Methods and Assessment Comparability Among State and Federal Biological Monitoring Protocols

Prepared for

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This report builds upon previous work that was done during the New England Wadeable Stream Survey (NEWS) and Wadeable Stream Assessment (WSA), as well as the Tiered Aquatic Life Use (TALU) workshops that were hosted by the New England Interstate Water Pollution Control Commission (NEIWPCC) and EPA New England Regional Laboratory. State participants are listed in the table below. The participants in this effort invested significant time and commitment in the process. We are grateful for their hard work and enthusiasm. We would like to thank Steve Fiske and Mike Beauchene in particular for their prompt and insightful comments.

Name	Organization
Ernie Pizzuto	CT DEP
Guy Hoffman	CT DEP
Mike Beauchene	CT DEP
Susan Davies	ME DEP
Tom Danielson	ME DEP
Leon Tsomides	ME DEP
Steve Fiske	VT DEC
Doug Burnham	VT DEC
David Neils	NH DES

ACRONYMS

BCG	Biological Condition Gradient
CT	Connecticut
EPA	United States Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera and Trichoptera
CT DEP	Connecticut Department of Environmental Protection
ME	Maine
ME DEP	Maine Department of Environmental Protection
MMI	Multi-metric Index
NEIWPCC	New England Interstate Water Pollution Control Commission
NEWS	New England Wadeable Stream Survey
NH	New Hampshire
NH DES	New Hampshire Department of Environmental Services
OTU	Operational Taxonomic Unit
SOP	Standard Operating Procedure
TALU	Tiered Aquatic Life Use
VT	Vermont
VT DEC	Vermont Department of Environmental Conservation
WSA	Wadeable Stream Assessment

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1 INTRODUCTION

A need to develop a consistent approach throughout the nation for assessing water quality data has been identified by EPA and the states. In particular, a consistent way to assess biological data, independent of sampling protocols and compatible with theories of biological condition gradients developed by EPA, would be beneficial to both EPA and the states for the purpose of conducting comprehensive assessments of water quality conditions across the country. In an effort to meet these water quality goals, EPA, the New England Interstate Water Pollution Control Commission (NEIWPCC), Connecticut Department of Environmental Protection (CT DEP), Maine Department of Environmental Protection (ME DEP), New Hampshire Department of Environmental Services (NH DES), and Vermont Department of Environmental Conservation (VT DEC), have partnered in monitoring efforts to conduct statistically valid assessments of the condition of wadeable streams in both the New England region and the entire nation- the New England Wadeable Streams (NEWS) project and the national Wadeable Streams Assessment (WSA). The NEWS project was a randomized design survey, based on EPA's Environmental Monitoring and Assessment Program (EMAP) sampling design protocols. This effort has resulted in the sampling of wadeable streams in all New England states during the summers of 2000 through 2003; a total of 320 locations were sampled. NEIWPCC and its partner states participated in the national WSA, sampling 45 locations in the region, conducting side-by-side sampling at many of the sites, implementing six different sampling methodologies: NEWS, WSA, CT DEP, ME DEP, NH DES, and VT DEC.

Currently, every state in New England has a unique biological assessment sampling methodology. In addition, EPA's NEWS and WSA projects also used separate collection methodologies. As a result, there is no comprehensive way for states to use EPA's or each other's data; or for EPA to use existing state data. Past attempts to use multiple assessment methods have resulted in discrepancies in the assignment of condition (good, fair, poor) to waterbodies along state lines.

This project attempts to bridge some of the compatibility issues associated with utilizing data collected from different organizations and agencies, in order to make a comprehensive assessment of wadeable streams at the state and regional level in New England. Using the data collected in the NEWS and WSA projects, we have developed a biological assessment system for New England that will allow for the determination of the health a given wadeable stream, regardless of the methodology utilized to collect the sample. The common assessment system is based on the Biological Condition Gradient (BCG) developed in the region for assessing stream segment samples for the NEWS project as the base assessment system for this project. Building on the NEWS project, we have worked with the states to re-calibrate the BCG for use with additional sampling methodologies.

2 METHODS

2.1 Study Design

In 2004 and 2005, EPA's WSA program supported side-by-side sampling in New England, such that four state methods (CT DEP, ME DEP, NH DES, VT DEC) were deployed side-by-side with EPA's WSA method and the NEWS method. Both random and targeted wadeable sites were sampled as part of this methods comparison study. The random sites had been selected using the randomized study design developed jointly by EPA's Office of Research and Development in Corvallis, Oregon and the EPA Atlantic Ecology Division in Narragansett, Rhode Island for the NEWS project (US EPA 2000, US EPA 2007). These random sites were selected using a grid system of 42 hexagonal shaped 'cells' that were laid over a 1:100,000 National Hydrographic Database (NHD) dataset. Targeted sites, which ranged in condition from reference to highly disturbed, were selected by the state participants and were included in this study to ensure that a full range of BCG conditions would be represented in the dataset. Attempts were made to exclude low gradient streams (< 1% slope) from the dataset because the state assessment methods were calibrated for medium to high gradient streams.

The initial goal was to sample 50 sites. For various reasons, only 44 sites yielded data meeting the selection criteria. Of these, samples collected using the VT DEC and CT DEP methods were taken at 44 of the sites, ME DEP and NH DES method samples were taken at 42 of the sites, WSA method samples were taken at 36 of the sites and NEWS method samples were taken at 20 of the sites. Twelve of the sites are located in Maine, 11 in Vermont, 11 in New Hampshire and 10 in Connecticut. A list of the sites, along with site information, can be found in Appendix A. Site locations are shown in Figure 2-1.

2.2 Sampling Methods

Six different macroinvertebrate sampling methods (NEWS, WSA, CT DEP, ME DEP, NH DES, and VT DEC) were used in this study. Each method was performed in accordance with the appropriate Standard Operating Procedures (SOP) for each technique, which are summarized in Table 2-1 (more detail can be found in the following references: US EPA 2006, US EPA 2007, CT DEP 2004, Davies and Tsomides 2002, NH DES 2004, and VT DEC 2004). Samples were collected by a number of different crews. State method samples were collected by state crews, WSA method samples were collected by contractor crews and NEWS method samples were collected by either state or contractor crews. In comparing the collection methods, VT DEC and CT DEP both sample in riffles using kick nets; WSA and NEWS methods both use a multihabitat kick net sample; and ME DEP and NH DES both use artificial substrates (rock basket) in riffle/run habitats. Because ME DEP and NH DES both use similar rock basket collection methods, only one set of rock baskets was deployed at each site and samples for both methods were derived from the same set of replicates.

Subsampling procedures differed among methods. The target number of organisms is 200 for CT DEP and NEWS, 100 for NH DES, 300 for VT DEC and 500 for WSA. ME DEP does use subsampling procedures as outlined in the ME DEP Methods Manual (Davies and Tsomides 2002), but for this project, the entire rock basket samples were processed. With the exception of

VT DEC method samples, all processing and identification was done by EcoAnalysts, Inc. When processing the rock basket samples (which served as both the ME DEP and NH DES samples), EcoAnalysts, Inc. first processed and identified the samples in accordance with NH DES protocols. Then they re-processed each replicate using ME DEP protocols. All of the samples that were collected using the VT DEC method were processed in the VT DEC laboratory in accordance with the VT DEC protocols prior to being sent to EcoAnalysts, Inc. for identification.

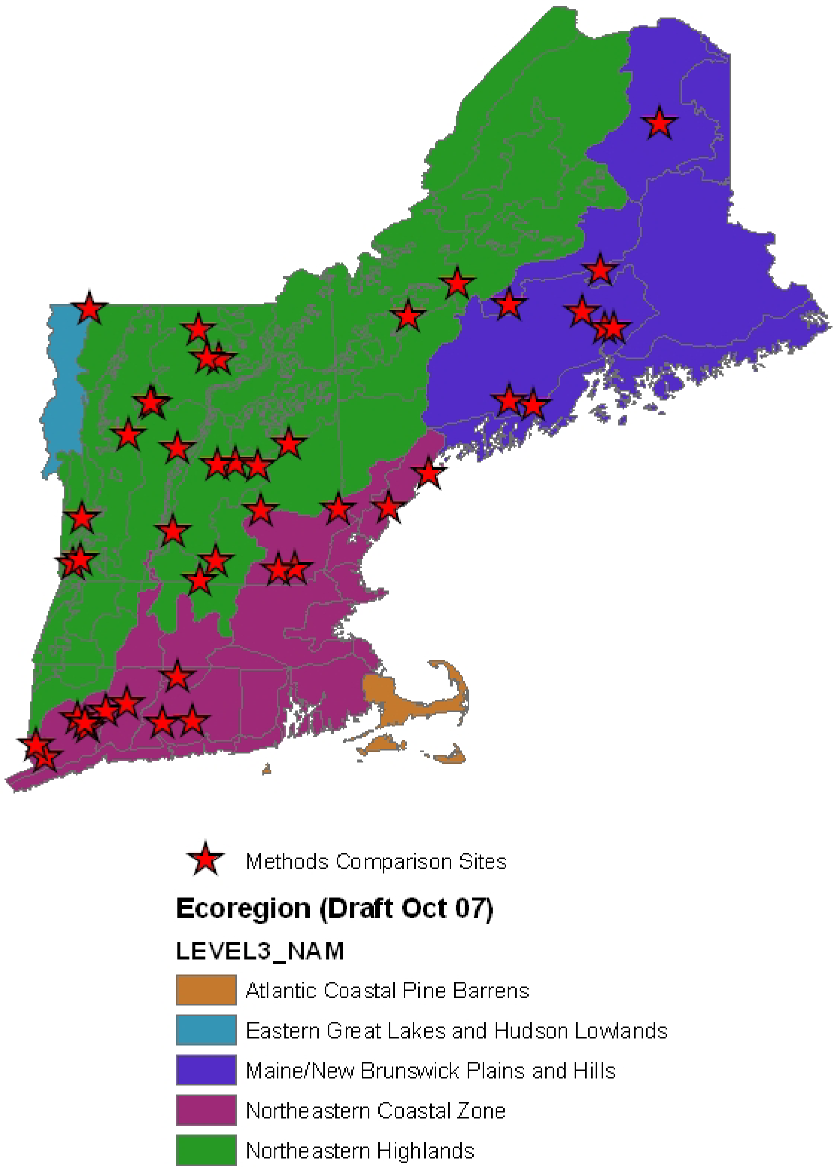

Figure 2-1. Locations of the methods comparison sites.

Table 2-1. Summary of the 6 sampling techniques (NEWS, WSA, CT DEP, ME DEP, NH DES, and VT DEC).

Collection Method		Gear	Habitat	Sampling Area	Subsampling	Index Period
CT	12 kick samples are taken throughout riffle habitats within the sampling reach	Rectangular net (18" x 18" x 10") with 800-900 µm mesh	Riffles	Approximately 2 square meters	200-organism minimum count, randomly selected from a Caton grid	October 1-November 30
VT	Kick samples are taken from riffle habitats in 4 different locations in the sampling reach. At each location the substrate is disturbed for approximately 30 seconds, for a total active sampling effort of 2 minutes.	D-frame net (18" wide x 12" high) with 500 µm mesh	Riffles	Approximately 1 square meter	1/4 of the sample, with a minimum of 300 organisms (if less than 300 organisms are found, 1 grid at a time is picked until the target is reached or the whole sample is picked)	September - mid-October
ME	3 cylindrical rock-filled wire baskets are placed in locations with similar habitat characteristics for 28 ± 4 days.	Contents are washed into a sieve bucket with 600 µm mesh	Riffle/run is the preferred habitat.	Approximately 0.3 square meters per basket	Subsampling rules are difficult to briefly summarize (see Davies and Tsomides 2002). For this project, the entire samples were processed and identified.	July 1 - September 30
NH	3 cylindrical rock-filled wire baskets are placed in riffle habitats or at the base of riffles at depths that cover the artificial substrate by at least 5 inches for 6 to 8 weeks.	Contents are washed into a sieve bucket with 600 µm mesh	Riffle/run is the preferred habitat.	Approximately 0.3 square meters per basket	Quarter of the sample with a minimum of 100 organisms (if less than 100 organisms are found, then the entire sample is processed)	late July - September

Table 2-1. continued…

Collection Method		Gear	Habitat	Sampling Area	Subsampling	Index Period
NEWS	A one-fifth meter square quadrat was randomly tossed within a particular mesohabitat of the stream reach. This area was sampled for 1 minute. 20 total quadrats were collected at each site location in proportion to the existing habitat in the reach.	1/5 meter square quadrat. D-frame net with 500 µm mesh.	Multihabitat Composite	Approximately 4 square meters	200-organism minimum count, randomly selected from a Caton grid	July-September
WSA	A 1 square foot area was sampled for 30 seconds at a randomly selected location at each of the 11 transects. The samples were composited into one sample per site.	Modified D-frame net (12" wide) with 500 µm mesh	Multihabitat Composite	Approximately 1 square meter	500-organism minimum count, randomly selected from a Caton grid	June - September*

*In 2004, samples were collected July-September. In 2005, 10 samples were collected in October and 2 were collected in November.

2.3 BCG Exercise

Biological condition levels and associated attributes are narrative statements on presence, absence, abundance, and relative abundance of several groups of taxa that have been empirically observed to have differing responses to stressors caused by human disturbance, as well as statements on system connectivity and ecosystem attributes (e.g., production, material cycling). The USEPA Tiered Aquatic Life Uses (TALU) national workgroup developed the statements out of consensus best professional judgments (Davies and Jackson 2006, US EPA 2005). The attributes and transitions between the levels that are described in the BCG model are based on years of biologists' field experience in a given region and reflect accumulated biological knowledge. The current generalized BCG model evolved from a prototype model that was adjusted following a series of exercises, conducted in several different regions of the United States, in which biologists attempted to place actual biomonitoring data into BCG levels (Figure 2-2). Greater detail about the BCG and TALU may be found in the reports by Davies and Jackson (2006) and US EPA (2005).

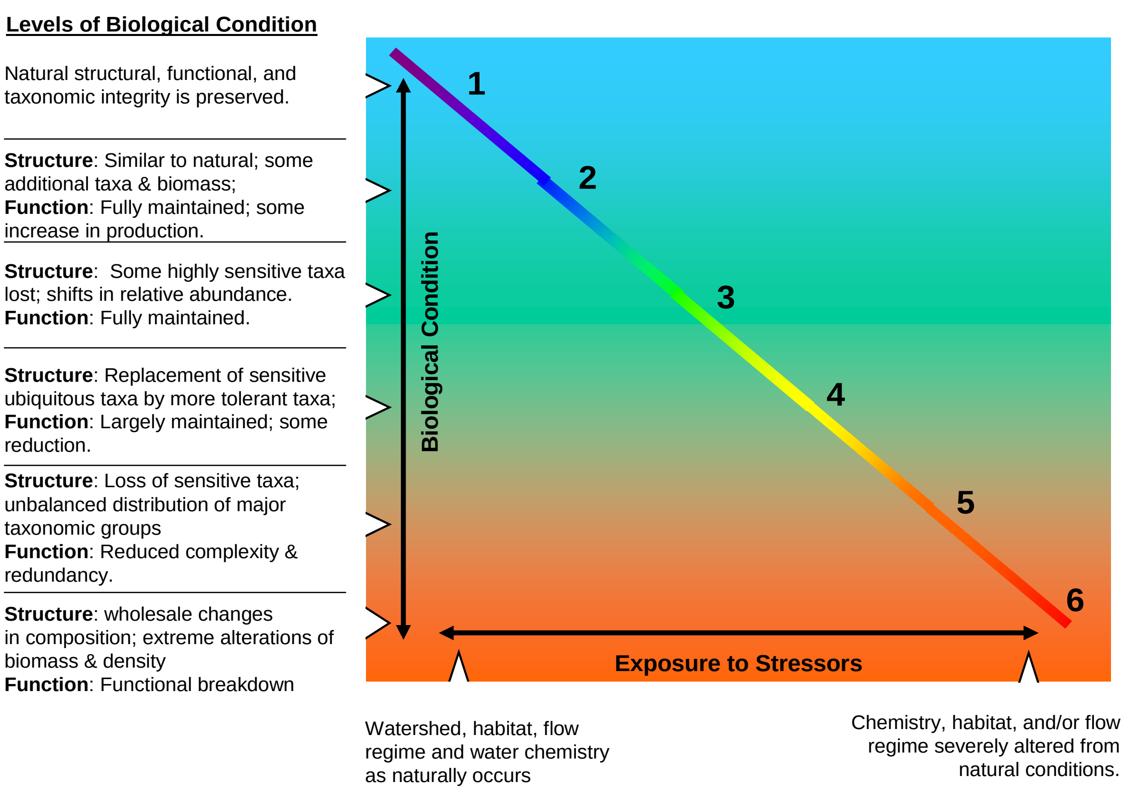

Figure 2-2. Conceptual model of the Biological Condition Gradient (US EPA 2005).

The BCG is presented as a 6 by 10 matrix of levels and attributes that describe differences in the relative condition of the levels (Appendix B). The attributes are:

I. Historically documented, sensitive, long-lived or regionally endemic taxa
II. Sensitive and rare taxa
III. Sensitive but ubiquitous taxa
IV. Taxa of intermediate tolerance
V. Tolerant taxa
VI. Non-native taxa
VII. Organism condition
VIII. Ecosystem functions
IX. Spatial and temporal extent of detrimental effects
X. Ecosystem connectance

The ten attributes presented in the BCG describe multiple aspects of ecological condition, including taxonomic and structural information at the site scale (Attributes I-VI), organism and system performance at the site scale (Attributes VII and VIII), and physical-biotic interactions at broader temporal and spatial scales (Attributes IX and X). Some of the attributes in the BCG represent core data elements that are commonly measured in most state/tribal biological monitoring programs (e.g., Attributes II, III, IV, V, VI,VII) while others, though recognized as very important (e.g., Attributes I, VIII, IX and X), are not commonly measured due to resource limitations and technical complexity.

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). As described in the NEWS report (US EPA 2007), a BCG was developed for the NEWS project, using CT DEP and NEWS data for calibration. For this project, the goal was to develop a BCG model that would apply to other New England methods as well.

As part of this process, state participants were given worksheets that contained data for each of the samples that were collected using their respective state methods. For example, participants from VT DEC were provided with data for all the samples collected and processed using VT DEC protocols, and participants from CT DEP were provided with data for all the samples collected and processed using CT DEP protocols. The worksheets contained lists of taxa, taxa abundances, BCG attribute levels assigned to the taxa and limited site information (elevation, watershed area, pH, conductivity, gradient (low, medium or high, based on best professional judgment) and land use (% developed, % agricultural, % forested). Participants were asked to make BCG level assignments for each sample, and were also asked to document what factors they took into consideration when making each assignment.

In addition to making BCG level assignments, state participants also used the data to calculate state assessment scores and/or ratings for each of the sites. For example, ME DEP ran the data through its linear discriminant models in accordance with ME DEP protocols and assigned each sample a classification (A, B, C, NA). VT DEC, NH DES and CT DEP calculated scores and assigned ratings for each sample using their respective multimetric indices (MMI). WSA MMI scores were calculated for each sample as described in Appendix C. In addition, BCG level assignments were calculated for each sample using the NEWS and CT BCG fuzzy models (see Appendix D for the decision rules that are used in each model). The results from the state assessment methods and the fuzzy models were then compared to the participants' BCG level assignments.

3 COMPARISON OF METRIC VALUES

One of the first steps in the methods comparison analysis was to examine values of commonly-used metrics to determine whether systematic differences were evident among the methods. When calculating the metrics, several decisions had to be made. For the richness metrics, we had to decide whether to base the calculations on genus or species-level operational taxonomic units (OTU). It was decided that it would be most appropriate to base the calculation on a genus-level OTU because it lessens the chance of results being influenced by taxonomic ambiguity (Moulton et al., 2000). Also, the CT and NEWS BCG fuzzy models were calibrated using a genus-level OTU. Another decision that had to be made was how to calculate richness values for the ME DEP and NH DES rock basket samples. One technique is to calculate a metric value for each replicate and take the average of the replicate values. Another is to compile the data from each replicate into one sample and calculate richness based on the composite sample (in this technique, any taxa present in any of the replicates is counted) (this 'compilation' technique is used by ME DEP).Yet another approach is to calculate richness for each replicate but only report the maximum replicate richness value (this approach is used by NH DES, after rarefaction is performed on the data). Results from each technique can be quite different, depending on the sample. In our analyses, we decided to make the calculation in the way that most closely matched the state methods, so richness calculations for ME DEP samples were based on the compilation of the replicates and calculations for NE DES samples were based on the maximum value of the individual replicates.

Calculating density in a way that was directly comparable across all the methods also posed some challenges. The raw data first had to be adjusted for subsampling factors[1]. Next it had to be adjusted for differences in sampling area (VT&WSA=1 meter^2, CT=2 meter^2, ME & NH=0.3 meter^2, NEWS=4 meter^2). For ME DEP and NH DES samples, total abundances were averaged across the replicates, and the mean value was assigned to the 0.3 meter^2 sampling area.

Once the metric calculations had been made, we created two different types of plots to examine how metric values differed across methods. In one type of graph, metric values for each sample were plotted by site, in order of increasing site average. These plots, which are shown in Appendix E, were created for 22 commonly-used metrics. The second approach involved calculating deviations from the overall means for 11 of the metrics. These results are shown in box and whisker plots in Figures 3-1 through 3-11.

[1] Because we were unable to obtain subsampling information for the WSA method samples, we excluded them from the density calculations.

Some general patterns were evident in the plots:

- Overall, CT DEP samples generally had the lowest richness values and ME DEP samples generally had the highest.
- CT DEP and NH DES samples tended to have the lowest numbers of total taxa and ME DEP and WSA samples tended to have highest.
- The kick method-riffle habitat samples (CT DEP and VT DEC) tended to have lower densities than the rock basket samples (ME DEP and NH DES).
- ME DEP samples tended to have the highest numbers of sensitive (Attribute 2 and 3) taxa, while CT DEP, NH DES and NEWS samples tended to have the lowest. A similar pattern was evident for number of EPT taxa.
- ME DEP and WSA samples tended to have higher numbers of Attribute level 4 and 5 taxa, while CT DEP, VT DEC and NH DES samples tended to have the lowest.
- ME DEP and WSA samples tended to have higher numbers of Chironomidae taxa, while CT DEP and VT DEC samples tended to have the lowest.
- VT DEC samples tended to have the highest % EPT individuals and the highest % Sensitive (Attribute 2 and 3) individuals, while NEWS and WSA samples tended to have the lowest.
- VT DEC samples tended to have the lowest % Chironomidae individuals.
- WSA and NEWS samples tended to have lower % dominant individuals and higher Shannon Wiener Diversity Index values.
- WSA samples tended to have lower % filterer individuals and higher % Oligochaeta individuals.
- Differences were not evident for the following metrics: % non-insect individuals, % tolerant (Attribute 5 and 6) individuals, % Attribute 4 individuals and number of Attribute 2 taxa.

It should be noted that differences in richness values can largely be attributed to subsampling. ME DEP samples tended to have higher richness values because the entire samples were processed, whereas most of the other samples were subsampled, with the target number of organisms ranging from 100 to 500 organisms. Subsampling effects were also evident in the ME DEP and NH DES density calculations. After adjustments were made to account for subsampling of the NH DES replicate samples, some of the NH DES abundance numbers ended up being higher than the ME DEP numbers, even though they came from the same rock baskets. This occurred with samples that happened to have high densities of organisms in the portions of the NH DES samples that were randomly selected for processing.

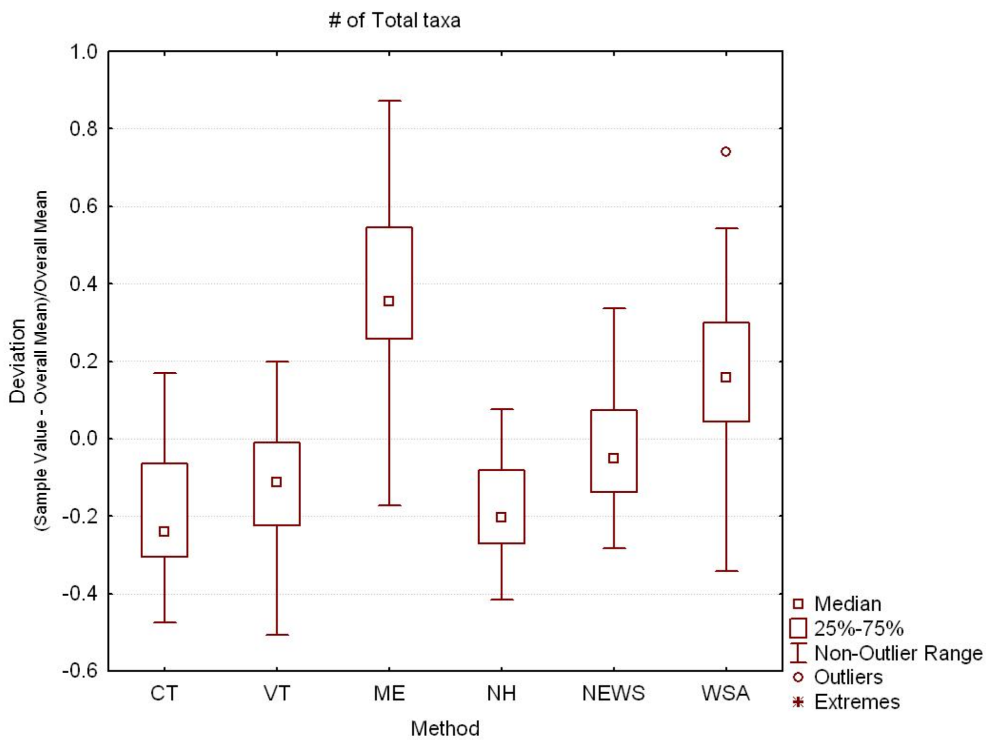

Figure 3-1. Box and whisker plots showing proportional deviations from site means for total taxa richness calculations.

