master taxa list

Also shows number of master taxa without a BCG attribute.

Results

Model results are shown in the sheets Model_Cold and Model_Cool. Results are broken down by sample and station in the sheets Model_Results_Samples and Model_Results_Stations. On some computers, but not all, we have noticed that the first row in the Results tables (the first sample) is repeated. We cannot find a reason for it.

NOTE: DO NOT ERASE OR DELETE THE FIRST ROW IN THE RESULTS TABLES BECAUSE FORMULAS ARE STORED IN THESE. THE RESULTS TABLES ARE AUTOMATICALLY MODIFIED AND SIZED EACH TIME THE MODEL IS RUN, SO THERE IS NO NEED TO EDIT THEM.

Test Data

Two files of test data are provided, one each for benthos and fish. Each file has a separate sheet for cold and cool samples. To see how the spreadsheet works, paste the test data into the appropriate Sample Data sheet.