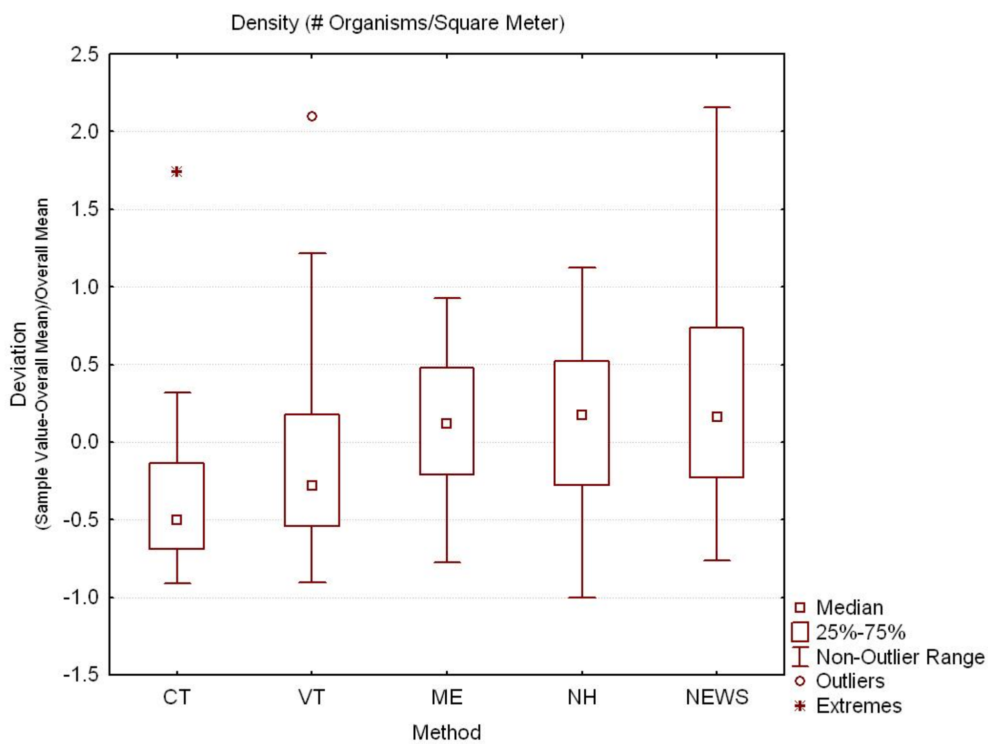

Figure 3-2. Box and whisker plots showing deviations from site means for density calculations.

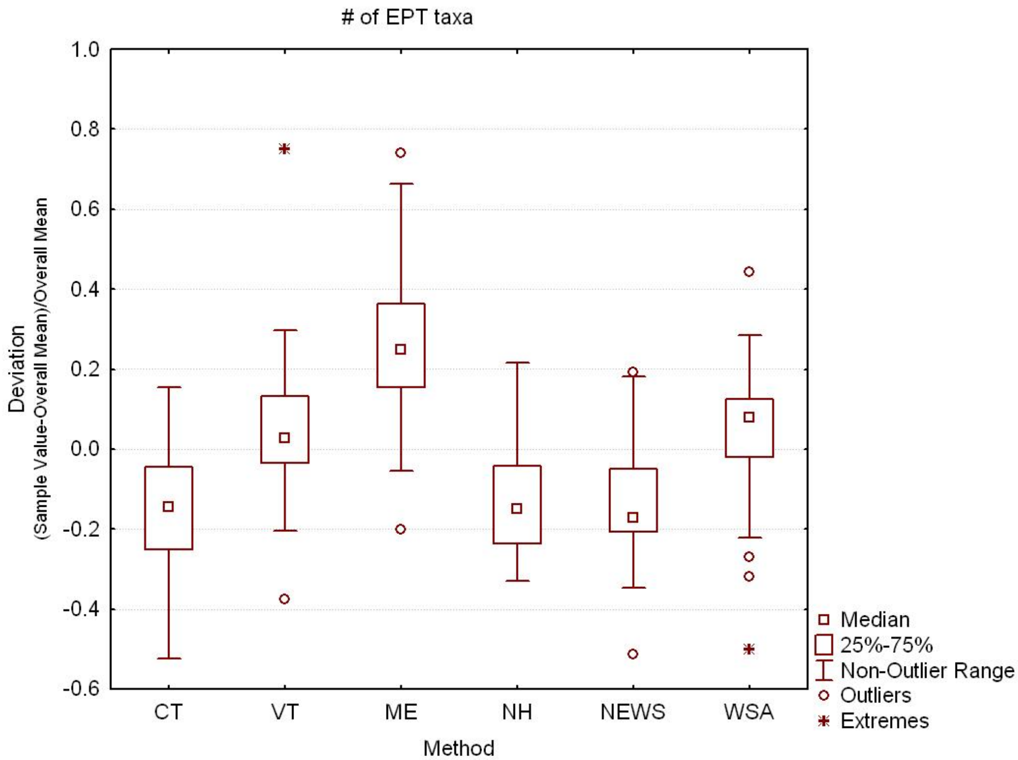

Figure 3-3. Box and whisker plots showing deviations from site means for # of EPT taxa calculations.

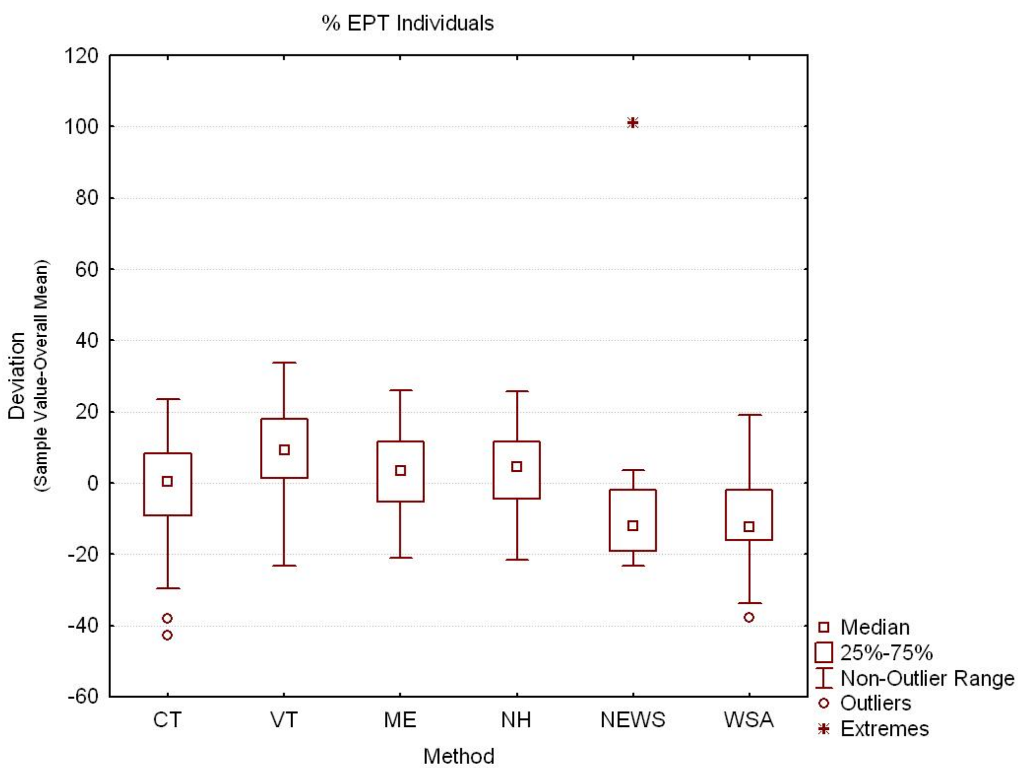

Figure 3-4. Box and whisker plots showing deviations from site means for % EPT calculations.

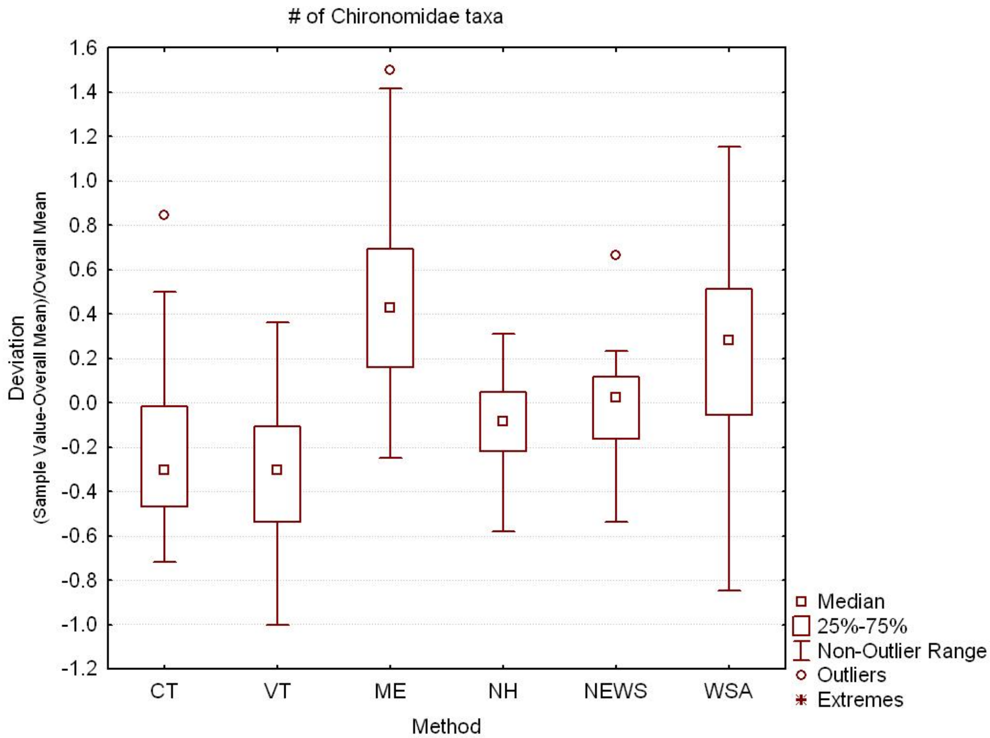

Figure 3-5. Box and whisker plots showing deviations from site means for # of Chironomidae taxa calculations.

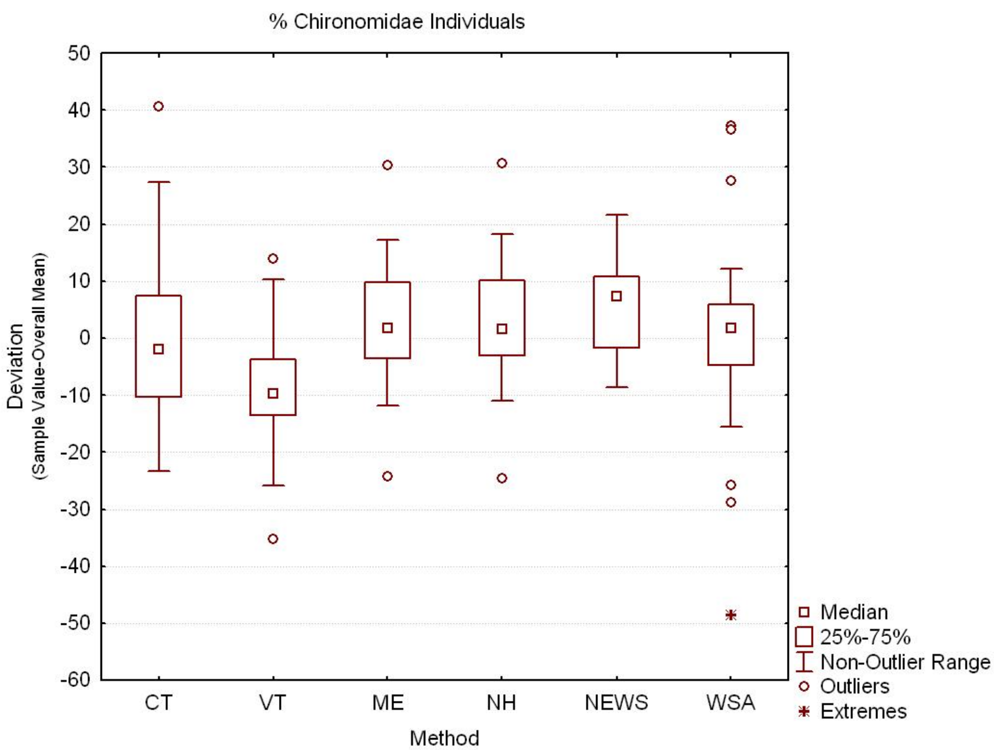

Figure 3-6. Box and whisker plots showing deviations from site means for % Chironomidae calculations.

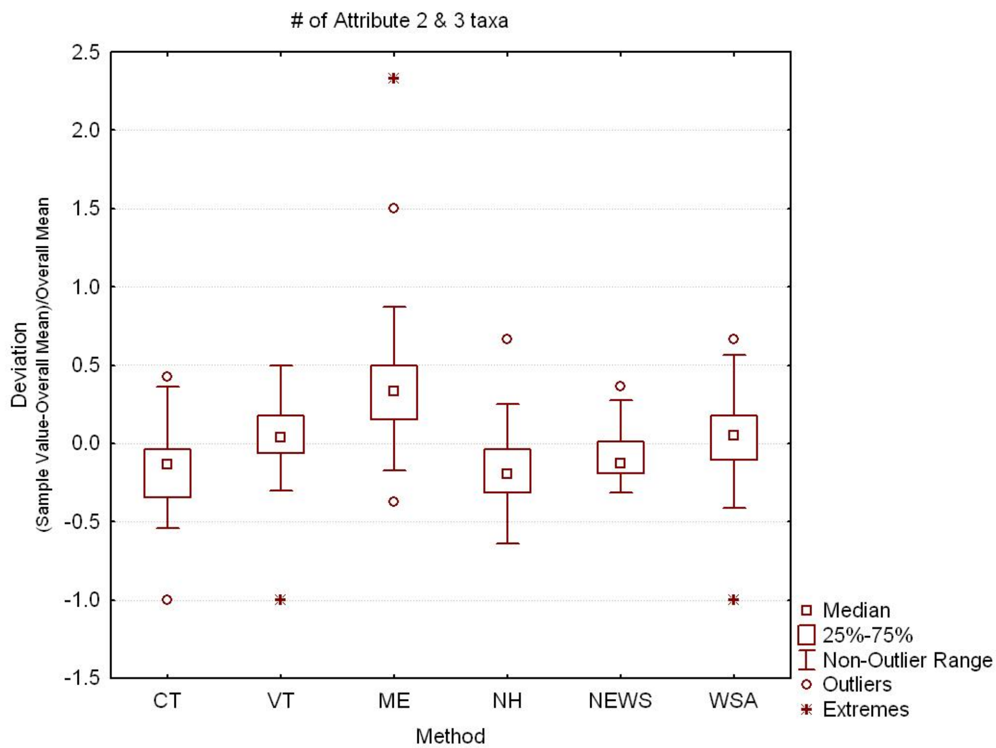

Figure 3-7. Box and whisker plots showing deviations from site means for # of Attribute 2 & 3 taxa.

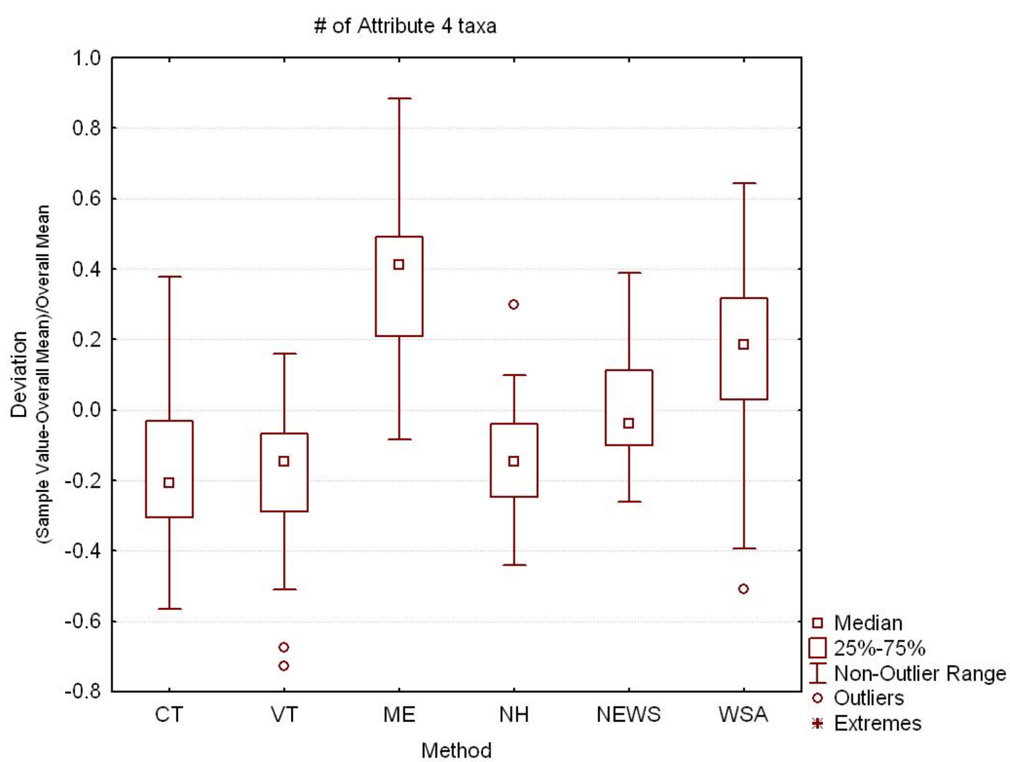

Figure 3-8. Box and whisker plots showing deviations from site means for # of Attribute 4 taxa.

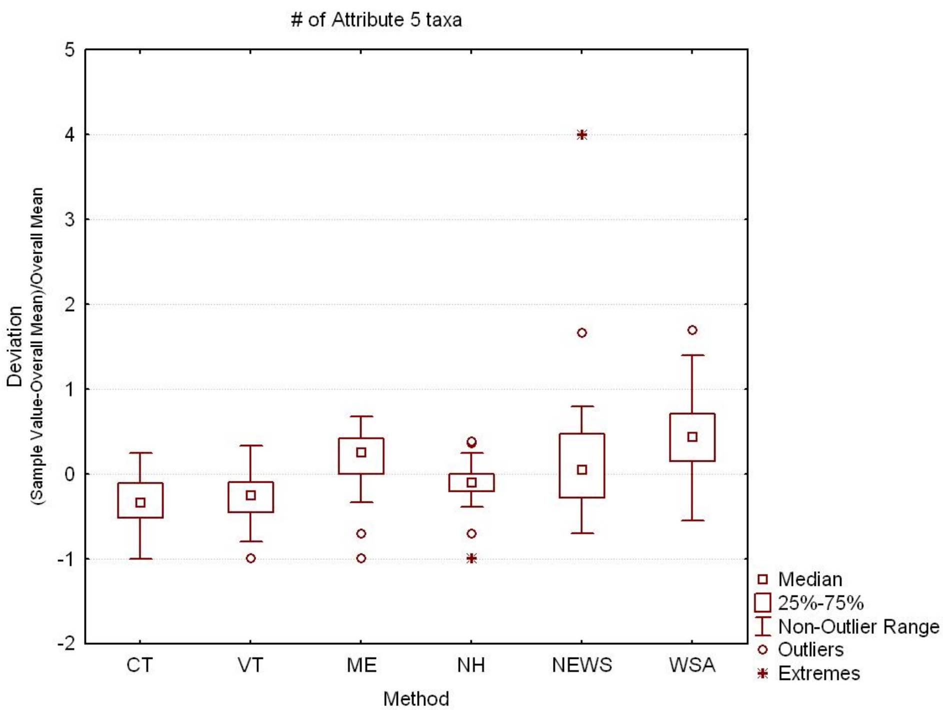

Figure 3-9. Box and whisker plots showing deviations from site means for # of Attribute 5 taxa.

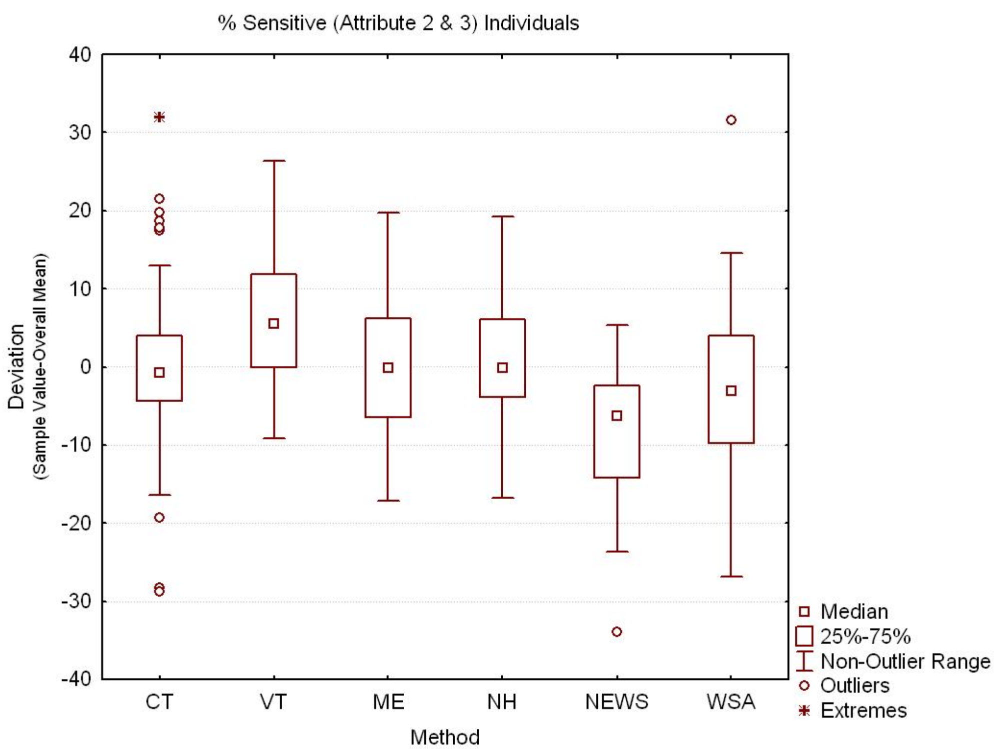

Figure 3-10. Box and whisker plots showing deviations from site means for % Sensitive taxa.

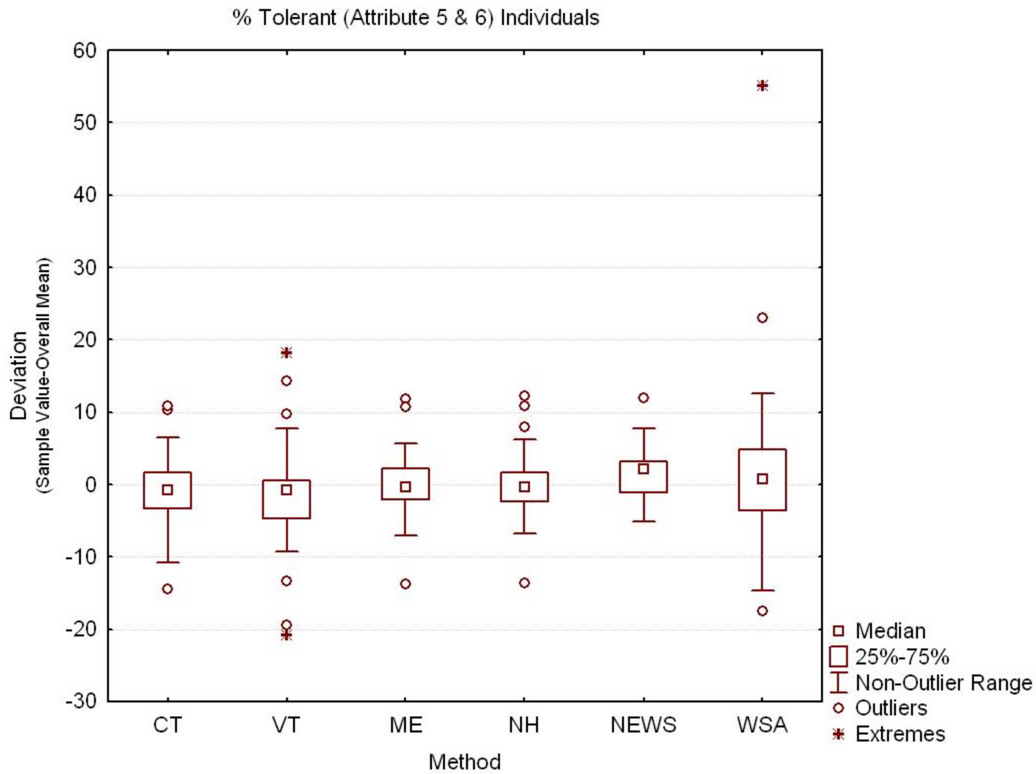

Figure 3-11. Box and whisker plots showing deviations from site means for % Tolerant taxa.

4 COMPARISON OF BCG LEVELS

4.1 Within States

There were 9 state participants in the BCG exercise: 3 from Maine, 1 from New Hampshire, 2 from Vermont and 3 from Connecticut. All of the participants had taken part in the NEWS project BCG development. Participants worked independently in coming up with BCG level assignments, but later discussed these assignments as a group, at which time some revisions were made. An evaluation of the differences in BCG level assignments within each state group (that had more than one participant) shows that assignments were almost always within a single level of each other (Table 4-1). The maximum difference in level assignments was 2. This occurred at 3 sites for both the ME DEP and VT DEC groups (it should be noted that one of these sites for the VT DEC group was a low gradient site). ME DEP participants differed by 1 level at most sites (32). The VT DEC participants had the greatest number of full agreements (22) ('full agreements' refers to sites at which the same BCG levels were assigned), followed by the CT DEP group (20). The most number of full agreements for the VT DEC and CT DEP groups occurred at BCG level 3 and 5 sites, while the ME DEP group had the greatest number of full agreements at BCG level 2 and 5 sites.

There were a few consistent patterns in how some participants made BCG level assignments. Within the ME DEP group, one participant tended to assign sites to lower levels than the others, while another participant did the opposite. In the VT DEC group, one participant consistently assigned higher BCG levels to sites. Despite these patterns, overall differences within the groups were slight (the maximum mean difference in BCG level assignments was 0.3).

Table 4-1. Summary of BCG level assignment differences within each state group.

Dif'ce (Max-Min) in Participant BCG Level Assignments at each site	# of Sites in each Dif'ce Category		
	ME	CT	VT
0	7	20	22
1	32	24	19
2	3	0	3

4.2 Across States

An evaluation of the differences in mean BCG level assignments among states shows that assignments were consistently within 1 level of one another. Mean state BCG assignments differed by 1 level at 30 sites and were in full agreement at 9 sites (Table 4-2). The maximum difference was 2, which occurred at 5 sites Hardy Brook (mean state level assignments ranged from 1 to 3), Beaver Brook (mean state level assignments ranged from 3 to 5), Saugatuck River (mean state level assignments ranged from 2 to 4), Stevens Branch (mean state level assignments ranged from 3 to 5) and Warren Brook (mean state level assignments ranged from 2 to 4). At 4 of these sites, ME DEP gave the sites the best ratings, and at all 5, NH DES assigned the worst ratings. This is consistent with the overall average, in which the mean of all the ME DEP level assignments was 0.3 less than the mean of all the state group assignments and the NH DES assignment was 0.3 more. Mean CT DEP and VT DEC level assignments did not differ from the overall mean.

Table 4-2. Summary of differences between maximum and minimum mean state BCG level assignments at each site.

Dif'ce (Max-Min) in Mean State BCG Level Assignments at each site	# of Sites in each Dif'ce Category
0	9
1	30
2	5

A comparison of mean BCG level assignments derived from CT DEP and VT DEC kick samples versus the ME DEP and NH DES rock basket samples shows that there is good overall agreement between the two types of collection methods (r^2=0.85) (Figure 4-1). The greatest difference occurred at Beaver Brook, which is considered to be a low gradient site.

At the workshop, the participants discussed several of the sites at which BCG level assignments were most different. It became apparent that these sites were generally influenced by unique site-specific factors. For example, at the Merriland River site, 2 of the CT DEP participants made BCG level 4 and 5 assignments, while the other state participants assigned BCG levels of 2 or 3. Closer examination of the site revealed that the habitat (predominantly boulders) was inappropriate for the CT DEP collection method, so the CT DEP method samples for this site were excluded from further analysis. At another site, Hardy Brook, individual BCG level assignments ranged from 1 to 4. This site appeared to have been influenced by a recent disturbance, such as a major flow event. Because of the unstable nature of the assemblage, participants felt that it was not a good site to include in the analyses. At the Dinsmore Pond Brook site, BCG level assignments initially ranged from 2 to 4. When it was revealed that the site was influenced by a nearby wetland and had low gradient characteristics, participants adjusted their expectations and came to closer agreement. Two questions arose several times during the discussion: 1. How to better define BCG level 2 versus level 3 sites; and 2. How to define a BCG level 6 site in a consistent way across states (i.e. VT DEC considers the West Branch Ompompanoosuc site to be a 6, but the worst site in Vermont is likely to be better than the worst site in Connecticut).

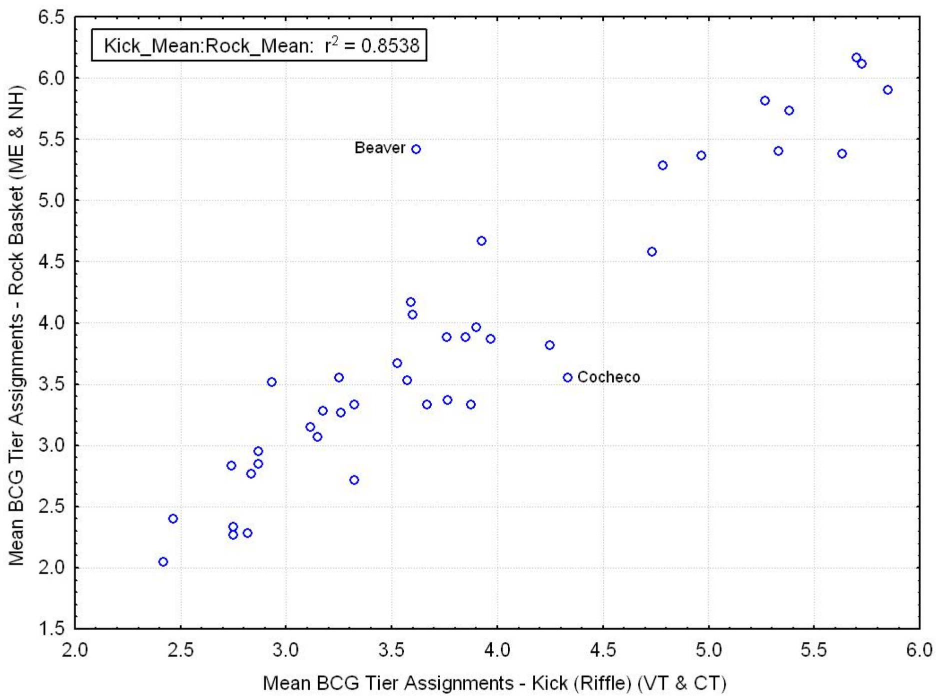

Figure 4-1. Plot of mean BCG level assignments for kick samples collected using the VT and CT methods versus rock basket samples collected using the ME and NH methods. Sites at which the greatest differences occurred are labeled (Beaver and Cocheco).

Reasons behind the participants' BCG level assignments were also discussed. The most commonly cited factors were:

- Total richness
- Total abundance or density
- Various measures of EPT taxa
- Numbers and relative abundances of the different BCG attribute level taxa
- Measures of balance/evenness/dominance
- Specific taxa (i.e. Hydropsychidae, Maine Class A indicator taxa, CT screening taxa)
- % Collector-filterers
- % Chironomidae
- % Oligochaetes
- % Non-insects
- Dipterans
- Fine particulate feeders
- Five most dominant taxa

4.3 CT and NEWS fuzzy models

Comparisons were made between state BCG level assignments and CT and NEWS fuzzy model results at each site. Overall, there was good agreement between the state and fuzzy model assignments. At most sites, results were within 1 level of one another (Tables 4-3 and 4-4). CT DEP and VT DEC method (kick net – riffle habitat) samples had slightly better agreement with the CT fuzzy model results than with the NEW fuzzy model results. They also had slightly better agreement with the CT fuzzy model results than the rock basket samples. It is worth noting that results from one of the CT DEP samples were excluded from this comparative analysis. This was the Hardy Brook sample, which the fuzzy models assigned to a BCG level 6 but the CT participants assigned to a BCG level 2. This was because the assignments were based on different replicates. The fuzzy model calculations had been based on the first replicate sample, which was an anomalous sample with very few individuals, while the CT participants had assessed the second replicate sample, which had higher abundances.

Table 4-3. Summary of differences between mean state BCG level assignments and CT fuzzy model assignments at each site.

Dif'ce between mean state BCG Level Assignments and CT fuzzy model BCG Level Assignments at each site	# of Sites in each Dif'ce category			
	CT	VT	NH	ME
0	24	19	16	22
1	18	24	22	18
2	0	1	3	2

Table 4-4. Summary of differences between mean state BCG level assignments and NEWS fuzzy model assignments at each site.

Dif'ce between mean state BCG Level Assignments and NEWS fuzzy model BCG Level Assignments at each site	# of Sites in each Dif'ce category			
	CT	VT	NH	ME
0	25	18	18	22
1	13	20	20	17
2	3	5	3	2
3	0	0	0	1

4.4 State assessment ratings

Comparisons were made between state BCG level assignments and state assessment results at each site. State assessment results generally matched with BCG level assignments, although there were some notable differences. The inconsistencies were most evident in the ME DEP method samples. As shown in Table 4-5 and Appendix G, 2 sites that received mean BCG level assignments of 4 or 5 were classified by the ME DEP linear discriminant models as being Class A. It is also worth noting that the ME DEP linear discriminant models categorized all 16 of the BCG level 3 sites as Class A, and that only 1 site was categorized as Class B. There are several possible reasons for the inconsistencies. The 2 Class A sites that had BCG level 4 or 5 assignments were affected by unique site-specific factors. One of the sites, Beaver Brook, is considered to be low gradient, and the West Branch Ompompanoosuc site is impacted by a nearby copper mine. Additional factors that likely account for the inconsistencies are the extended deployment periods of the rock baskets[2] and the fact that the ME DEP linear discriminant models are calibrated specifically for macroinvertebrate assemblages in Maine. Some of the ME DEP method samples that were collected in the other states had more EPT taxa than the participants were accustomed to seeing.

There are also some inconsistencies worth noting in the NH DES method samples. As shown in Table 4-6 and Appendix H, there were 4 sites that had BCG level 5 or 6 assignments that were categorized as 'fully supporting' based on NH MMI results. One of the sites, Stevens Branch, had an MMI score (54.2) that was on the threshold of being fully/non-supporting (54). Two of the other samples (West Branch Ompompanoosuc and Mad River) were also fairly close to the threshold (within 5 points). As noted earlier, the assemblage at the West Branch Ompompanoosuc site was influenced by unique site-specific factors.

Table 4-5. Comparison of mean ME DEP BCG level assignments and ME DEP linear discriminant model classifications (A, B, C NA).

Mean State BCG Level Assignment	# Sites			
	A	B	C	NA
1	3			
2	12			
3	16			
4	1		1	1
5	1	1		5
6				1

Table 4-6. Comparison of NH DES BCG level assignments and NH MMI results. FS=fully supporting, NS=not supporting water quality standards.

State BCG Level Assignment	# Sites	
	FS	NS
1		
2	6	
3	15	
4	6	3
5	3	5
6	1	2

As shown in Table 4-7 and Appendix I, CT MMI ratings were in close agreement with the CT DEP BCG level assignments. Samples that received BCG level assignments of 2 or 3 were all

[2] normally ME method samples are deployed for 28 ± 4 days but in this study, deployment periods averaged about 40 days (see Appendix A, Table A2**)**.

categorized as ‘meeting’ water quality standards based on the CT MMI results, and all those that received assignments of 5 were categorized as either ‘ambiguous’ or ‘failing.’ The CT MMI categorized BCG level 4 samples as either ‘meeting’ or ‘ambiguous.’ The VT DEC method samples had similar levels of agreement. Samples that received BCG level assignments of 5 or 6 were all rated as ‘Poor’ or ‘Fair-Poor’ and all the samples that were rated as ‘Excellent’ or ‘Excellent-Very Good’ received assignments of 2 or 3 (Table 4-8 and Appendix J). The BCG level 4 samples received a variety of ratings, ranging from ‘Very Good’ to ‘Fair-Poor.’

Table 4-7. Comparison of CT DEP BCG level assignments and CT MMI results.

Mean State BCG Level Assignment	# Sites		
	Meeting	Ambiguous	Failing
1			
2	9		
3	18		
4	3	3	
5		4	6
6			

Table 4-8. Comparison of mean VT DEC BCG level assignments and VT DEC state assessment results.

Mean State BCG Level Assignment	# Sites								
	Exc	Ex-Vgood	VGood	Vg-Good	Good	G-Fair	Fair	F-Poor	Poor
1									
2	2		1	1					
3	3	7	2	3	3	2	2		
4			1		4	1	1	1	
5								2	4
6									4

The relationship between the CT MMI and the NH MMI was also examined. There was a fair level of agreement between the 2 calculations (r^2=0.44) (Figure 4-2). The MMI scores tended to match most closely at the very best and the very worst sites.

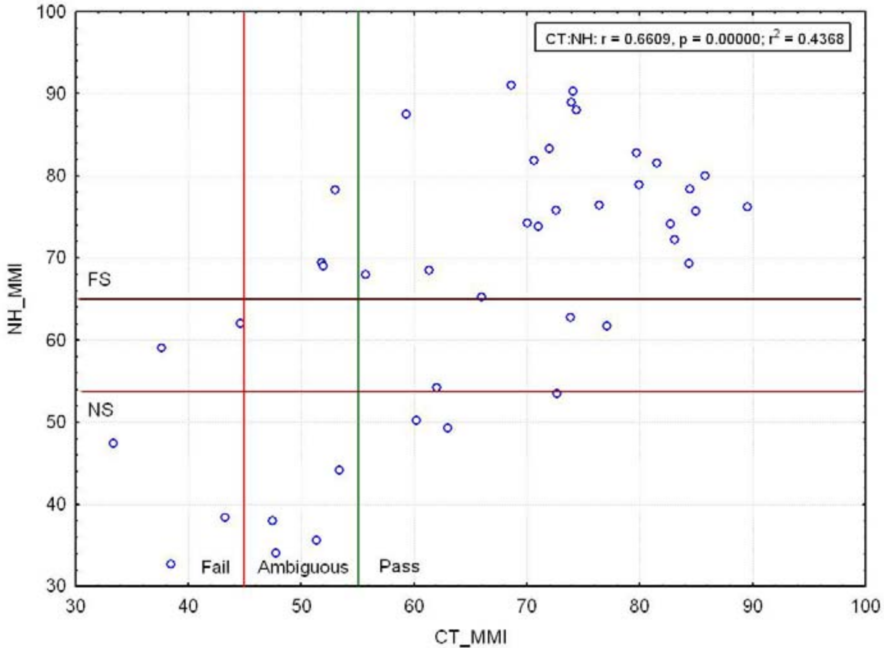

Figure 4-2. Plot of NH MMI scores versus CT MMI scores (n=42). For the NH MMI, FS = fully supporting water quality standards, NS=not supporting; the threshold is either 54 or 65, depending on site location. For the CT MMI, samples are considered to be 'failing' if scores are less than 45, 'ambiguous' 45-55 and 'meeting' standards if greater than 55.

4.5 WSA ratings

Comparisons were made between state BCG level assignments, state assessment results and WSA MMI ratings. There is fairly strong agreement between the WSA MMI and CT MMI scores (linear regression r^2=0.61) (Figure 4-3), as well as between WSA ratings and CT DEP BCG level assignments. There are 3 sites at which the CT MMI categorized samples as 'meeting' water quality standards and the WSA MMI categorized samples as being in 'poor' condition. The site at which the greatest difference occurred (WSA MMI score of 21.7 versus a CT MMI score of 63) is Beaver Brook, which is considered to be a low gradient site. The other 2 sites have scores that are close to the WSA and CT MMI scoring thresholds.

There is less agreement between the WSA MMI and NH MMI, but overall the two methods are fairly well matched (linear regression r^2=0.44) (Figure 4-4). The MMI scores tend to match most closely at the very best and the very worst sites. The biggest difference occurred at the Mad River site (NH MMI score of 59 versus WSA MMI score of 20). MMI scores differ by over 30 points at 5 other sites as well. There is a fair amount of consistency between BCG level assignments and WSA ratings. Most of the samples that received BCG assignments of 5 or 6 are rated as 'poor' by the WSA MMI. Samples that were categorized as 'good' by the WSA MMI received BCG level assignments ranging from 2 to 4, and those that were categorized as 'fair' received BCG level assignments ranging from 2 to 5.

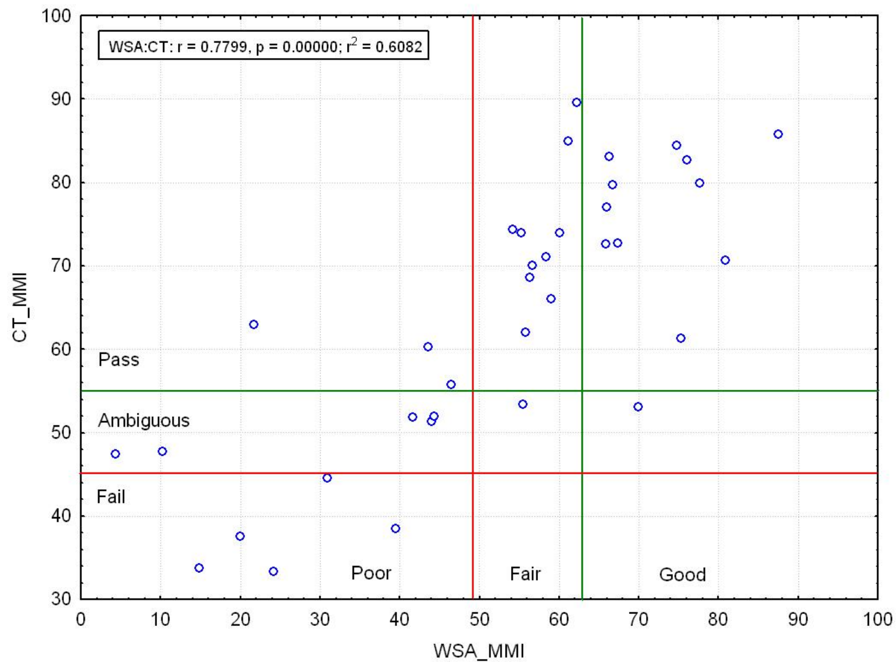

Figure 4-3. Plot of CT MMI scores versus WSA MMI scores (n=36). For the CT MMI, samples are considered to be failing if scores are less than 45, ambiguous 45-55 and meeting standards if greater than 55. For the WSA MMI scores, samples are considered to be 'poor' if scores are less than 49, 'fair' if 49-63 and 'good' if scores are greater than 63.

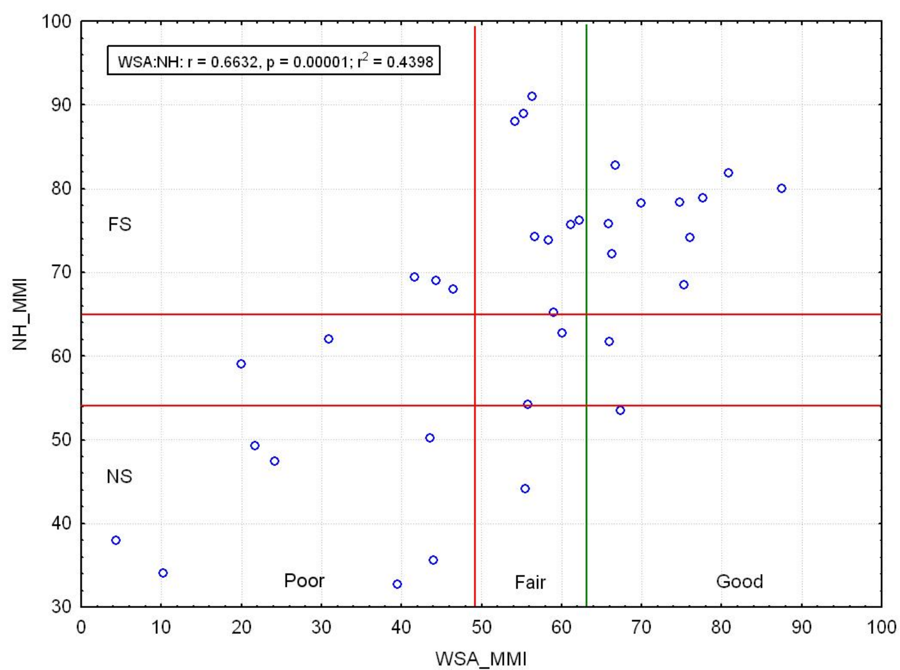

Figure 4-4. Plot of NH MMI scores versus WSA MMI scores (n=36). For the NH MMI, FS = fully supporting water quality standards, NS=not supporting; the threshold is either 54 or 65, depending on site location. For the WSA MMI scores, samples are considered to be 'poor' if scores are less than 49, 'fair' 49-63 and 'good' if scores are greater than 63.

VT DEC takes into account multiple metrics when assessing samples, but they do not calculate a final numeric MMI score like CT DEP and NH DES. Instead they assign 1of 9 possible ratings to a sample, ranging from 'excellent' to 'poor.' The lack of a numeric MMI score prevents us from being able to quantify the relationship between the VT state rating and the WSA MMI. However, plotting the results as shown in Figure 4-5 allows for comparison of the 2 methods. Overall there is a fair amount of agreement, with ratings tending to match most closely at the very best and the very worst sites. There was one site in particular that had a fairly large discrepancy. This was the Kenduskeag River sample, which the VT state assessment method categorized as 'very good' and the WSA MMI categorized as 'poor.' The Kenduskeag River is considered to be a low gradient site. There is a fair amount of consistency between BCG level assignments and WSA ratings. Most of the samples that received BCG level assignments of 4, 5 or 6 were rated as 'poor' by the WSA MMI. Samples that were categorized as 'good' by the WSA MMI received BCG level assignments of 2 or 3, and those that were categorized as 'fair' received assignments ranging from 2 to 5.

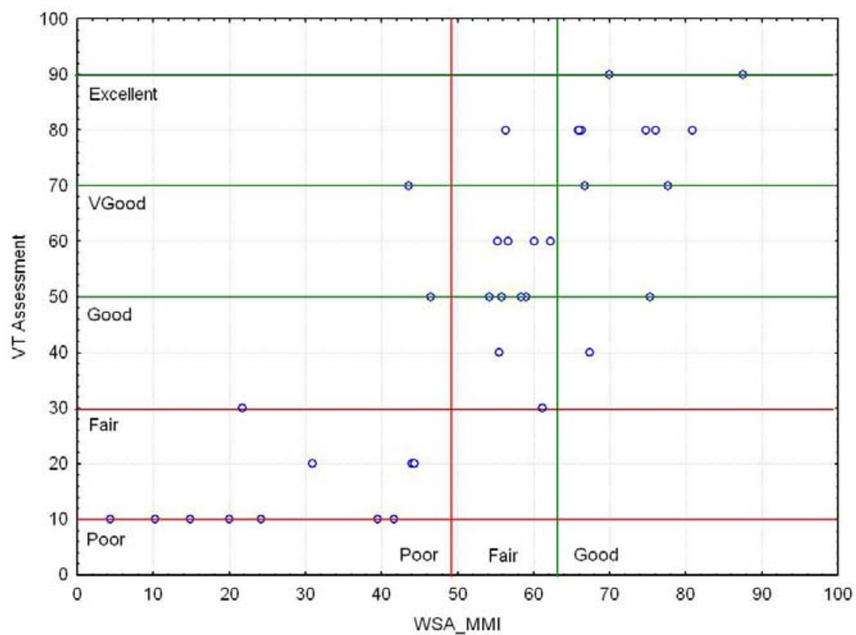

Figure 4-5. Plot of VT DEC state ratings versus WSA MMI scores (n=36). Vermont does not calculate a numeric value, but rather assigns one of 9 ratings, ranging from excellent to poor. For purposes of creating this plot, numeric values were assigned to each of these 9 categories. For the WSA MMI scores, samples are considered to be 'poor' if scores are less than 49, 'fair' 49-63 and 'good' if scores are greater than 63.

Similar to VT DEC, ME DEP takes into account multiple metrics when assessing samples, but does not calculate a final numeric MMI score. Instead, ME DEP assigns 1of 4 possible classifications to a sample, ranging from Class A to NA. Results are plotted in Figure 4-6. Comparisons are difficult because the samples for which WSA ratings are available only received A, C, or NA classifications, and most of these samples are categorized as Class A. The greatest difference between ratings occurred at Beaver Brook, which is a low gradient site. The other low gradient site, the Kenduskeag River, also had a discrepancy between the ME DEP assessment (Class A) and the WSA rating (poor), but at this site the WSA MMI score was close to the poor/fair threshold. Overall there is consistency between BCG level assignments and WSA ratings, although some of the samples that were categorized as 'fair' received better BCG level assignments than expected (BCG levels ranged from 1 to 3). Samples that received BCG level assignments of 4, 5 or 6 were rated as 'poor' by the WSA MMI, and those that were rated as 'good' by the WSA MMI received BCG level assignments of 2 or 3.

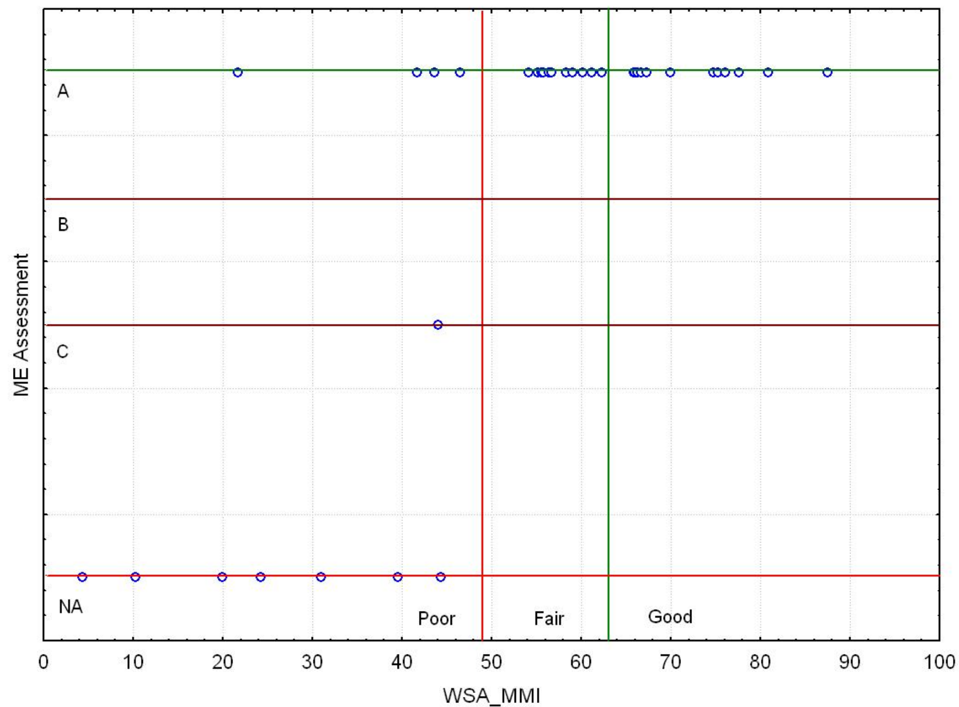

Figure 4-6. Plot of ME state classifications versus WSA MMI scores (n=36). ME DEP does not calculate a numeric value, but rather assigns samples to one of 4 classifications: A, B, C or NA (there were no B samples in the dataset that was used to make this plot). For purposes of creating this plot, numeric values were assigned to each of classifications. For the WSA MMI scores, samples are considered to be 'poor' if scores are less than 49, 'fair' 49-63 and 'good' if scores are greater than 63.

5.0 COMPREHENSIVE DECISION RULES AND THE NEW ENGLAND BCG MODEL

5.1 Site Assignments and BCG level Descriptions

As mentioned in Section 2.3, the workgroup examined macroinvertebrate data from 44 sites and each state assigned BCG levels to each site (except for 3 sites with missing data; Appendix F). Data for each site, notes and decisions are shown in Appendix F. The assignments, and level of agreement, were discussed above in Section 4. The WSA and NEWS samples were not assigned a BCG level because participants were not familiar enough with the sampling methodology and resultant data to be comfortable making assignments.

The group was able to distinguish 4 separate BCG levels (BCG levels 2-5). The first BCG level described in Davies and Jackson (2006) consists of entirely pristine sites, and was not included because there was no clear consensus whether BCG level 1 (pristine) sites occurred in the data set. Nevertheless, several individual participants assigned BCG level 1 to some sites, but there was never a majority opinion for Level 1. Further examination may be necessary to determine if these sites meet criteria for "minimally disturbed" (Stoddard et al., 2006). Similarly, there was never a majority opinion for BCG Level 6.

5.2 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. Statistical summaries of each attribute metric and BCG level are given in Table 5-1, and are shown graphically in Figures 5-1 and 5-2. Two of the metrics, total taxa and number of Attribute IV taxa (Figure 5-1) seem to show an "intermediate disturbance" effect, having higher values in BCG Level 3 (total taxa) or BCG Level 4 (Attribute IV taxa), than in the lower or higher BCG Levels. Other attributes were relatively more monotonic, increasing or decreasing as the assigned BCG went from 2 to 5 (Figs. 5-1, 5-2)

We found that most biologists preferred to use taxon richness within the two sensitive attributes as the most important criteria for determining site BCG level assignments. Thus, the number of highly sensitive taxa was most often used to distinguish between BCG level 2 and level 3 sites. BCG level 2 should have several highly sensitive taxa (Attribute II), but their richness may be reduced in level 3 (Figure 5-1). For example, a rule for BCG level 2 could be that highly sensitive taxon richness (Attribute II taxon richness) should be more than three to five taxa (Figure 5-1; Table 5-2). BCG level 3 is also discriminated from level 4 by total number of sensitive taxa, and by % sensitive individuals. BCG levels 4 and 5 are discriminated from each other by the almost complete loss of sensitive taxa in level 5 (richness and relative abundance); and concomitant increase in relative abundance of tolerant taxa.

Table 5-1. Ranges of attribute metrics in samples by group nominal (majority) BCG levels.

Attributes	Group assigned BCG level (nominal)				
	1	BCG 2 (n=9)	BCG 3 (n=20)	BCG 4 (n=6)	BCG 5 (n=9)
0 General		Richness 17 - 82	Richness 25 - 97	Richness 15 - 88	Richness 10 - 65
I Endemics					
II Highly sensitive taxa		# Taxa 1 - 12 % of taxa 2.5 – 35%	# Taxa 0 - 13 % of taxa 0 - 23%	# Taxa 0 - 6 % of taxa 0 – 22%	# Taxa 0 - 2 % of taxa 0 – 6%
III Intermediate Sensitive taxa		# Taxa 6 - 27 % of taxa 23 – 61%	# Taxa 4 - 27 % of taxa 8 – 47%	# Taxa 4 - 22 % of taxa 8 – 40%	# Taxa 0 - 12 % of taxa 0 – 25%
II + III All sensitive taxa		# Taxa 12 - 37 % of taxa 31 – 83% % of indiv. 16 – 80%	# Taxa 7 - 38 % of taxa 16 – 67% % of indiv. 5 – 76%	# Taxa 5 - 27 % of taxa 12 – 60% % of indiv. 2.4 – 45%	# Taxa 0 - 12 % of taxa 0 – 25% % of indiv. 0 – 21%
IV Intermediate Tolerant taxa		% of indiv. 13 – 71%	% of indiv. 7.5 – 89%	% of indiv. 17 – 77%	% of indiv. 5 – 89%
V Tolerant taxa		% of indiv. 0.7 – 41%	% of indiv. 2.2 – 65%	% of indiv. 2.5 – 73%	% of indiv. 7 – 95%

Table 5-2. Candidate decision rules for New England streams. Ranges in parentheses denote fuzzy membership function.

Attributes	BCG level					
	1	2	3	4	5	6
0 General		2.1 Total taxa > (19-23) 2.2 count > (50–55%) of target	3.1 Total taxa > (19–23) 3.2 count > (50–55%) of target	4.1 Total taxa > (17–21) 4.2 count > (50–55%) of target	5.1 Total taxa > (8–12) 5.2 count > (50–55%) of target	6.1 Total taxa < (8–12) 6.2 Count < (50 - 55%) of target
I Endemics						
II Highly sensitive taxa		2.3 % Taxa II > (10 – 15%)	May be absent			
III Sensitive taxa		2.4 % Taxa (II+III) > (40–50%) 2.5 % Indiv (II + III) > (30–40%)	3.3 % Taxa (II+III) > (25 – 30%) 3.4 % Indiv (II+III) > (30–40%)	4.3 % Taxa (II+III) > (15 – 25%) 4.4 % Indiv (II+III) > (10–20%)		
IV Intermediate tolerant taxa		(no rule)	(no rule)	(no rule)	(no rule)	
V Tolerant taxa (all)		2.6 % Indiv V < (15–20%)	3.5 % Indiv V < (40–50%)	4.5 % Indiv V < (65–75%)		
Combining Rule		2.1, 2.2, 2.3, 2.4 and (2.5 or 2.6) Total taxa (rule 2.1) allowed to fail if all other rules succeed	Fails any level 2 rules 2.2-2.6, and 3.1, 3.2, 3.3, and (3.4 or 3.5)	Fails any level 2 rules 2.2–2.6 and fails level 3 rules 3.3–3.5 and 4.1, 4.2, 4.3, and (4.4 or 4.5)	Fails level 2 rules 2.2–2.6, and level 3 rules 3.2–3.5 and level 4 rules 4.2–4.5, and 5.1 and 5.2	Fails all higher levels

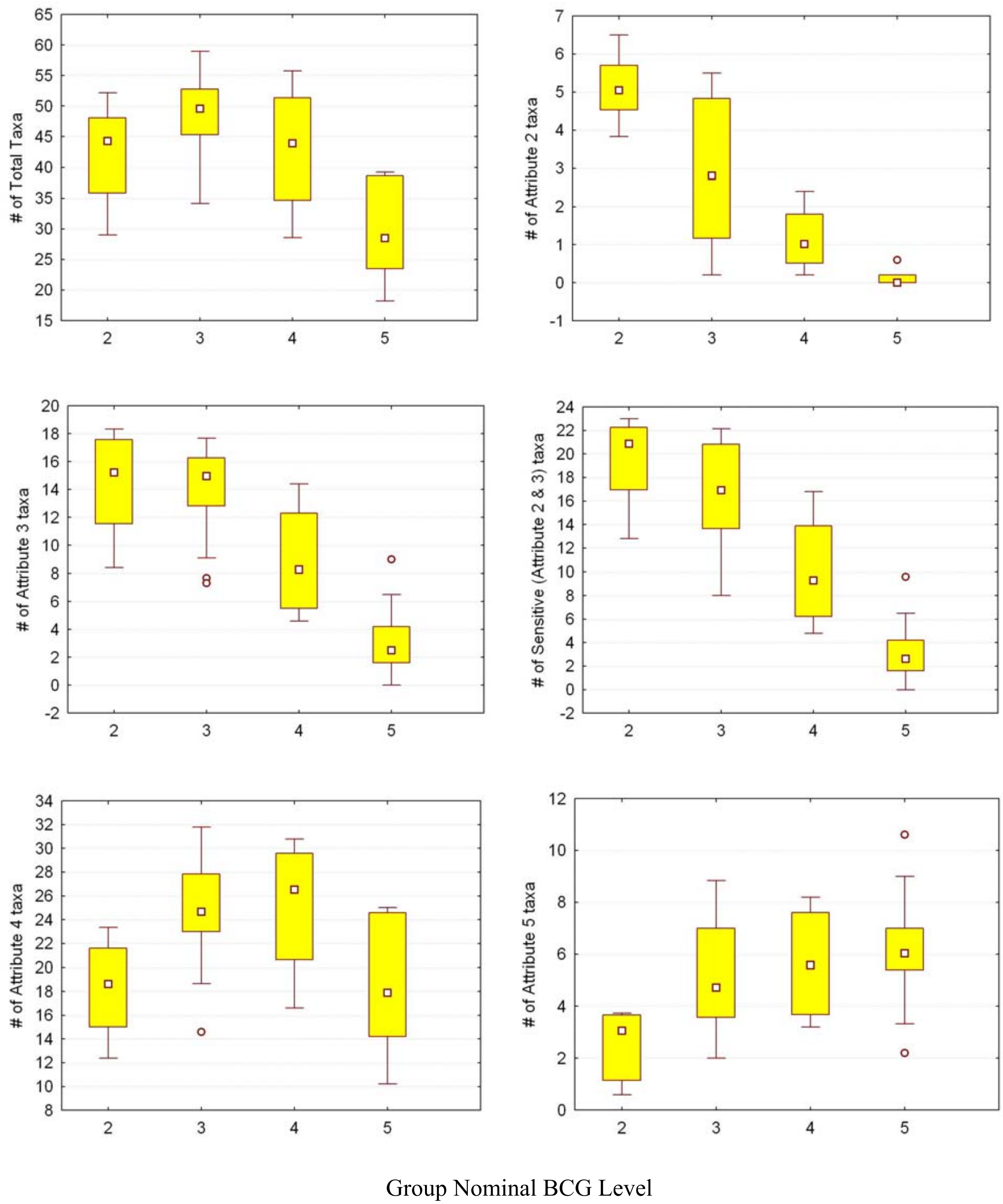

Figure 5-1. Box plots of BCG taxon richness metrics, by nominal BCG level (group majority choice) for 44 assigned sites, state methods. Metric values represent the overall mean values for each site.

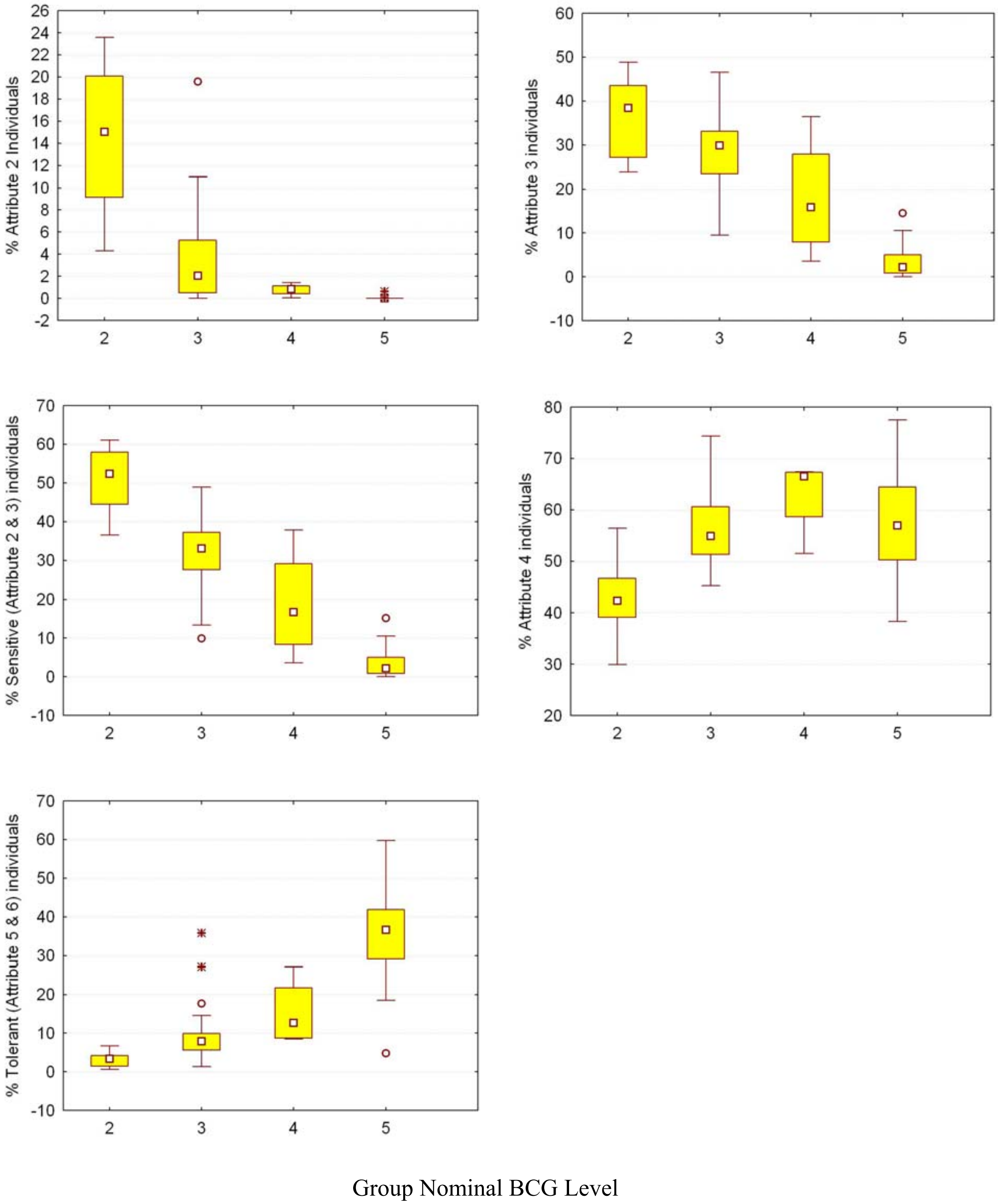

Figure 5-2. Box plots of percent composition BCG metrics, by nominal BCG level (group majority choice) for 44 assigned sites, state methods. Metric values represent the overall mean values for each site.

In order to have a set of universal rules that could be used to assess all samples regardless of methodology, we needed a standardization of quantities or metrics to be used in the rules. Because the subsampling and sampling effort differs among the methods (100 count subsamples to complete counts; 1-4 m^2 area sampled), total counts and taxa richness also differ among the methods (e.g., Figures 3-1, 3-3, 3-5). In contrast, metrics of the percent of individuals vary much less among methods (e.g., Figures 3-4, 3-6). We standardized taxa richness metrics by the total number of taxa in a sample, expressed as percent of taxa (Table 5-1).

5.3 BCG Rule Development

The Connecticut BCG model, when applied to all data, predicted the group consensus for all sites with 65% acuracy. It was subsequently used as a basis for developing the more generalized BCG model for all methods. Based on the characterization of sites identified as belonging to different BCG levels (Table 5-1), we developed a set of rules for distinguishing levels. The candidate rules are shown in Table 5-2. The rules are candidate because they have not yet been verified by the expert panel of state biologists.

Following the observations shown in Table 5-1, Figure 5-1, and 5-2; and statements made by panel members in this and earlier (NEWS, Connecticut) BCG calibrations, the rules follow a general pattern of decreasing richness of sensitive taxa and increasing relative abundance of tolerant individuals as biological condition degrades. BCG Level 2 requires the highest representation of highly sensitive taxa (Attribute II), and these may be absent in Level 3 and lower samples (Table 5-2). Level 3 requires a minimum proportion of taxa and individuals of sensitive taxa, but does not distinguish between highly sensitive and moderately sensitive (Attributes II and III). Both Levels 2 and 3 have a rule for the maximum proportion of tolerant taxa.

BCG Level 4 is characterized by decreased richness and abundance of sensitive taxa (Attribute II taxa are only occasionally encountered in sites rated Level 4), but the sensitive taxa are not absent – they must still comprise more than 15 – 25% of taxa, and more than 10 – 20% of individuals (Table 5-2). Level 5 is discriminated from Level 4 by the disappearance of sensitive taxa to occasional individuals, such that they are no longer a functional part of the assemblage. Level 5 may still have substantial total taxa richness, but nearly all are either intermediate (Attribute IV) or tolerant (Attribute V). Level 6 is discriminated from Level 5 by the collapse of ecosystem function and taxa richness: richness may be severely reduced, or nearly all individuals are tolerant, or total abundance is severely reduced as indicated by failure to capture the target number of individuals (Table 5-2). The rules for BCG level 5 discriminate level 5 from level 6: failure of one of these rules means that a sample is assigned to level 6.

The rules are applied as a downward cascade: for a site to be rated as BCG level 2 (the highest described BCG level), all attributes must meet the level 2 condition (Table 4-2). A BCG level 3 rating requires one or more failures of level 2 rules, but the site must meet all minimum level 3 rules. The quantitative rules that follow from the linguistic rules are shown in Table 4-2.

5.4 Automated Decision Criteria Model

Many participants were also involved in developing decision rules for the earlier NEWS data analysis; and Connecticut had developed its own BCG calibration. Both of these sets of decision rules were also developed into multi-attribute decision models (implemented in MS-Excel and MS-Access). We applied both the Connecticut model and the NEWS model to the current data to help develop a single model that could be applied to all methods.

In order to develop the decision criteria inference model, each 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, and the membership functions of different classes of taxon richness are shown in Figure 5-3. We used piecewise linear functions to assign membership of a sample to the fuzzy sets shown (Figure 5-3). Numbers below a lower threshold have membership of 0, and numbers above an upper threshold have membership of one, and membership is a straight line between the lower and upper thresholds. For example, in Figure 5-3, a sample with 20 taxa would have a membership of 0.50 in the set "Low-moderate Taxa" and a membership of 0.50 in the set "Moderate Taxa."

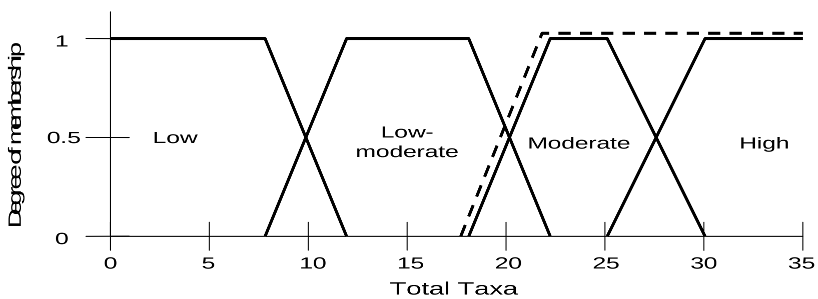

Figure 5-3. Fuzzy set membership functions assigning linguistic values of Total Taxa to defined quantitative ranges. Heavy dashed line shows membership of fuzzy set defined by "Total taxa are moderate to high."

Inference uses the logic statements developed by expert consensus. In "crisp" logic, an AND statement is the same as "Intersection" in crisp set theory, and logical OR is equivalent to set theory "Union". These are the same in fuzzy logic, however, a fuzzy AND uses the minimum membership of the two sets, and a fuzzy OR uses the maximum (Klir, 2004). For example, we may have a rule "If Highly Sensitive taxa are Moderate AND Sensitive Taxa are High, THEN level is 2." To illustrate this rule, suppose a sample has membership of 0.25 in the set: "Highly Sensitive taxa are Moderate" and membership of 0.75 in "Sensitive Taxa are High;" then its membership in level 2 is min(0.75, 0.25) = 0.25. Output of the inference model may include membership of a sample in a single level only, ties between levels, and varying memberships among two or more levels. The level with the highest membership value is taken as the nominal level.

The model was developed as an Excel spreadsheet, and is included as an attachment (electronic only).

5.4.1 Model Performance

Model output is membership of a sample in each of the levels described in Table 3-2. In most cases, a single level is given a membership value of 1, and all the rest 0. Often, a single level will have a highest value and one or more other levels will be given a lower, non-zero membership value. We considered any two membership values within 0.1 as a tied decision between the levels.

The fuzzy decision model was calibrated with the 42 high-gradient samples rated by the group. The final model treats the levels as a logical cascade from level 2 to level 6: failure of a rule for any level is considered a "success" for the next lower level.

Since all data (42 sites) were used to calibrate the model, we had no independent data set to test model performance. The only measure of the new model performance was the calibration data itself. We examined the performance of the NEIWPCC model, and the predecessor CT and NEWS models. 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 decision model nominal level matched the minority opinion of the panel (if there was a minority opinion). Percent correct are shown in Table 5-3. The NEIWPCC data collected with Connecticut methods also served as an independent test of the Connecticut decision model.

Table 5-3. Exact match and minority match rates of NEIWPCC, Connecticut, and NEWS decision models.

Model	Exact match (%)	Exact or minority match (%)	N
NEWS	55.7	73.1	218
Connecticut	67.4	85.3	218
CT model on CT assessments*	72.5	87.5	40
NEIWPCC	68.3	90.8	218

* This is an independent test of the CT model

The recalibrated NEIWPCC model performed substantially better than the NEWS model, but was not very different from the Connecticut model (Table 5-3). As would be expected, the CT model performed slightly better on CT data alone than on all data, and also slightly better than the NEIWPCC model performed on all data (The NEIWPCC model was very slightly better than the CT model on all data).

The NEIWPCC model had a slight tendency to rate sites a level better than the panel (40 samples received a better rating than the panel vs. 29 received a poorer rating), while the CT model was unbiased. The model's high bias tended to be all or nothing – all sampling methods from a site, or none, received the erroneous better rating. The lower ratings were not all or nothing.

Examination of the disagreements may also reveal inconsistencies by the human assessors; for example, the group may have assessed a sample as level 5 because of a single sensitive taxon among only 7 taxa total, while the rule had required more taxa to qualify for level 5. In other instances, the comparisons revealed the need for refining model calibration.

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APPENDIX A

Site Information

Table A1. List of the sites that were analyzed as part of the New England Methods Comparison study. Data was available for all 6 collection methods at 20 of the sites. Data are sorted by waterbody name. Note: Black Creek (StationID NEWS04-0905) was sampled in 2004 but the data were not used because it is considered to be a low gradient site.

#	StationID	WaterbodyName	State	Year Sampled	Site Selection	Collection Methods
1	ME-REF4	Aroostook River	ME	2004	Targeted - reference	ME, NH, VT, CT
2	VT-MC-05	Barney Brook	VT	2005	Targeted – Stressed (iron precipitate)	ME, NH, VT, CT, WSA
3	NEWS04-3406	Beaver Brook	NH	2004	Random	All
4	ME-MC-01	Birch Stream	ME	2005	Targeted - Stressed (Urban NPS, Airport)	ME, NH, VT, CT, WSA
5	VT-MC-06	Bolles Brook	VT	2005	Targeted – Stressed (pH)	ME, NH, VT, CT, WSA
6	NEWS04-1202	Carrying Place Stream	ME	2004	Random	All
7	NEWS04-3004	Cocheco River	NH	2004	Random	All
8	NH-01M-17	Cockermouth River	NH	2005	Targeted - Stressed (diffuse human disturbance)	ME, NH, VT, CT, WSA
9	NEWS04-3303	Dinsmore Pond Brook	NH	2004	Random	All
10	NEWS04-VT01	East Branch Passumpsic	VT	2004	Targeted - Reference	All
11	VT-MC-03	Gunner Bk	VT	2005	Targeted - Stressed (urban)	ME, NH, VT, CT, WSA
12	ME-19.01	Hardy Brook	ME	2004	Random	ME, NH, VT, CT, NEWS
13	ME-20.02	Higgins Brook	ME	2004	Random	ME, NH, VT, CT, NEWS
14	NEWS04-2401	Indian River	NH	2004	Random	All
15	NEWS04-1303	Kenduskeag River	ME	2004	Random	All
16	CT-65	Mad River	CT	2005	Targeted - Stressed (NPS, Habitat)	ME, NH, VT, CT, WSA
17	ME-27.01	Medomak River	ME	2004	Random	ME, NH, VT, CT
18	ME-MC-05	Merriland River	ME	2005	Targeted - Reference	ME, NH, VT, CT, WSA
19	NEWS04-2805	Mettawee River	VT	2004	Random	All
20	NEWS04-1801	Millers Run	VT	2004	Random	All
21	NH-00M-17	Nesenkeag Brook	NH	2005	Targeted - Stressed (moderate human disturbance)	ME, NH, VT, CT, WSA
22	NEWS04-4104	Pease Brook	CT	2004	Random	All
23	ME-MC-03	Penjajawoc Stream	ME	2005	Targeted - Stressed (Urban NPS)	ME, NH, VT, CT, WSA
24	CT-PR7	Pequabuck River	CT	2005	Targeted - Stressed (NPS, Habitat, Effluent)	ME, NH, VT, CT, WSA

Table A1. Continued…

#	StationID	WaterbodyName	State	Year Sampled	Site Selection	Collection Methods
25	NH-99C-58	Priest Brook	NH	2005	Targeted - Stressed (moderate human disturbance)	ME, NH, VT, CT, WSA
26	VT-MC-01	Rock River	VT	2005	Targeted - Stressed (agriculture)	ME, NH, VT, CT, WSA
27	NEWS04-CT03	Salmon River	CT	2004	Targeted - Reference	All
28	NEWS04-CT05	Saugatuck River	CT	2004	Targeted - Reference	All
29	NEWS04-1302	Schoodic Brook	ME	2004	Random	ME, NH, VT, CT, WSA
30	ME-MC-04	Sheepscot River	ME	2005	Targeted - Reference	ME, NH, VT, CT
31	NH-01M-06	Squam Brook	NH	2005	Targeted - Stressed (high human disturbance)	ME, NH, VT, CT
32	CT-NR21B	Steele Brook	CT	2004	Random	VT, CT, WSA
33	NEWS04-4003	Steele Brook	CT	2005	Random, then Targeted	All
34	VT-MC-04	Stevens Branch	VT	2005	Targeted - Stressed	ME, NH, VT, CT, WSA
35	CT-SR1A	Still River	CT	2005	Targeted - Stressed (NPS, Habitat)	VT, CT
36	NH-00M-18	Tannery Brook	NH	2005	Targeted - Stressed (high human disturbance)	ME, NH, VT, CT, WSA
37	NEWS04-2301	Third Branch White River	VT	2004	Random	All
38	CT-58	Trout Brook	CT	2005	Targeted - Stressed (NPS, Habitat)	ME, NH, VT, CT, WSA
39	ME-MC-02	Trout Brook	ME	2005	Targeted - Stressed (Urban NPS)	ME, NH, VT, CT, WSA
40	VT-MC-02	W Br Ompompanoosuc	VT	2005	Targeted – Stressed (metals from copper mine causing toxicity/habitat stress)	ME, NH, VT, CT, WSA
41	NEWS04-2907	Warren Brook	NH	2004	Random	All
42	NH-REF3	Whiteface River	NH	2004	Targeted - Reference	ME, NH, VT, CT, NEWS
43	NEWS04-3603	Willimantic River	CT	2004	Random	All
44	NEWS04-1001	Willoughby River	VT	2004	Random	All

Table A2. Collection dates for samples that were analyzed from each of the different methods. # Days Deployed refers to the ME and NH rock baskets. Based on ME protocols, rock baskets should be deployed for 28 ± 4 days. NH protocols call for a 42 to 56 day deployment period. One can see that there is a fair amount of variation from these standards in this dataset (minimum=25 days, maximum=77 days, mean=41 days), and this affects results for the state assessment methods (Maine's linear discriminant models in particular). Data are sorted by waterbody name.

State	StationID	WaterbodyName	# Days Deployed	Collection Method				
				ME & NH	CT	VT	NEWS	WSA
ME	ME-REF4	Aroostook River	41	9/30/2004	9/30/2004	9/30/2004	NA	NA
VT	VT-MC-05	Barney Brook	33	9/21/2005	9/21/2005	9/21/2005	NA	9/15/2005
NH	NEWS04-3406	Beaver Brook	54	10/18/2004	10/18/2004	10/18/2004	8/9/2004	8/9/2004
ME	ME-MC-01	Birch Stream	41	9/19/2005	9/19/2005	9/19/2005	NA	11/7/2005
VT	VT-MC-06	Bolles Brook	33	9/21/2005	9/21/2005	9/21/2005	NA	9/15/2005
ME	NEWS04-1202	Carrying Place Stream	41	10/19/2004	10/19/2004	10/19/2004	9/19/2004	9/17/2004
NH	NEWS04-3004	Cocheco River	48	10/14/2004	10/14/2004	10/14/2004	8/10/2004	8/10/2004
NH	NH-01M-17	Cockermouth River	34	10/6/2005	10/6/2005	10/6/2005	NA	10/6/2005
NH	NEWS04-3303	Dinsmore Pond Brook	43	10/13/2004	10/13/2004	10/13/2004	8/8/2004	8/8/2004
VT	NEWS04-VT01	East Branch Passumpsic River	33	9/23/2004	9/23/2004	9/23/2004	9/23/2004	8/21/2004
VT	VT-MC-03	Gunner Bk	37	9/25/2005	9/25/2005	9/25/2005	NA	9/13/2005
ME	ME-19.01	Hardy Brook	40	10/18/2004	10/18/2004	10/18/2004	9/16/2004	NA
ME	ME-20.02	Higgins Brook	41	10/19/2004	10/19/2004	10/19/2004	9/18/2004	NA
NH	NEWS04-2401	Indian River	54	10/21/2004	10/21/2004	10/21/2004	8/14/2004	8/14/2004, 9/8/2004**
ME	NEWS04-1303	Kenduskeag Stream	42	10/20/2004	10/20/2004	10/20/2004	9/22/2004	9/22/2004
CT	CT-65	Mad River	35	10/24/2005	10/24/2005	10/24/2005	NA	10/20/2005
ME	ME-27.01	Medomak River	43	10/21/2004	10/21/2004	10/21/2004	NA	NA

*2 replicates rather than 3 were collected at these sites (this may affect metric values).
**Repeat samples were taken at these sites (on different dates). We averaged data from the 2 sampling events when deriving metric values for these sites.
***We decided to exclude the WSA sample from the Whiteface site because there it was believed to have been taken from a different location.

Table A2. Continued…

State	StationID	WaterbodyName	# Days Deployed	Collection Method				
				ME & NH	CT	VT	NEWS	WSA
ME	ME-MC-05	Merriland River	41	9/22/2005	9/22/2005	9/22/2005	NA	10/7/2005
VT	NEWS04-2805	Mettawee River	35	9/28/2004	9/28/2004	9/28/2004	9/28/2004	8/15/2004
VT	NEWS04-1801	Millers Run	33	9/23/2004	9/23/2004	9/23/2004	9/23/2004	8/19/2004, 9/11/2004*
NH	NH-00M-17	Nesenkeag Brook	77	11/16/2005	11/16/2005	11/16/2005	NA	10/3/2005
CT	NEWS04-4104	Pease Brook	42	10/25/2004*	10/25/2004	10/25/2004	7/13/2004	7/13/2004
ME	ME-MC-03	Penjajawoc Stream	41	9/19/2005	9/19/2005	9/19/2005	NA	11/8/2005
CT	CT-PR7	Pequabuck River	31	10/20/2005*	10/20/2005	10/20/2004	NA	10/19/2005
NH	NH-99C-58	Priest Brook	71	11/10/2005	11/10/2005	11/10/2005	NA	10/4/2005
VT	VT-MC-01	Rock River	25	10/20/2005	9/19/2005	9/19/2005	NA	9/13/2005
CT	NEWS04-CT03	Salmon River	42	10/25/2004	10/25/2004	10/25/2004	7/9/2004	7/9/2004
CT	NEWS04-CT05	Saugatuck River	42	10/26/2004	10/26/2004	10/26/2004	7/7/2004	7/7/2004
ME	NEWS04-1302	Schoodic Brook	42	10/20/2004	10/20/2004	10/20/2004	NA	9/19/2004
ME	ME-MC-04	Sheepscot River	41	9/21/2005	9/21/2005	9/21/2005	NA	NA
NH	NH-01M-06	Squam Brook	34	10/6/2005	10/6/2005	10/6/2005	NA	NA
CT	CT-NR21B	Steele Brook		NA	10/20/2005	10/20/2005	NA	10/20/2005
CT	NEWS04-4003	Steele Brook	34	10/18/2004	10/18/2004	10/18/2004	7/10/2004	7/10/2004
VT	VT-MC-04	Stevens Branch	35	9/23/2005	9/23/2005	9/23/2005	NA	9/13/2005
CT	CT-SR1A	Still River		NA	10/24/2005	10/24/2005	NA	NA
NH	NH-00M-18	Tannery Brook	34	10/6/2005	10/6/2005	10/6/2005	NA	10/5/2005
VT	NEWS04-2301	Third Branch White River	34	9/27/2004	9/27/2004	9/27/2004	9/27/2004	8/16/2004
CT	CT-58	Trout Brook	32	10/21/2005	10/21/2005	10/21/2005	NA	10/19/2005

*2 replicates rather than 3 were collected at these sites (this may affect metric values).

**Repeat samples were taken at these sites (on different dates). We selected data from the dates that were closest to the NEWS sampling dates (or if NEWS samples were not taken, closest to the state method dates).

***We decided to exclude the WSA sample from the Whiteface site because there it was believed to have been taken from a different location.

Table A2. Continued…

State	StationID	WaterbodyName	# Days Deployed	Collection Method				
				ME & NH	CT	VT	NEWS	WSA
ME	ME-MC-02	Trout Brook	41	9/20/2005	9/20/2005	9/20/2005	NA	10/8/2005
VT	VT-MC-02	W Br Ompompanoosuc	38	9/26/2005	9/26/2005	9/26/2005	NA	9/14/2005
NH	NEWS04-2907	Warren Brook	51	10/21/2004	10/21/2004	10/21/2004	7/21/2004	7/21/2004
NH	NH-REF3	Whiteface River	60	10/25/2004	10/25/2004	10/25/2004	8/11/2004	NA***
CT	NEWS04-3603	Willimantic River	36	10/13/2004	10/13/2004	10/13/2004	7/12/2004	8/6/2004, 7/12/2004**
VT	NEWS04-1001	Willoughby River	33	9/23/2004	9/23/2004	9/23/2004	9/23/2004	8/20/2004

*2 replicates rather than 3 were collected at these sites (this may affect metric values).
**Repeat samples were taken at these sites (on different dates). We selected data from the dates that were closest to the NEWS sampling dates (or if NEWS samples were not taken, closest to the state method dates).
***We decided to exclude the WSA sample from the Whiteface site because there it was believed to have been taken from a different location.

Table A3. Site information for sites that were analyzed for the New England Methods Comparison study. The land use values are for the upstream catchment area. %DEVL=% developed, %FOR=%forested, %AGR=% agriculture. WS Area=upstream catchment area. Data are sorted by waterbody name. Additional information (i.e. TN and TP, % sand/fines) is available for some sites but not others. It was difficult to find parameters that were consistently collected at every site and that were reported in a standardized format.

State	StationID	WaterbodyName	Long_Dec	Lat_Dec	Source of Data	Elev (ft)	WS Area (km2)	pH	COND	% DEVL	% FOR	% AGR
ME	ME-REF4	Aroostook River	-68.36315	46.50380	ME	558	2313	7.6	30	1.3	98.5	0.1
VT	VT-MC-05	Barney Brook	-73.16000	42.87944	VT	981	6	7.7	247	7.6	82.8	1.2
NH	NEWS04-3406	Beaver Brook*	-71.34712	42.84646	WSA	211	8	6.9	455	53.0	37.9	5.5
ME	ME-MC-01	Birch Stream	-68.80769	44.82373	NEWS	130	8	6.7	50	0.5	93.1	0.0
VT	VT-MC-06	Bolles Brook	-73.10222	42.92472	VT	1809	18	5.9	18	0.0	99.9	0.0
ME	NEWS04-1202	Carrying Place Stream	-70.01648	45.18149	WSA	820	28	7.3	32	0.0	92.6	0.0
NH	NEWS04-3004	Cocheco River	-70.99671	43.33652	WSA	231	232	6.6	161	2.8	81.2	6.1
NH	NH-01M-17	Cockermouth River	-71.83333	43.71389	NH	825	34	6.4	60	0.3	92.2	2.5
NH	NEWS04-3303	Dinsmore Pond Brook	-71.99635	42.91025	WSA	948	71	6.1	43	0.0	86.4	8.5
VT	NEWS04-VT01	East Branch Passumpsic River	-71.96389	44.56028	VT	739	185	7.8	133	3.0	90.9	2.4
VT	VT-MC-03	Gunner Bk	-72.50667	44.20389	VT	614	22	8.2	536	13.9	56.0	17.4
ME	ME-19.01	Hardy Brook	-70.41620	44.92365	WSA	1439	15	7.3	45	0.0	96.8	2.1
ME	ME-20.02	Higgins Brook	-69.58401	45.02045	WSA	317	116	7.5	62	0.0	89.1	7.4
NH	NEWS04-2401	Indian River	-71.98218	43.69598	WSA	1117	25	7.3	104	0.2	90.7	4.0
ME	NEWS04-1303	Kenduskeag River*	-68.99832	44.96056	WSA	152	246	7.6	196	0.4	76.3	17.7
CT	CT-65	Mad River	-73.03839	41.54393	CT	253	67	8.0	326	37.3	47.1	12.0
ME	ME-27.01	Medomak River	-69.39181	44.18651	NEWS	142	160	6.1	51	0.3	66.1	26.5
ME	ME-MC-05	Merriland River	-70.57917	43.34927	ME	78	35	7.0	82	3.7	88.3	1.1
VT	NEWS04-2805	Mettawee River	-73.08861	43.26055	WSA	1001	26	8.0	196	0.2	87.3	11.4
VT	NEWS04-1801	Millers Run	-72.06861	44.57972	WSA	797	79	7.9	175	2.2	83.1	9.1
NH	NH-00M-17	Nesenkeag Brook	-71.47361	42.83583	NH	133	21	6.2	248	14.8	72.9	7.3
CT	NEWS04-4104	Pease Brook	-72.19232	41.59466	WSA	458	24	7.3	212	2.7	52.7	36.0
ME	ME-MC-03	Penjajawoc Stream	-68.73937	44.82610	ME	60	17	7.8	286	14.9	62.7	6.7

*These are considered to be low gradient sites.

Table A3. Continued…

State	StationID	WaterbodyName	Long_Dec	Lat_Dec	Source of Data	Elev (ft)	WS Area (km2)	pH	COND	% DEVL	% FOR	% AGR
CT	CT-PR7	Pequabuck River	-72.89774	41.67381	CT	197	118	7.7	345	28.0	51.9	16.0
NH	NH-99C-58	Priest Brook	-72.12778	42.74444	NH	1012	28	4.9	104	4.3	87.5	3.2
VT	VT-MC-01	Rock River	-73.02583	44.98000	NEWS	218	50	7.9	356	0.1	32.2	64.2
CT	NEWS04-CT03	Salmon River	-72.42823	41.57534	CT	192	214	7.0	137	13.9	68.6	15.0
CT	NEWS04-CT05	Saugatuck River	-73.39483	41.29447	WSA	291	55	7.7	236	5.6	81.9	7.3
ME	NEWS04-1302	Schoodic Brook	-68.85165	45.29814	WSA	308	117	6.9	23	0.1	92.8	1.2
ME	ME-MC-04	Sheepscot River	-69.59334	44.22319	ME	122	363	7.0	71	3.9	87.7	2.4
NH	NH-01M-06	Squam Brook	-71.64750	43.68917	NH	456	168	6.9	65	2.7	88.9	3.4
CT	CT-NR21B	Steele Brook	-73.07029	41.58051	CT	309	44	7.3	337	33.8	35.8	29.0
CT	NEWS04-4003	Steele Brook	-73.11932	41.61267	WSA	321	10	7.4	227	31.4	41.2	21.9
VT	VT-MC-04	Stevens Branch	-72.52861	44.21333	VT	627	286	8.2	564	11.3	69.1	8.3
CT	CT-SR1A	Still River	-73.46360	41.38981	NEWS	463	37	5.9	78	0.3	71.8	16.2
NH	NH-00M-18	Tannery Brook	-71.62944	43.32333	NH	292	21	6.1	112	6.3	76.1	12.6
VT	NEWS04-2301	Third Branch White River	-72.71194	43.94583	WSA	715	111	7.1	51	0.2	91.3	5.4
CT	CT-58	Trout Brook	-72.72307	41.73135	CT	66	46	8.1	401	46.5	30.0	20.0
ME	ME-MC-02	Trout Brook	-70.24588	43.62946	ME	73	5	6.5	743	27.0	51.1	4.2
VT	VT-MC-02	W Br Ompompanoosuc	-72.31056	43.83250	VT	754	114	8.3	413	3.1	86.9	3.9
NH	NEWS04-2907	Warren Brook	-72.34914	43.15189	WSA	542	33	7.4	109	0.9	85.0	10.5
NH	NH-REF3	Whiteface River	-71.38966	43.86648	NH	690	31	6.2	25	0.4	93.8	0.8
CT	NEWS04-3603	Willimantic River	-72.30359	41.95077	WSA	307	136	7.0	96	6.6	74.3	9.7
VT	NEWS04-1001	Willoughby River	-72.13750	44.80528	WSA	1092	90	7.8	121	2.3	78.1	15.0

*These are considered to be low gradient sites.

Table A4. Subsampling information (=ratio of the sample that was processed). This information is for the first 3 rock basket replicates and 1 replicate for the kick net samples. We did not have subsampling information for the WSA samples at the time of this report.

State	StationID	WaterbodyName	Collection Method						
			ME	NH			CT	VT	NEWS
			All Reps	Rep 1	Rep2	Rep3			
ME	ME-REF4	Aroostook River	1	0.25	0.25	0.25	0.11	0.25	
VT	VT-MC-05	Barney Brook	1	0.25	1	1	0.57	1.00	
NH	NEWS04-3406	Beaver Brook	1	1	0.25	1	0.09	1.00	0.02
ME	ME-MC-01	Birch Stream	1	0.25	0.25	1	0.03	0.50	
VT	VT-MC-06	Bolles Brook	1	1	1	1	0.31	0.25	
ME	NEWS04-1202	Carrying Place Stream	1	1	1	1	0.07	0.67	0.01
NH	NEWS04-3004	Cocheco River	1	0.25	1	0.25	0.07	0.25	0.04
NH	NH-01M-17	Cockermouth River	1	0.25	0.25	0.25	0.06	0.50	
NH	NEWS04-3303	Dinsmore Pond Brook	1	0.25	1	1	0.13	0.25	0.02
VT	NEWS04-VT01	East Branch Passumpsic River	1	1	1	0.25	0.34	0.29	0.05
VT	VT-MC-03	Gunner Bk	1	0.25	0.25	0.25	0.14	0.25	
ME	ME-19.01	Hardy Brook	1	1	1	1	1.00	1.00	0.10
ME	ME-20.02	Higgins Brook	1		0.25	0.25	0.09	0.33	0.02
NH	NEWS04-2401	Indian River	1	1	1	1	0.09	0.25	0.04
ME	NEWS04-1303	Kenduskeag Stream	1	0.25	1	1	0.07	0.50	0.03
CT	CT-65	Mad River	1	1	1	1	1.00	1.00	
ME	ME-27.01	Medomak River	1	0.25	0.25	0.25	0.11	0.25	
ME	ME-MC-05	Merriland River	1	0.25	0.25	0.25	0.04	0.54	
VT	NEWS04-2805	Mettawee River	1	1	1	1	0.43	0.33	0.01
VT	NEWS04-1801	Millers Run	1	0.25	0.25	0.25	0.16	0.33	0.04
NH	NH-00M-17	Nesenkeag Brook	1	0.25	0.25	0.25	0.09	0.25	
CT	NEWS04-4104	Pease Brook	1	0.25		0.25	0.27	0.50	0.08
ME	ME-MC-03	Penjajawoc Stream	1	0.25	0.25	0.25	0.08	0.25	

Table A4. Continued…

State	StationID	WaterbodyName	Collection Method						
			ME	NH			CT	VT	NEWS
			All Reps	Rep 1	Rep2	Rep3			
CT	CT-PR7	Pequabuck River	1	1	1		0.24	1.00	
NH	NH-99C-58	Priest Brook	1	0.25	1	0.25	0.08	0.25	
VT	VT-MC-01	Rock River	1	0.25	0.25	0.25	0.05	0.25	
CT	NEWS04-CT03	Salmon River	1	1	0.25	1	0.18	1.00	0.15
CT	NEWS04-CT05	Saugatuck River	1	0.25	0.25	0.25	0.25	0.33	0.01
ME	NEWS04-1302	Schoodic Brook	1	1	0.25	1	0.15	0.25	
ME	ME-MC-04	Sheepscot River	1	0.25	0.25	0.25	0.06	0.25	
NH	NH-01M-06	Squam Brook	1	0.25	0.25	0.25	0.32	0.50	
CT	CT-NR21B	Steele Brook	NA	NA	NA	NA	1.00	0.67	
CT	NEWS04-4003	Steele Brook	1	1	1	1	0.15	1.00	0.04
VT	VT-MC-04	Stevens Branch	1	0.25	0.25	0.25	0.03	0.25	
CT	CT-SR1A	Still River	NA	NA	NA	NA	0.08	0.25	
NH	NH-00M-18	Tannery Brook	1	1	1	1	0.23	0.25	
VT	NEWS04-2301	Third Branch White River	1	1	0.25	0.25	0.14	0.33	0.04
CT	CT-58	Trout Brook	1	0.25	0.25	0.25	0.07	0.29	
ME	ME-MC-02	Trout Brook	1	1	1	1	0.02	0.25	
VT	VT-MC-02	W Br Ompompanoosuc	1	1	1	1	1.00	1.00	
NH	NEWS04-2907	Warren Brook	1	0.25	0.25	0.25	0.14	0.25	0.08
NH	NH-REF3	Whiteface River	1	1	1	0.25	0.11	0.25	0.02
CT	NEWS04-3603	Willimantic River	1	1	0.25	1	0.45	0.58	0.07
VT	NEWS04-1001	Willoughby River	1	0.25	1	0.25	0.23	0.25	0.04

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 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
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

WSA MMI Calculation

WSA IBI Calculation Information

Compiled by Erik Leppo (Erik.Leppo@tetratech.com, 2009-05-26), based on personal communications with Alan Herlihy and John Stoddard (February 26-28, 2006). Data is compared to what is available in the WSA report (EPA 841-B-06-002, May 2006).

NOTE: If people want to find out more about how reference site data was used to develop the thresholds for the MMI, they should contact Ellen Tarquinio (Tarquinio.Ellen@epamail.epa.gov). Apparently it was a very complicated process that varied by ecoregion.

Regions

These data are missing from the report in table format but are included in a map (Figure 1-8, EPA 841-B-06-002).

Table C1. National Level 3 Ecoregion Groups for WSA Reference Site Screening and IBI Development.

WSA Region	Ecoregion Level 3 Number	Ecoregion Level 3Name
Northern Appalachians (NAP)	58	Northeastern Highlands
	59	Northeastern Coastal Zone
	60	Northern Appalachian Plateau and Uplands
	61	Erie Drift Plain
	62	North Central Appalachians
	82	Laurentian Plains and Hills
	83	Eastern Great Lakes and Hudson Lowlands
Southern Appalachians/Ozarks (SAP)	36	Ouachita Mountains
	37	Arkansas Valley
	38	Boston Mountains
	39	Ozark Highlands
	45	Piedmont
	64	Northern Piedmont
	66	Blue Ridge
	67	Ridge and Valley
	68	Southwestern Appalachians
	69	Central Appalachians
	70	Western Allegheny Plateau
	71	Interior Plateau
Coastal Plains (CPL)	34	Western Gulf Coastal Plain
	35	South Central Plains
	63	Middle Atlantic Coastal Plain
	65	Southeastern Plains
	73	Mississippi Alluvial Plain
	74	Mississippi Valley Loess Plains
	75	Southern Coastal Plain

Table C1. Continued…

WSA Region	Ecoregion Level 3 Number	Ecoregion Level 3Name
Coastal Plains (CPL) Cont'd	76	Southern Florida Coastal Plain
	84	Atlantic Coastal Pine Barrens
Upper Midwest (UMW)	49	Northern Minnesota Wetlands
	50	Northern Lakes and Forests
	51	North Central Hardwood Forests
	52	Driftless Area
	56	S. Michigan/N. Indiana Drift Plains
Temperate Plains (TPL)	28	Flint Hills
	40	Central Irregular Plains
	46	Northern Glaciated Plains
	47	Western Corn Belt Plains
	48	Lake Agassiz Plain
	53	Southeastern Wisconsin Till Plains
	54	Central Corn Belt Plains
	55	Eastern Corn Belt Plains
	57	Huron/Erie Lake Plains
	72	Interior River Valleys and Hills
Northern Semi-Arid Plains (NPL)	42	Northwestern Glaciated Plains
	43	Northwestern Great Plains
Southern Semi-Arid Plains (SPL)	25	High Plains
	26	Southwestern Tablelands
	27	Central Great Plains
	29	Cross Timbers
	30	Edwards Plateau
	31	Southern Texas Plains
	32	Texas Blackland Prairies
	44	Nebraska Sand Hills
Western Mountains (WMT)	1	Coast Range
	11	Blue Mountains
	15	Northern Rockies
	16	Idaho Batholith
	17	Middle Rockies
	19	Wasatch and Uinta Mountains
	2	Puget Lowland
	21	Southern Rockies
	23	Arizona/New Mexico Mountains
	3	Willamette Valley
	4	Cascades
	41	Canadian Rockies
	5	Sierra Nevada
	77	North Cascades
	78	Klamath Mountains
	8	Southern California Mountains
	9	Eastern Cascades Slopes and Foothills

Table C1. Continued…

WSA Region	Ecoregion Level 3 Number	Ecoregion Level 3Name
Xeric West (XER)	10	Columbia Plateau
	12	Snake River Plain
	13	Central Basin and Range
	14	Mojave Basin and Range
	18	Wyoming Basin
	20	Colorado Plateaus
	22	Arizona/New Mexico Plateau
	24	Chihuahuan Deserts
	6	Southern and Central California Chaparral and Oak Woodlands
	7	Central California Valley
	79	Madrean Archipelago
	80	Northern Basin and Range
	81	Sonoran Basin and Range

Metrics and IBI Calculation

Metrics by Region

These data should match the May 2006 report (Table A-2, EPA 841-B-06-002). But the "Universal" index was dropped from the report.

Table C2. Final metrics selected for the regional and universal IBIs.

Metric	NAP	SAP	CPL	UMW	TPL	NPL	SPL	WMT	XER	Universal
EPT % Taxa	X					X		X		X
EPT % Individuals					X		X			
Non-Insect % Individuals			X						X	
Ephemeroptera % Taxa		X								
Chironomid % Taxa				X						
==================	===	===	===	===	===	===	===	===	===	======
Shannon Diversity		X	X	X	X	X	X			X
% Individuals in Top 5 taxa	X							X	X	
==================	===	===	===	===	===	===	===	===	===	======
Scrapper Richness	X	X			X	X	X	X	X	X

Table C2. Continued…

Metric	NAP	SAP	CPL	UMW	TPL	NPL	SPL	WMT	XER	Universal
Shredder Richness			**X**	**X**						
=================	===	===	===	===	===	===	===	===	===	======
Burrower % Taxa		**X**		**X**		**X**	**X**			**X**
Clinger % Taxa	**X**		**X**					**X**	**X**	
Clinger Richness					**X**					
=================	===	===	===	===	===	===	===	===	===	======
Ephemeroptera Richness					**X**	X				**X**
EPT Richness	**X**	**X**	**X**	**X**			**X**	**X**	**X**	
=================	===	===	===	===	===	===	===	===	===	======
Intolerant Richness							**X**			
Tolerant % Taxa		**X**	**X**					**X**	**X**	
Hillsenhoff Biotic Index										**X**
PTV 0-5.9 Richness						**X**				
PTV 0-5.9 % Taxa	**X**									
PTV 8-10 % Taxa				X	X					

Metric Calculation Standard Best Values

Within each row of the table : ecoregion code (remember each ecoregion was scored separately), metric name, floor (assigned a value of zero), ceiling (assigned a value of 10), and the name we gave to the scored metric. For the negative metrics, reverse the floor and ceiling values (the first value gets a 10, the second one gets a zero). This data is not available in the report or on the website.

TableC3. WSA metric standard best values by WSA region.

Metric Response to Increasing Perturbation	WSA Region	Metric Name	Floor	Ceiling
%posit	NAP	EPT_PTAX	9.52	57.6
%negat	NAP	DOM5PIND	37.2	76.2
%posit	NAP	SCRPRICH	3	12
%posit	NAP	CLNGPTAX	28.6	70

Table C3. Continued…

Metric Response to Increasing Perturbation	WSA Region	Metric Name	Floor	Ceiling
%posit	NAP	EPT_RICH	3	24
%posit	NAP	TL05PTAX	46.2	86.1
%posit	SAP	EPHEPTAX	5.41	28.6
%posit	SAP	HPRIME	2.05	3.44
%posit	SAP	SCRPRICH	3	12
%negat	SAP	BURRPTAX	3.45	25
%posit	SAP	EPT_RICH	5	25
%negat	SAP	TOLRPTAX	2.44	27.6
%negat	CPL	NOINPIND	0.7	73
%posit	CPL	HPRIME	1.62	3.31
%posit	CPL	SHRDRICH	1	9
%posit	CPL	CLNGPTAX	14.3	54.8
%posit	CPL	EPT_RICH	1	17
%negat	CPL	TOLRPTAX	5.56	50
%negat	UMW	CHIRPTAX	11.2	50.8
%posit	UMW	HPRIME	2.01	3.56
%posit	UMW	SHRDRICH	3	10
%negat	UMW	BURRPTAX	3.77	28.6
%posit	UMW	EPT_RICH	4	22
%negat	UMW	TL89PTAX	2.51	29.5
%posit	TPL	EPT_PIND	0.67	80.3
%posit	TPL	HPRIME	1.41	3.17
%posit	TPL	SCRPRICH	1	9
%posit	TPL	CLNGRICH	3	20
%posit	TPL	EPHERICH	1	11
%negat	TPL	TL89PTAX	4.35	33.3
%posit	NPL	EPT_PTAX	3.85	50
%negat	NPL	HPRIME	1.1	3.07
%posit	NPL	SCRPRICH	1	6
%negat	NPL	BURRPTAX	6.45	35.3
%posit	NPL	EPHERICH	0	7
%posit	NPL	TL05RICH	4	28
%posit	SPL	EPT_PIND	0.67	66
%posit	SPL	HPRIME	1.16	3.27
%posit	SPL	SCRPRICH	1	8
%negat	SPL	BURRPTAX	5	36.1
%posit	SPL	EPT_RICH	1	16
%posit	SPL	INTLRICH	1	8
%posit	WMT	EPT_PTAX	18.5	62.9
%negat	WMT	DOM5PIND	40.6	82.3
%posit	WMT	SCRPRICH	1	8

Table C3. Continued…

Metric Response to Increasing Perturbation	WSA Region	Metric Name	Floor	Ceiling
%posit	WMT	CLNGPTAX	27	69.6
%posit	WMT	EPT_RICH	6	23
%negat	WMT	TOLRPTAX	2.27	25
%negat	XER	NOINPIND	3.33	36
%negat	XER	DOM5PIND	44.7	92.3
%posit	XER	SCRPRICH	0	7
%posit	XER	CLNGPTAX	15.8	65.8
%posit	XER	EPT_RICH	1	18
%negat	XER	TOLRPTAX	3.57	36.4

IBI Narrative Rating Thresholds

This data is provided in the report (Table A-3, EPA-841-B-06-002). Greater than or equal to the 25th percentile is Good, less than the 5th percentile is Poor, and greater than or equal to the 5th percentile and less than the 25th percentile is Fair.

Table C4. Threshold values for the nine regional Macroinvertebrate Indexes.

Region	Least-Disturbed / Intermediate (25th percentile)	Intermediate / Most-Disturbed (5th percentile)
NAP	63	49
SAP	56	42
CPL	56	42
UMW	48	34
TPL	52	38
NPL	62	49
SPL	50	36
WMT	59	45
XER	53	40

Master Taxa List

The report does not provide a master taxa list with phylogenetic or autecological information (habits, functional feeding groups, and tolerance values). This data could be compiled by downloading the benthic data from the WSA website and then creating a master taxa list.

APPENDIX D

NEWS and CT BCG fuzzy model rules

Table D1. Biological Condition Gradient: description of gradient and rules for cold-water streams of New England. Modified after Davies and Jackson (2006). Rules apply to benthic macroinvertebrates sampled with CT DEP or NEWS methods (kick net, genus ID, 200 organism subsample). Grayed text not part of model development.

Resource Condition Tiers	Biological Condition Characteristics (Effects)
1	**I** ***Historically documented, sensitive, long-lived, or regionally endemic taxa*** ➔ Long-lived native species of fish-host specialist or long-term brooder mussels such as Brook floater- *Alasmodonta varicosa;* Triangle floater- *Alasmodonta undulata;* Yellow lampmussel- *Lampsilis cariosa* are present in naturally occurring densities ➔ **Fishes**: Brook stickleback, Swamp darter, accessible to migratory fish (Atlantic salmon, eel)
Natural or native condition *Native structural, functional and taxonomic integrity is preserved; ecosystem function is preserved within the range of natural variability*	**II** ***Highly Sensitive taxa*** ➔ The proportion of total richness represented by rare, specialist and vulnerable taxa is high, for example, without limitation, the following taxa are representative: **Plecoptera**: Peltoperlidae*, Amphinemura, Isogenoides, Neoperla, Pteronarcys, Leuctra*; **Ephemeroptera**: *Centroptilum, Heterocloeon, Brachycercus, Drunella, Rhithrogena, Epeorus, Leucrocuta*; **Trichoptera**: *Protoptila; Psilotreta, Lepidostoma, Ceraclea*; **Diptera**: Blephariceridae, *Stempellina, Limnophila*
	III ***Intermediate Sensitive taxa*** ➔ Densities of Intermediate Sensitive taxa are as naturally occur. The following taxa are representative of this group for Maine: **Plecoptera**: *Acroneuria*; **Ephemeroptera**: *Ephemerella, Baetisca, Procloeon;* **Coleoptera**: *Psephenus* **Diptera:** *Rheocricotopus, Stempelinella*; **Fishes**: Brook trout, Burbot, Lake chub
	IV ***Taxa of Intermediate (indifferent) tolerance*** ➔ Densities of indifferent tolerance taxa are as naturally occur. The following taxa are representative of this category: **Trichoptera**: *Diplectrona, Hydroptila*, *Chimarra*, *Neureclipsis;* **Diptera**: *Tvetenia, Polypedilum ,Microtendipes, Simulium;* **Coleoptera**: *Stenelmis;* **Fishes**: Common shiner, Fallfish
	V ***Tolerant taxa*** ➔ Occurrence and densities of Tolerant taxa are as naturally occur. The following taxa are representative of this category: **Diptera**: *Cricotopus*, *Chironomus, Rheotanytarsus*; **Non-Insects**: *Caecidotea*, Isopoda*;* **Fishes***:* White sucker, Blacknose dace, Creek chub
	Va ***Highly Tolerant taxa*** ➔ Occurrence and densities of Highly Tolerant taxa are as naturally occur. Rare and sparse in high-gradient streams (usually absent from samples). The following taxa are representative of this category: **Diptera**: Psychodidae, *Dicrotendipes*; **Non-Insects**: Erpobdellidae, Tubificidae, Glossiphoniidae
	VI ***Non native or intentionally introduced taxa*** ➔ Non native taxa such as Brown trout, Rainbow trout, Yellow perch, are absent or, if they occur, their presence does not displace native biota or alter native structure and function
	VII ***Physiological condition of long-lived organisms*** ➔ Anomalies are absent or rare; any that occur are consistent with naturally occurring incidence and characteristics
	VIII ***Ecosystem Function*** ➔ Rates and characteristics of *life history (e.g., reproduction, immigration, mortality, etc.)*, and materials exchange processes *(e.g., production, respiration, nutrient exchange, decomposition, etc.)* are comparable to that of "natural" systems ➔ The system is predominantly heterotrophic, sustained by leaf litter inputs from intact riparian areas, with low algal biomass; P/R<1 (Photosynthesis: Respiration ratio)
	IX ***Spatial and temporal extent of detrimental effects*** ➔ Not applicable- disturbance is limited to natural events such as storms, droughts, fire, earth-flows. A natural flow regime is maintained.
	X ***Ecosystem connectance*** ➔ Reach is highly connected with groundwater, its floodplain, and riparian zone, and other reaches in the basin, at least annually. Allows for access to habitats and maintenance of seasonal cycles that are necessary for life history requirements, colonization sources, migration and *refugia* for extreme events.

Table D1. Continued…

2	
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*	***Whole assemblage and sample*** ➔ Overall taxa richness and density is as naturally occurs ➔ **RULE 1:** Taxa richness is high and subsample density is near target ➔ **Quantitative Rule 1**: Total taxa > (30-35) genera and Total individuals > (45-55% of target) **I *Historically documented, sensitive, long-lived, regionally endemic taxa*** ➔ Some endemic species (e.g., the Dwarf wedgemussel- *Alasmidonta heterodon*, and/or Brook stickleback are absent. Migratory species (eels, Atlantic salmon) may be absent due to dams; possible reduced recruitment of Unionid mussels. **II *Highly Sensitive taxa*** ➔ Richness of rare and/or specialist invertebrate taxa is low to moderate though densities may be low : **Plecoptera**: Peltoperlidae*, Amphinemura, Isogenoides, Neoperla, Pteronarcys, Leuctra*; **Ephemeroptera**: *Centroptilum, Heterocloeon, Brachycercus, Drunella, Rhithrogena, Epeorus, Leucrocuta*; **Trichoptera**: *Protoptila; Psilotreta, Lepidostoma, Ceraclea*; **Diptera**: Blephariceridae, *Stempellina, Limnophila* ➔ Fish assemblage is predominantly native including Slimy sculpin, Longnose sucker, Longnose dace. ➔ **RULE 2:** At least some taxa are present ➔ **Quantitative Rule 2**: Taxa (II) > (2-4) **III *Intermediate Sensitive taxa*** ➔ Richness and abundance of intermediate sensitive taxa is high. Some may have increased due to slightly elevated production (e.g., : **Plecoptera**: *Acroneuria*; **Ephemeroptera**: *Ephemerella, Baetisca, Procloeon;* **Coleoptera**: *Psephenus* **Diptera:** *Rheocricotopus, Stempelinella***;** ➔ Populations of such native fish taxa as Brook trout, Lake chub, Burbot are common. ➔ **RULE 3:** All sensitive taxa (highly sensitive + intermediate sensitive): comprise nearly half or more of all taxa ➔ **RULE 4** : All sensitive individuals: comprise nearly half or more of all organisms ➔ **Quantitative Rule 3**: Taxa (II + III) > (35 – 40%) of all taxa ➔ **Quantitative Rule 4**: Individuals (II + III) > (35-40%) **IV *Taxa of Intermediate (indifferent) tolerance*** ➔ Possible Increased biomass of diatoms that respond to increased nutrients and temperatures, but sensitive diatom species are maintained. Diatom richness increased; filamentous forms are rare ➔ May be slight increases in densities of macroinvertebrate taxa such as : **Trichoptera**: *Diplectrona, Hydroptila*, *Chimarra*, *Neureclipsis;* **Diptera**: *Tvetenia, Polypedilum ,Microtendipes, Simulium* **Coleoptera**: *Stenelmis*. Common shiner and Fallfish are in good condition ➔ **RULE:** None **V *Tolerant taxa*** ➔ Occurrence and densities of Tolerant taxa are as naturally occur. Typically present but a very small fraction of organisms. **Diptera**: *Chironomus, Cricotopus, Rheotanytarsus;* **Non-Insects**: Isopoda*, Physa* **Fishes**: White sucker; Creek chub, Blacknose dace ➔ **RULE 5:** Tolerant individuals (tolerant + highly tolerant) comprise a small fraction or less of all organisms ➔ **Quantitative Rule 5**: Individuals (V + Va) < (10-20%) **Va *Highly Tolerant taxa*** ➔ Occurrence and densities of Highly Tolerant taxa are as naturally occur. . Rare and sparse in high-gradient streams (usually absent from samples). The following taxa are representative of this category: **Diptera**: Psychodidae, *Dicrotendipes*; **Non-Insects**: Erpobdellidae, Tubificidae, Glossiphoniidae ➔ **RULE:** see rule for Group V **VI-IX *Non-native taxa; Physiological condition; Ecosystem Function; Spatial and temporal extent*** ➔ Not addressed for macroinvertebrates; See Davies and Jackson (2006). **X *Ecosystem connectance*** ➔ Connectance on a local scale (floodplain, tributaries) remains good but dams and other flow obstructions downstream impede migration of fish and mussels (eels, salmonids, migration-dependent unionids) **COMBINATORIAL RULE** ➔ To be considered Tier 2 for macroinvertebrates, all rules for Attributes II through V must apply; combined with AND.

Table D1. Continued…

3

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 sensitive-ubiquitous taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system

Whole assemblage and sample

- ➔ Overall taxa richness and density is as naturally occurs
- ➔ **RULE 1:** Taxa richness is moderately high and subsample density is near target
- ➔ **Quantitative Rule 1**: Total taxa > (20-25) and Total individuals > (45-55% of target)

I ***Historically documented, sensitive, long-lived, or regionally endemic*** **taxa**

- ➔ Endemic mussels uncommon or absent due to extirpation

II ***Highly Sensitive taxa***

- ➔ Some replacement of taxa having narrow or specialized environmental requirements, with functionally equivalent *intermediate-sensitive* taxa; coldwater obligate taxa are disadvantaged. Reduced richness; may be absent. Taxa such as **Plecoptera**: Capniidae, *Taeniopteryx, Isoperla, Perlesta, Pteronarcys, Leuctra*, *Agnetina*; **Ephemeroptera**: *Cinygmula, Rhithrogena, Epeorus, Serratella, Leucrocuta*; **Trichoptera**: *Glossosoma, Psilotreta, Brachycentrus*; **Diptera**: *Stempellina, Rheopelopia; Hexatoma, Probezzia*; **Coleoptera**: *Promoresia;* **Fishes**: Brook stickleback, Longnose sucker, Longnose dace are uncommonly or absent
- ➔ **RULE:** May be absent (no rule)

III ***Intermediate Sensitive*** **taxa**

- ➔ Intermediate sensitive or generalist taxa are common and abundant; taxa with broader temperature-tolerance range are favored (e.g., : **Plecoptera**: *Acroneuria*; **Ephemeroptera**: *Ephemerella, Baetisca, Procloeon;* **Coleoptera**: *Psephenus* **Diptera:** *Rheocricotopus, Stempelinella***)**
- ➔ Brook trout are reduced due to introduction of Brown trout and increased temperature
- ➔ **RULE 2:** All sensitive taxa (highly sensitive + intermediate sensitive) are moderately diverse
- ➔ **Quantitative Rule 2**: Taxa (II + III) > 10-12
- ➔ **RULE 3:** All sensitive taxa (highly sensitive + intermediate sensitive) comprise a substantial fraction of all taxa
- ➔ **Quantitative Rule 3**: Taxa (II + III) > (30 – 40%) of all taxa
- ➔ **RULE** 4: All sensitive individuals: comprise a substantial fraction of all organisms
- ➔ **Quantitative Rule 4**: Individuals (II + III) > (30-50%)

IV ***Taxa of Intermediate (indifferent) tolerance***

- ➔ Filter-feeding blackflies (*Simulium*) and indifferent net-spinning caddisflies (e.g.,*Polycentropus, Neureclipsis*) may show increased densities in response to nutrient enrichment, but relative abundance of all expected major groups is well-distributed : **Trichoptera**: *Diplectrona, Hydroptila*, *Chimarra*, *Neureclipsis;* **Diptera**: *Tvetenia, Polypedilum ,Microtendipes, Simulium;* **Coleoptera**: *Stenelmis*
- ➔ Increased temperature and increased available nutrients result in increased algal productivity causing an increase in the thickness of the diatom mat. This results in a “slimy” covering on hard substrates.
- ➔ Fish assemblage exhibits increased occurrence of Common shiner and Fallfish
- ➔ **RULE:** None

V ***Tolerant taxa***

- ➔ Richness of **Diptera**: Chironomidae is increased; relative abundance of Diptera and Non-insects is somewhat increased but overall relative abundance is well-distributed among taxa from Groups III, IV and V, with the majority of taxa represented from Groups III and IV. Blacknose dace, white sucker are more common.
- ➔ **RULE 5:** Tolerant individuals (tolerant + highly tolerant) comprise a moderately small fraction or less of all organisms
- ➔ **Quantitative Rule 5**: Individuals (V + Va) < (20-30%)

Va ***Highly Tolerant taxa***

- ➔ Occurrence and densities of Highly Tolerant taxa are as naturally occur. Rare and sparse in high-gradient streams (usually absent from samples). The following taxa are representative of this category: **Diptera**: Psychodidae, *Dicrotendipes*; **Non-Insects**: Erpobdellidae, Tubificidae, Glossiphoniidae
- ➔ **RULE:** see rule for Group V, above

VI-X ***Non-native taxa; Physiological condition; Ecosystem Function; Spatial and temporal extent; Connectance***

- ➔ Not addressed for macroinvertebrates. See Davies and Jackson (2006).

COMBINATORIAL RULE

Must fail Tier 2 and must meet minimum Rules for Tier 4 (Tier 4 Rules 1, 2, and 5, and either of Rules 3 or 4; See Tier 4 rules next page). To distinguish from Tier 4, an average of Tier 3 Rules 2, 3, 4, and 5 is used.

Table D1. Continued…

4

Moderate changes in structure of the biotic community and minimal changes in ecosystem function

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

Whole assemblage and sample

- ➔ Overall taxa richness is slightly reduced, and density may be high
- ➔ **RULE 1:** Taxa richness is moderately high and subsample density is near target
- ➔ **Quantitative Rule 1**: Total taxa > (20-25) and Total individuals > (45-55% of target)

I Historically documented, *sensitive, long-lived, regionally endemic* taxa

- ➔ Generalist mussel species are present (e.g., *Elliptio; Lampsilis radiata radiata or* Eastern floater-*Pyganodon cataracta*) but sensitive taxa (e.g., *Alasmodonta varicosa; Alasmodonta undulata; Lampsilis cariosa* are absent.

II *Highly Sensitive taxa*

- ➔ Richness of specialist and vulnerable taxa is notably reduced; if present, densities are low (e.g., **Plecoptera**: Capniidae, *Taeniopteryx, Isoperla, Perlesta, Pteronarcys, Leuctra*; *Agnetina*; **Ephemeroptera**: *Cinygmula, Rhithrogena, Epeorus, Serratella, Leucrocuta*; **Trichoptera**: *Glossosoma; Psilotreta; Brachycentrus*; **Diptera**: *Stempellina, Rheopelopia; Hexatoma, Probezzia*; **Coleoptera**: *Promoresia,* **Fishes***:* Occurrence of Slimy sculpin, Longnose sucker and Longnose dace is reduced
- ➔ **RULE:** May be absent (no rule)

III *Intermediate Sensitive taxa*

- ➔ Densities of sensitive- ubiquitous scraper and gatherer insects (e.g., **Plecoptera**: *Acroneuria*; **Ephemeroptera**: *Ephemerella, Baetisca, Procloeon;* **Coleoptera**: *Psephenus* **Diptera:** *Rheocricotopus, Stempelinella*) are sufficient to indicate that reproducing populations are present but relative abundance is reduced due to increased densities of opportunist invertebrate taxa (Group IV)
- ➔ Overall mayfly taxonomic richness is reduced relative to the Tier 2 condition.
- ➔ Predatory stoneflies are reduced (e.g., *Acroneuria*)
- ➔ **RULE 2:** Sensitive taxa (highly sensitive + intermediate sensitive) are moderately diverse; may be less than Tier 3
- ➔ **Quantitative Rule 2**: Taxa (II + III) > (8-12)
- ➔ **RULE 3:** All sensitive taxa (highly sensitive + intermediate sensitive) comprise at least a moderate and functional fraction of all taxa
- ➔ **Quantitative Rule 3**: Taxa (II + III) > (20 -30%) of all taxa
- ➔ **RULE 4**: All sensitive individuals comprise at least a moderate and functional fraction of all organisms
- ➔ **Quantitative Rule 4**: Individuals (II + III) > (10-20%)

IV *Taxa of Intermediate (indifferent) tolerance*

- ➔ Possible increase of bryophytes and macro-algae due to increased nutrients.
- ➔ Increased loads of suspended particles favor collector-filterer invertebrates resulting in increased densities and relative abundance of filter-feeding caddisflies and chironomids (e.g., **Trichoptera**: Hydropsychidae, *Chimarra*, *Neureclipsis*, *Polycentropus;* **Diptera***: Tvetenia, Polypedilum, Microtendipes, Rheocricotopus, Simulium;* **Fishes***:* Common shiner and Fallfish are common and abundant
- ➔ **RULE:** None

V *Tolerant taxa*

- ➔ There is an increase in the relative abundance of tolerant generalists (for example*, Eukeifferiella, Cricotopus*) and tolerant net-spinning caddisflies (e.g., *Hydropsyche, Cheumatopsyche*) but they do not exhibit significant dominance
- ➔ Overall relative abundance is well distributed among taxa from Groups III, IV and V, with the majority of the total abundance represented from Group IV.
- ➔ Native fish such as White sucker, Blacknose dace, Creek chub are common**.**
- ➔ **RULE 5:** Tolerant individuals (tolerant + highly tolerant) comprise less than half of all organisms
- ➔ **Quantitative Rule 5**: Individuals (V + Va) < (40 - 50%)

Va *Highly Tolerant taxa*

- ➔ Occurrence and densities of Highly Tolerant taxa are as naturally occur. Often absent. The following taxa are representative of this category: **Diptera**: Psychodidae, *Dicrotendipes*; **Non-Insects**: Erpobdellidae, Tubificidae, Glossiphoniidae
- ➔ **RULE:** see rule for Group V, above

VI-X *Non-native taxa; Physiological condition; Ecosystem Function; Spatial and temporal extent; Connectance*

- ➔ Not addressed for macroinvertebrates. See Davies and Jackson (2006).

COMBINATORIAL RULE

Must fail Tier 2 and must meet Rules 1, 2, and 5, and either of Rules 3 or 4. To distinguish from Tier 3, an average of Rules 2, 3, 4, and 5 is used.

Table D1. Continued…

5	***Whole assemblage and sample*** ➔ Overall taxa richness is reduced, but density may be high ➔ **RULE 1:** Taxa richness is moderate and subsample density is near target ➔ **Quantitative Rule 1**: Total taxa > (8-12) and Total individuals > (45-55% of target)
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*	**I *Historically documented, sensitive, long-lived, or regionally endemic taxa*** ➔ Mussel fauna, including commonly occurring, generalist taxa is markedly diminished due to poor water quality **II *Highly Sensitivetaxa*** ➔ Only the rare occurrence of individual representatives of specialist and vulnerable taxa with no evidence of successful reproduction ➔ **RULE:** May be absent (no rule) **III *Intermediate Sensitive taxa*** ➔ Either absent or present in very low numbers, indicating impaired recruitment and/or reproduction ➔ **RULE:** May be absent ➔ **Quantitative Rule:** Failure of Tier 4 rules (complement) **IV *Taxa of Intermediate (indifferent) tolerance*** ➔ Filter-feeding invertebrates such as Hydropsychid caddisflies (e.g., *Cheumatopsyche*) and filter-feeding midges (e.g., *Rheotanytarsus, Microtendipes*) may occur in very high numbers ➔ **RULE:** None **V *Tolerant taxa*** ➔ Frequent occurrence of tolerant collector-gatherers (e.g., Orthocladiini, *Micropsectra, Pseudochironomus,* Isopoda- *Caecidotea;* Amphipoda- *Hyalella, Gammarus*); ➔ Relative abundance of non-insects often equal to or higher than relative abundance of insects ➔ Deposit-feeders such as Oligochaeta are increased ➔ Numbers of tolerant predators are increased (Hirudinea, *Thienemannimyia, Cryptochironomus*) ➔ Native fish species are essentially absent with the exception of tolerant taxa like White sucker, Blacknose dace and Creek chub ➔ **RULE:** May be very abundant ➔ **Quantitative Rule:** Failure of Tier 4 rule (complement) **Va *Highly Tolerant taxa*** ➔ Occurrence and densities of Highly Tolerant may be increased, but do not dominate taxa richness or abundance. The following taxa are representative of this category: **Diptera**: *Dicrotendipes*; **Non-Insects**: Erpobdellidae, Tubificidae, Glossiphoniidae ➔ **RULE 2:** Highly Tolerant individuals are less abundant than Tolerant Individuals ➔ **Quantitative Rule 2**: Individuals (Va) < Individuals (V) **VI-X *Non-native taxa; Physiological condition; Ecosystem Function; Spatial and temporal extent; Connectance*** ➔ Not addressed for macroinvertebrates. See Davies and Jackson (2006). **COMBINATORIAL RULE** Failure of Tier 4 rules and must meet both Rules 1 and 2

Table D1. Continued…

6

Severe changes in structure of the biotic community and major loss of ecosystem function

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

Whole assemblage and sample

- ➔ Overall taxa richness is greatly reduced, but density may be high, or greatly reduced (indicating toxicity)
- ➔ **RULE:** Taxa richness may be extremely low or subsample density may be below target
- ➔ **Quantitative Rule**: Total taxa < (8-12) or Total individuals < (45-55% of target) (fails Tier 5)

I *Historically documented, sensitive, long-lived, regionally endemic taxa*

- ➔ Poor water quality, compaction of substrate, elevated temperature regime and absence of fish hosts for reproductive functions preclude the survival of any mussel fauna

II *Highly Sensitive taxa*

- ➔ These taxa are absent due to poor water quality, elevated temperature regime, alteration of habitat, loss of riparian zone, etc.

III *Intermediate Sensitive taxa*

- ➔ Absent due to above listed factors, though an occasional transient individual, usually in poor condition, may be collected.

IV *Taxa of Intermediate (indifferent) tolerance*

- ➔ Filter-feeding insects and other macroinvertebrate representatives of this group are severely reduced in density and richness, or are absent.

V *Tolerant taxa*

- ➔ Low dissolved oxygen conditions preclude survival of most insect taxa except those with special adaptations to deficient oxygen conditions (e.g., *Chironomus*)
- ➔ The macroinvertebrate assemblage is dominated by tolerant non-insects (Planariidae, Oligochaeta, Hirudinea, Sphaeriidae, etc.)

Va *Highly Tolerant taxa*

- ➔ Occurrence and densities of Highly Tolerant taxa are as naturally occur. The following taxa are representative of this category: **Diptera**: Psychodidae, *Dicrotendipes*; **Non-Insects**: Erpobdellidae, Tubificidae, Glossiphoniidae
- ➔ **RULE:** Highly Tolerant individuals may be dominant
- ➔ **Quantitative Rule**: Individuals (Va) > Individuals (V) (fails Tier 5)

VI-X *Non-native taxa; Physiological condition; Ecosystem Function; Spatial and temporal extent; Connectance*

- ➔ Not addressed for macroinvertebrates. See Davies and Jackson (2006).

COMBINATORIAL RULE

RULE: Rule for Tier 6 is any failure of Tier 5 rule

Rule-based Fuzzy Inference

In order to develop the fuzzy inference model, each linguistic variable (e.g., “high taxa richness”) must be defined quantitatively as a fuzzy set (e.g., Klir 2004). A fuzzy set has a membership function, and the membership functions of different classes of taxa richness are shown in Figure 4-3. We used piecewise linear functions to assign membership of a sample to the fuzzy sets shown (Figure 4-3). Numbers below a lower threshold have membership of 0, and numbers above an upper threshold have membership of one, and membership is a straight line between the lower and upper thresholds. For example, in Figure 2-1, a sample with 15 taxa would have a membership of 0.75 in the set “Low-moderate Taxa” and a membership of 0.25 in the set “Moderate Taxa.”

Table D2. Candidate decision rules for Connecticut High Gradient Streams. Ranges in parentheses denote fuzzy membership function.

Attributes	BCG level					
	1	2	3	4	5	6
0 General		2.1 Total taxa > (25–30) 2.2 count > (50–60%) of target	3.1 Total taxa > (19–23) 3.2 count > (50–60%) of target	4.1 Total taxa > (17–21) 4.2 count > (50–60%) of target	5.1 Total taxa > (8–12) 5.2 count > (50–60%) of target	Total taxa < (8–12) count < (45–55%) of target
I *Endemics*						
II *Highly sensitive taxa*		2.3 Taxa II > (3–5)				
III *Sensitive taxa*		2.4 % Taxa (II+III) > (45–55%) 2.5 % Indiv (II + III) > (30–40%)	3.3 Taxa (II+III) > (8–10) 3.4 % Indiv (II+III) > (30–40%)	4.3 Taxa (II+III) > (3–5) 4.4 % Indiv (II+III) > (10–20%)		
IV *Intermediate tolerant taxa*		(no rule)	(no rule)	(no rule)	(no rule)	
V *Tolerant taxa* (all)		2.6 % Indiv V < (10–15)%	3.5 % Indiv V < (40–50%)	4.5 % Indiv V < (65–75%)		
Indicator Taxa		[E taxa > 2]		[E taxa > 0]		
Combining Rule		2.1, 2.2, 2.3, 2.4 and (2.5 or 2.6)	Fails any level 2 rules 2.2-2.6, and 3.1, 3.2, 3.3, and (3.4 or 3.5)	Fails any level 2 rules 2.2–2.6 and fails level 3 rules 3.3–3.5 and 4.1, 4.2, 4.3, and (4.4 or 4.5)	Fails level 2 rules 2.2–2.6, and level 3 rules 3.2–3.5 and level 4 rules 4.2–4.5, and 5.1 and 5.2	Fails all higher levels

APPENDIX E

Plots of metric values

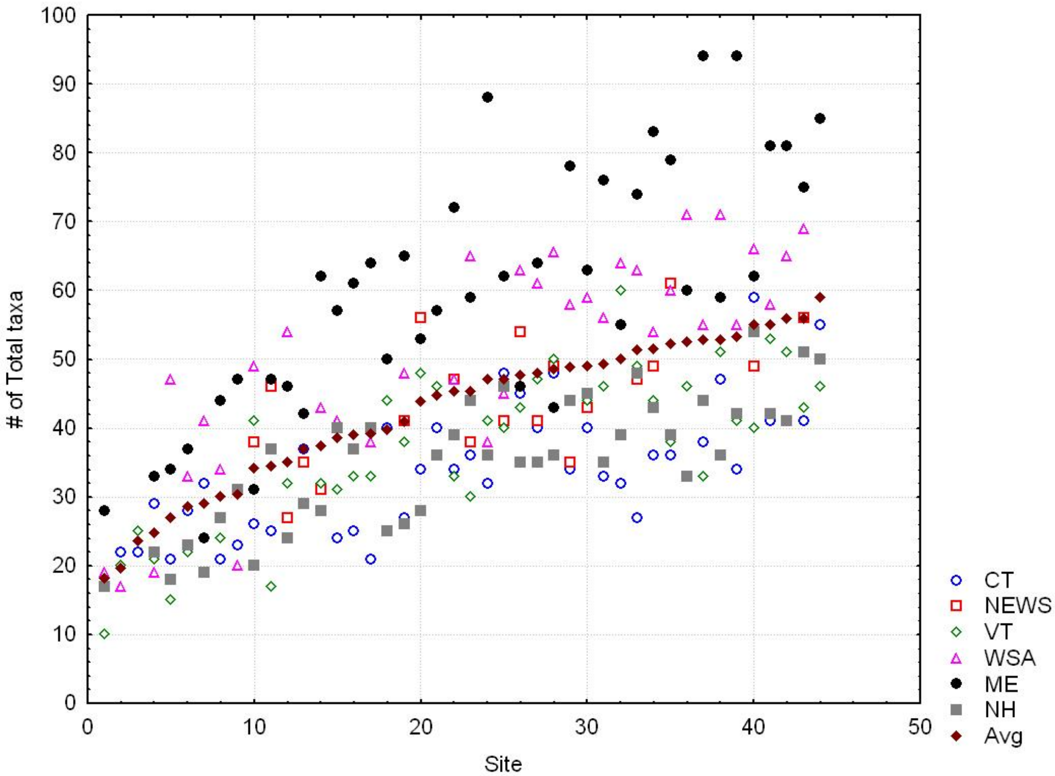
The following metric values were calculated for samples collected using the VT DEC, CT DEP, ME DEP, NH DES, WSA and NEWS methods:

Metric
Total taxa (genus-level)
# of Attribute 2 taxa
# of Attribute 3 taxa
# of Attribute 2 & 3 taxa
# of Attribute 4 taxa
# of Attribute 5 taxa
# of Chironomidae taxa
# of EPT taxa
# of Ephemeroptera taxa
# of Plecoptera taxa
# of Trichoptera taxa
% Chironomidae
% Most Dominant
% EPT
% Filterers
% Oligochaeta
% Sensitive taxa (=Attribute 2 & 3 taxa)
% Attribute level 4 taxa
% Tolerant taxa (=Attribute 5 & 6 taxa)
% Non-Insects
Shannon Wiener Diversity Index
Density

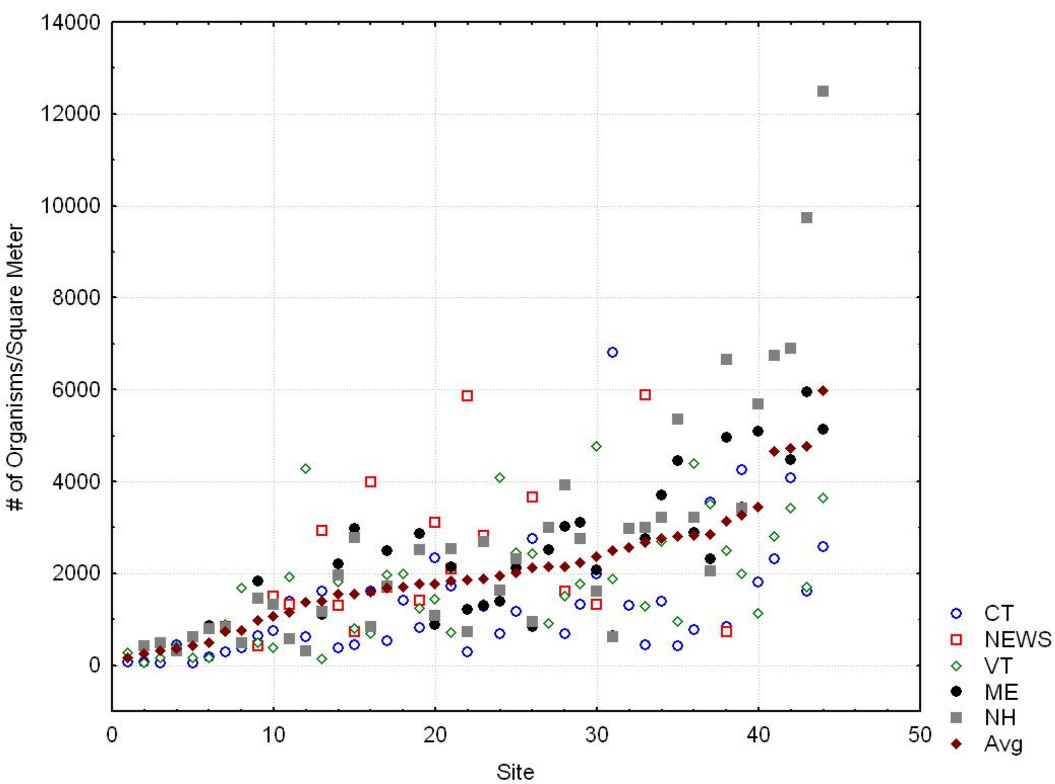
The metrics values are plotted by site, in order of increasing site average for each metric (in the plots, Avg = average metric value across methods). These plots allow one to see the systematic differences among the methods.

IMPORTANT NOTES:

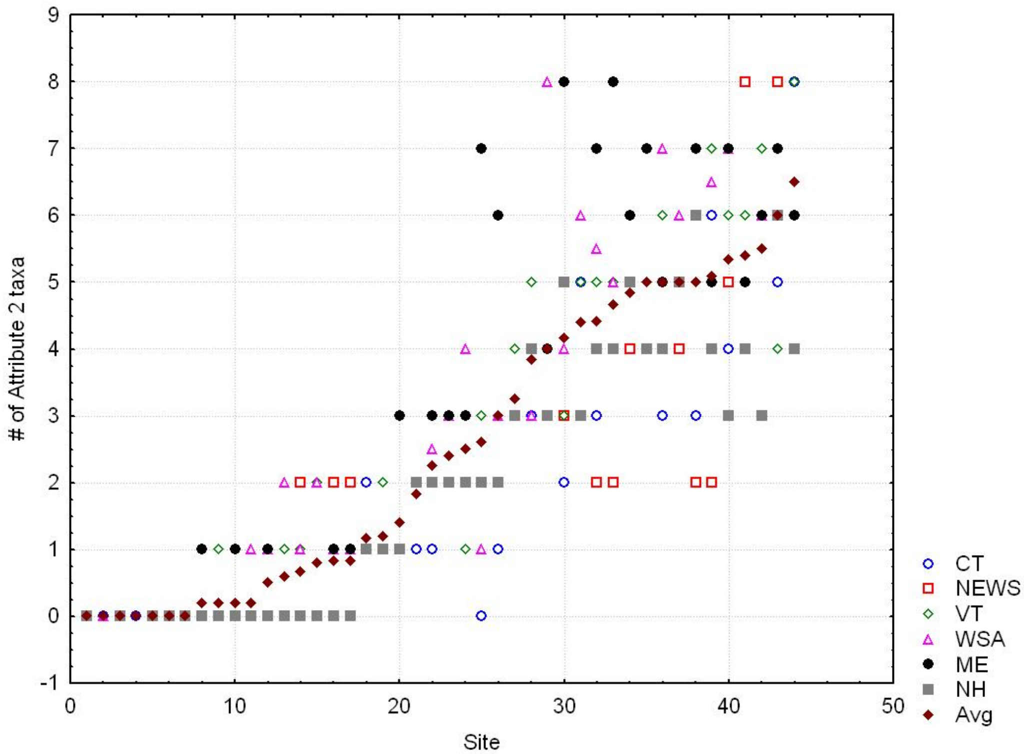
- The richness metric calculations are based on a genus-level operational taxonomic unit.
- ME DEP richness metric calculations were performed on combined replicate samples (data from each replicate was compiled into one sample, so that taxa present in any of the replicates were counted)
- NH DES richness calculations were based on the maximum replicate values.
- The CT DEP sample from the Merriland River site was excluded from the plots because the CT DEP collection method was inappropriate for the boulder habitat at this site.



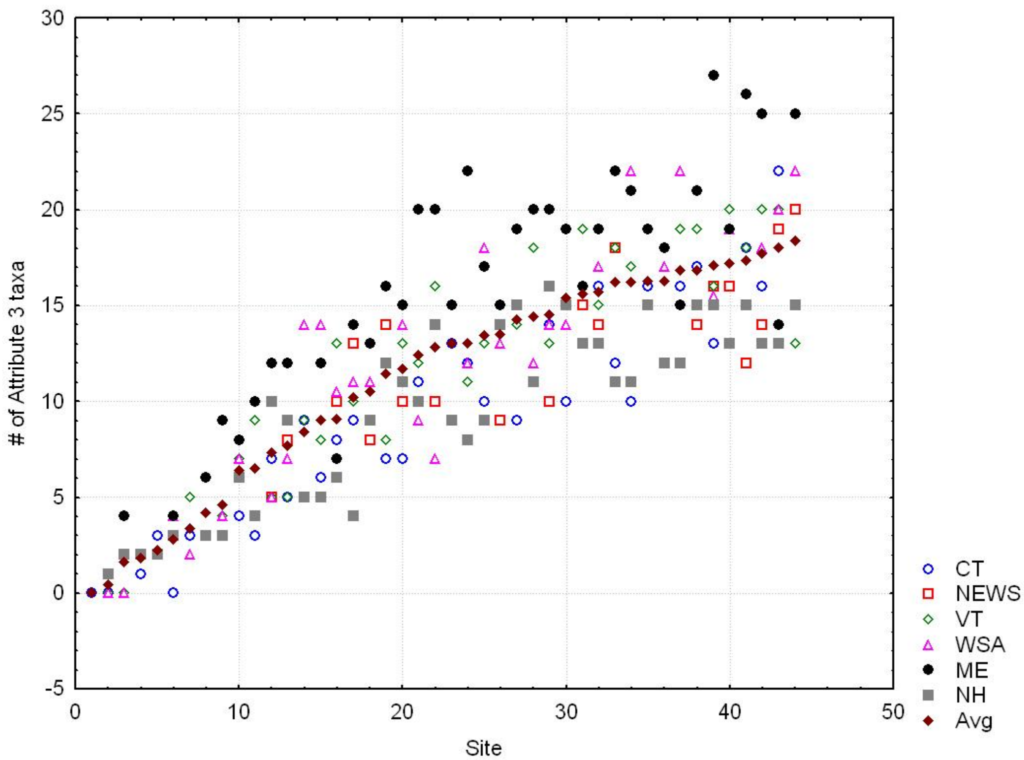
# of Total taxa
Site
CT
NEWS
VT
WSA
ME
NH
Avg



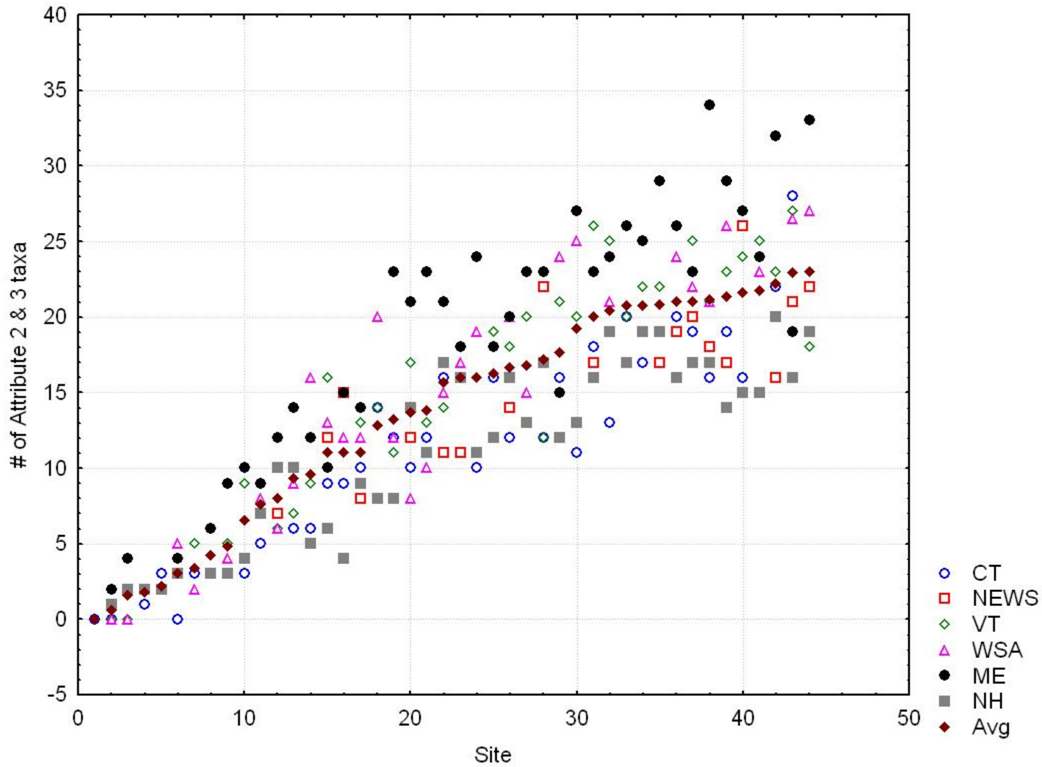
# of Organisms/Square Meter
Site
CT
NEWS
VT
ME
NH
Avg



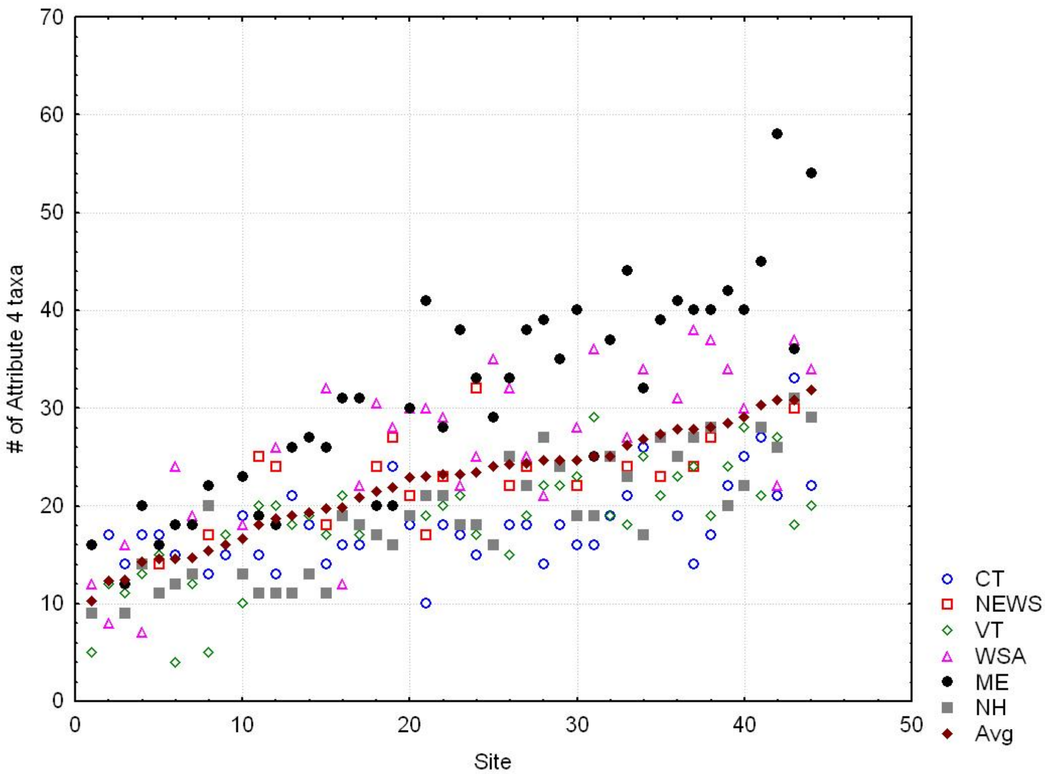
# of Attribute 2 taxa
Site
CT
NEWS
VT
WSA
ME
NH
Avg



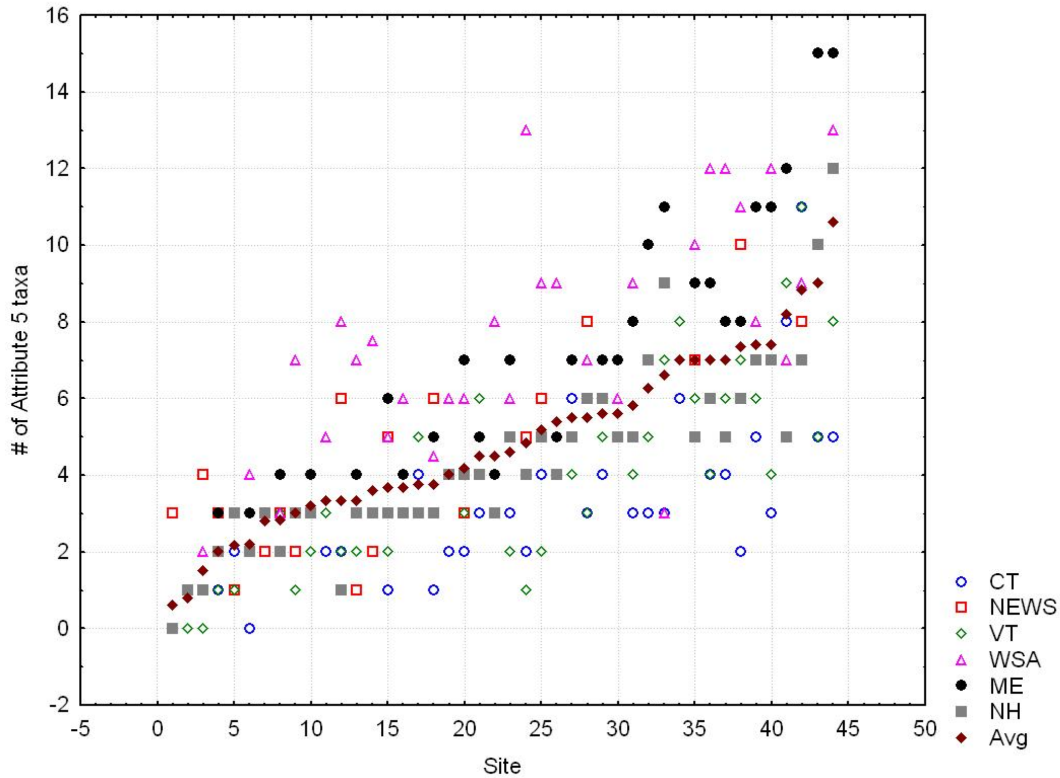
# of Attribute 3 taxa
Site
CT
NEWS
VT
WSA
ME
NH
Avg



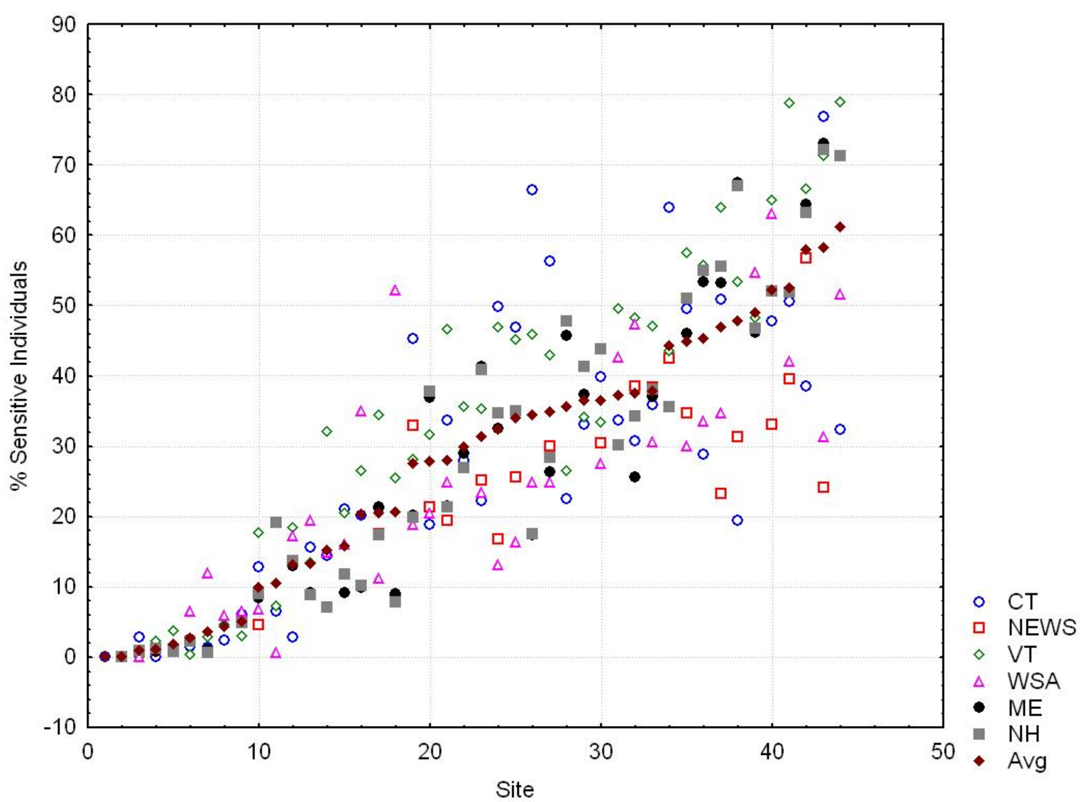
# of Attribute 2 & 3 taxa
Site
CT
NEWS
VT
WSA
ME
NH
Avg



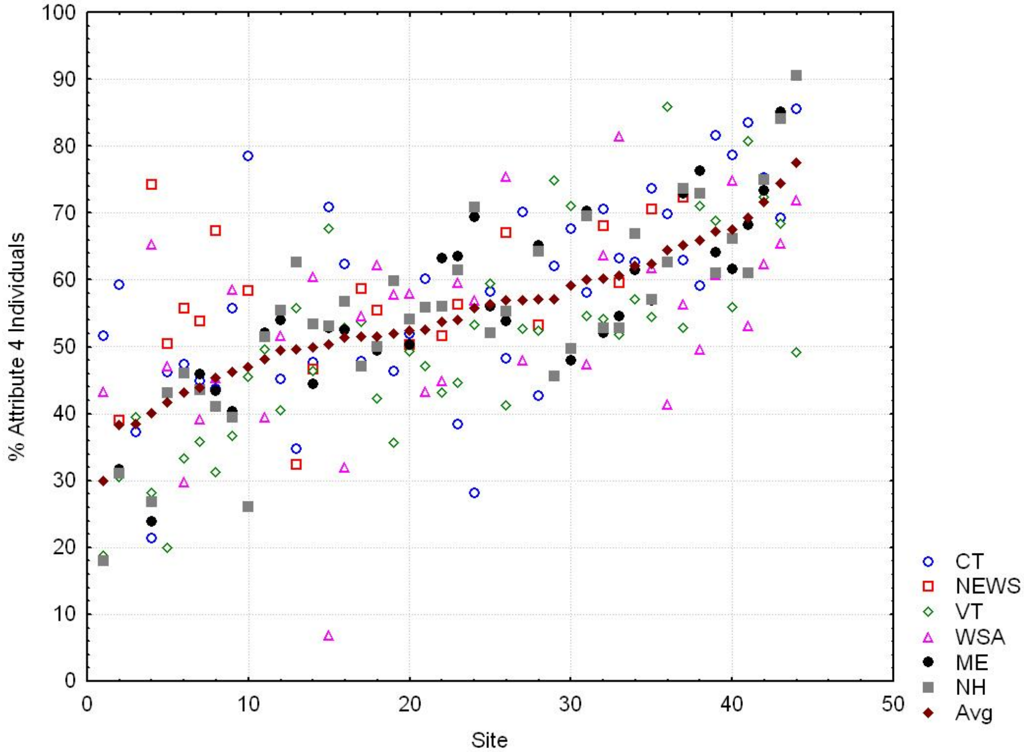
# of Attribute 4 taxa
Site
CT
NEWS
VT
WSA
ME
NH
Avg

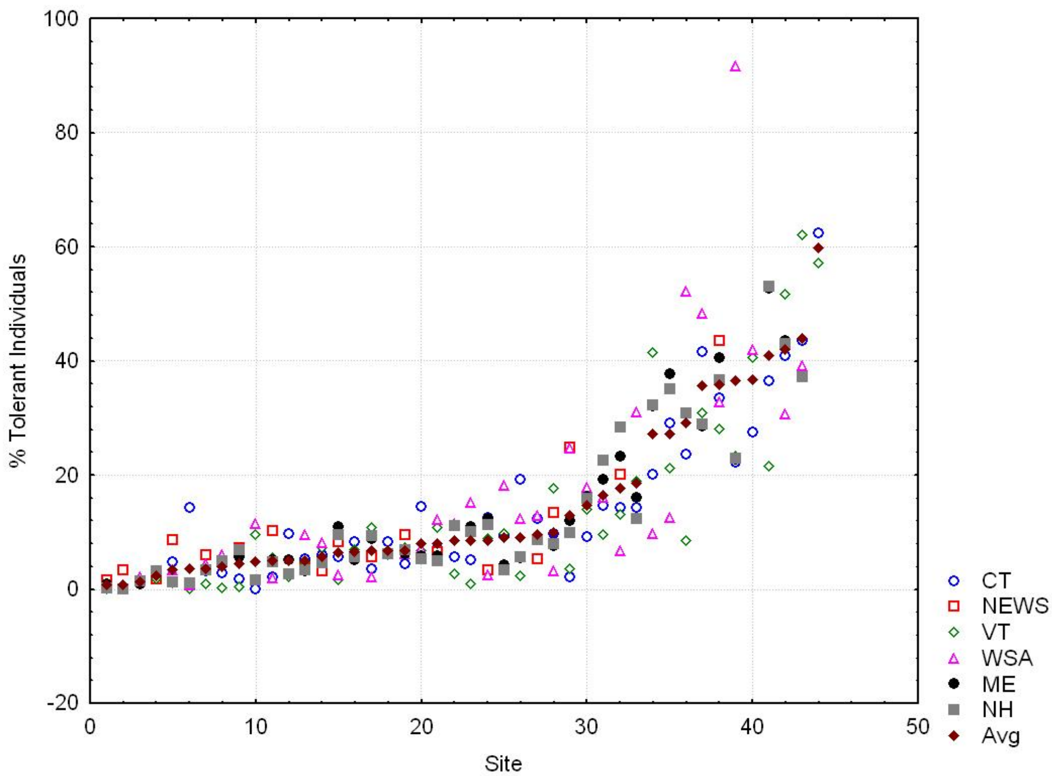


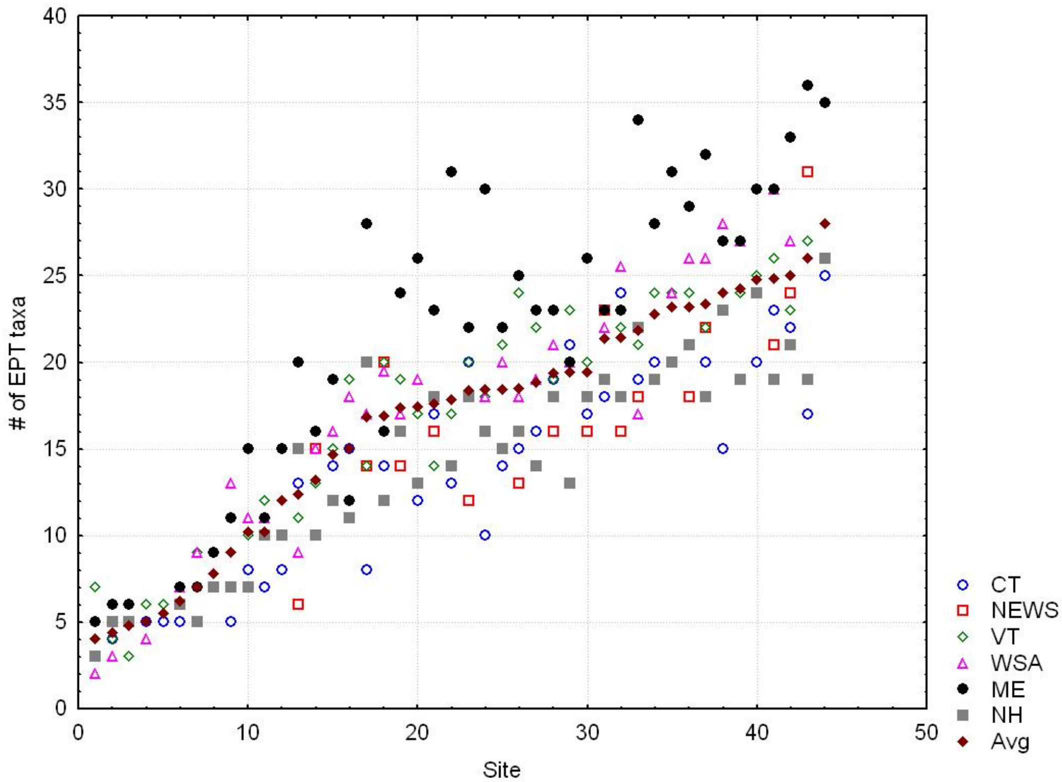
# of Attribute 5 taxa
Site
CT
NEWS
VT
WSA
ME
NH
Avg



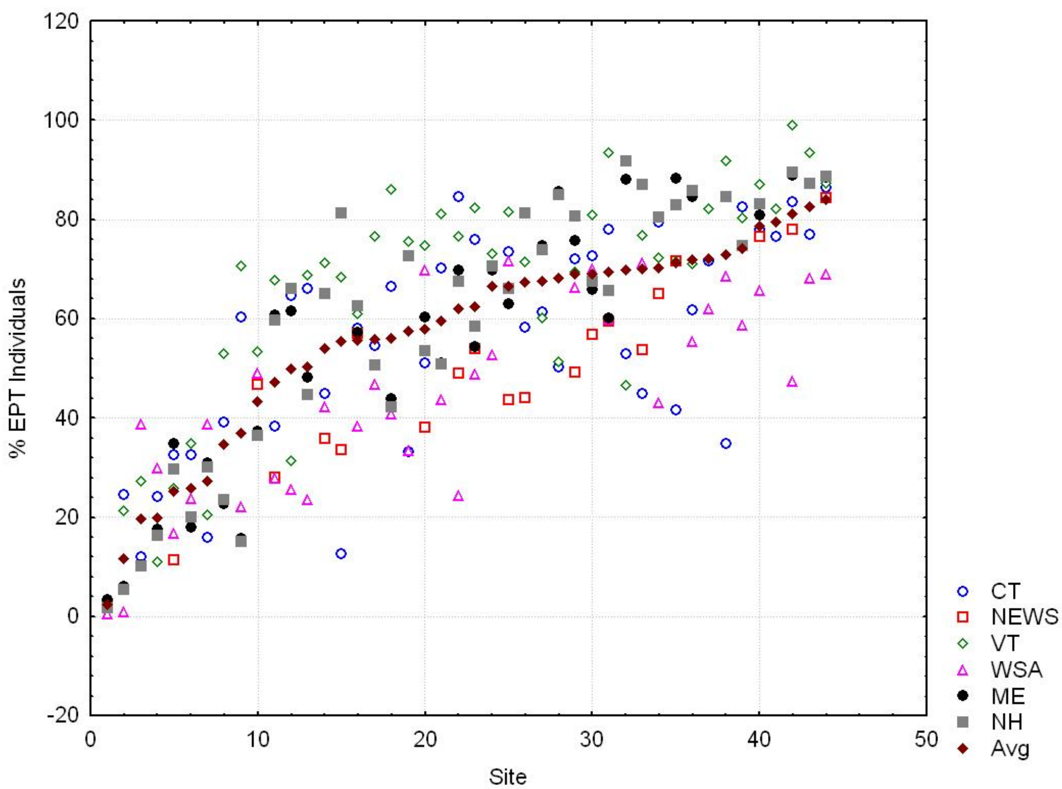
% Sensitive Individuals
Site
CT
NEWS
VT
WSA
ME
NH
Avg


100
90
80
70
60
50
40
30
20
10
0
% Attribute 4 Individuals
0
10
20
30
40
50
Site
CT
NEWS
VT
WSA
ME
NH
Avg

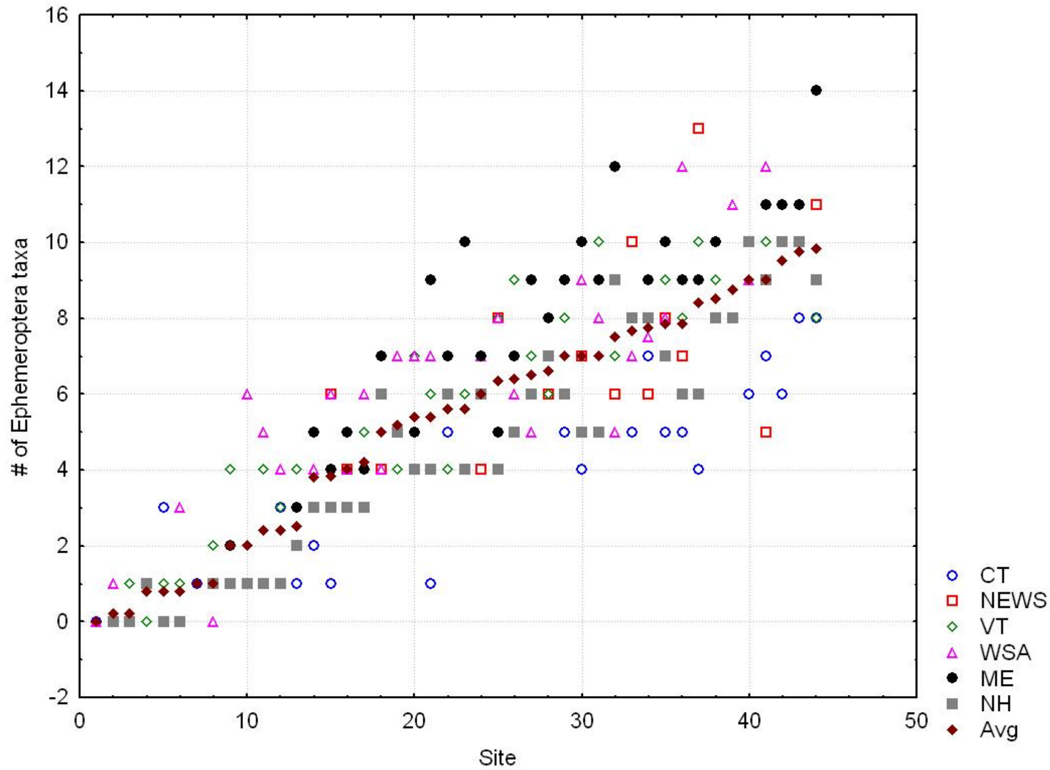

100
80
60
40
20
0
-20
% Tolerant Individuals
0
10
20
30
40
50
Site
CT
NEWS
VT
WSA
ME
NH
Avg



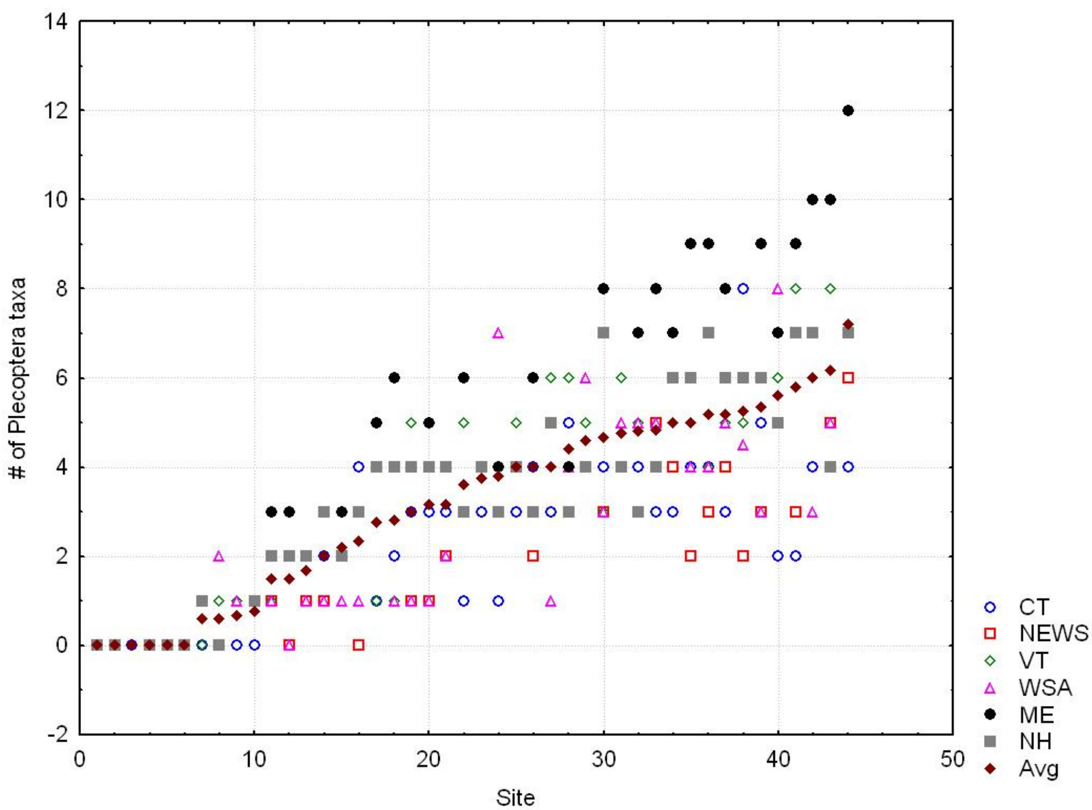
# of EPT taxa
Site
CT
NEWS
VT
WSA
ME
NH
Avg



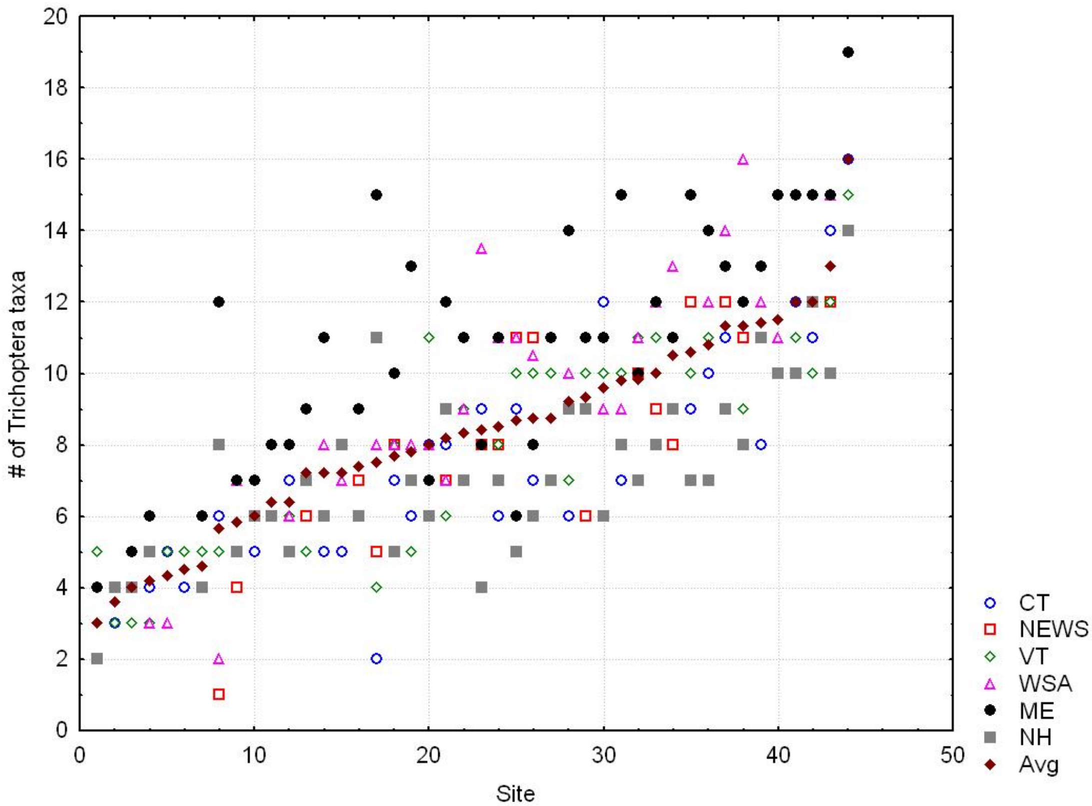
% EPT Individuals
Site
CT
NEWS
VT
WSA
ME
NH
Avg



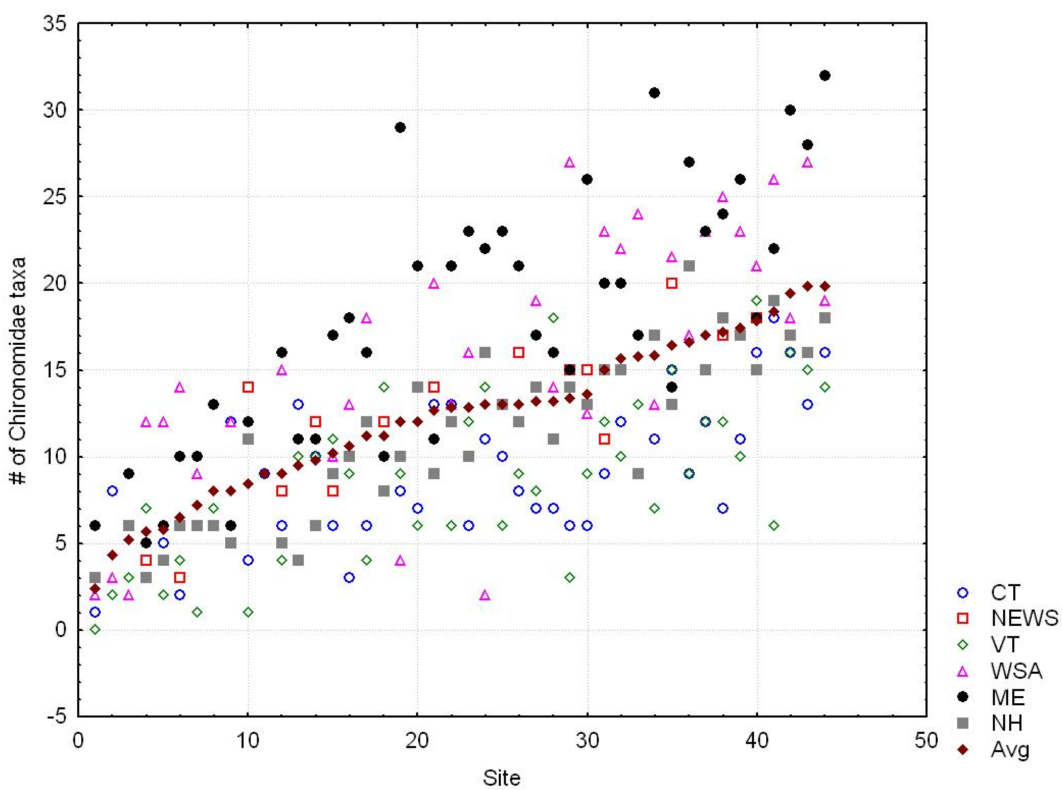
# of Ephemeroptera taxa
Site
CT
NEWS
VT
WSA
ME
NH
Avg



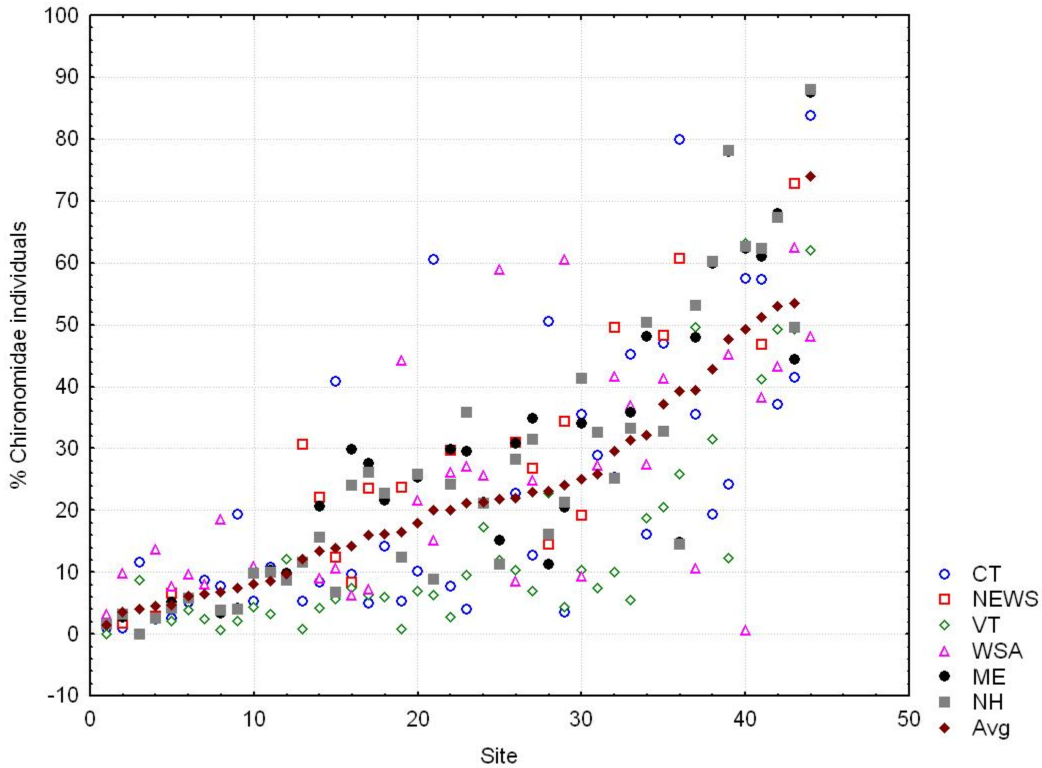
# of Plecoptera taxa
Site
CT
NEWS
VT
WSA
ME
NH
Avg

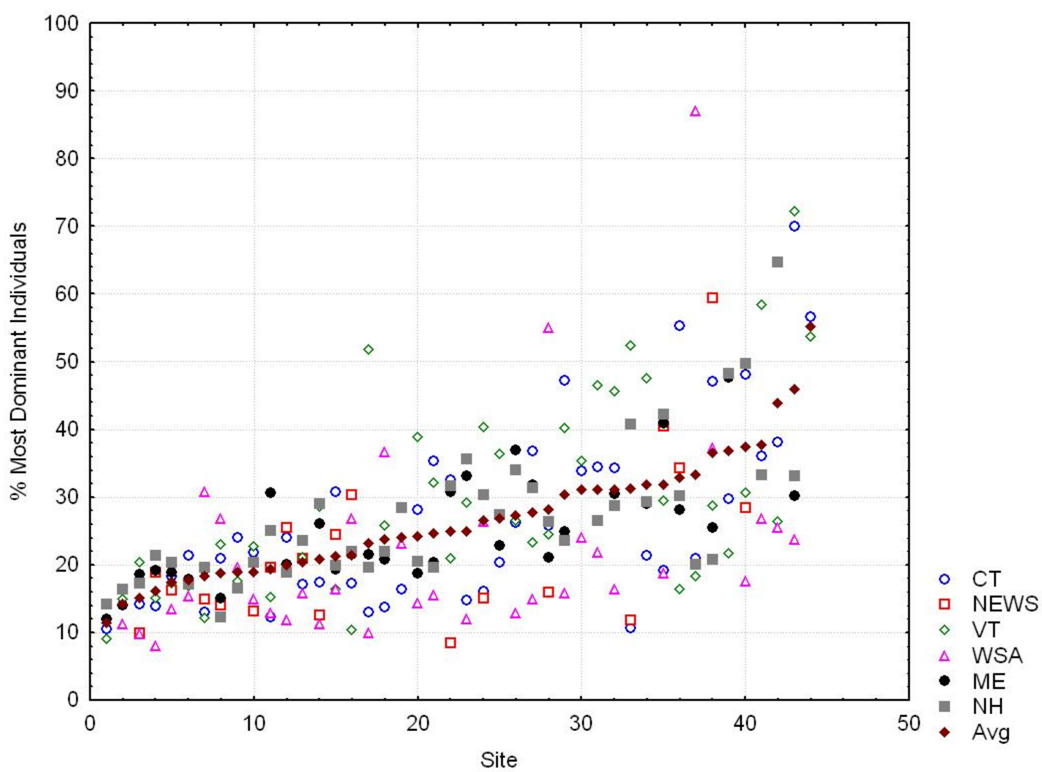


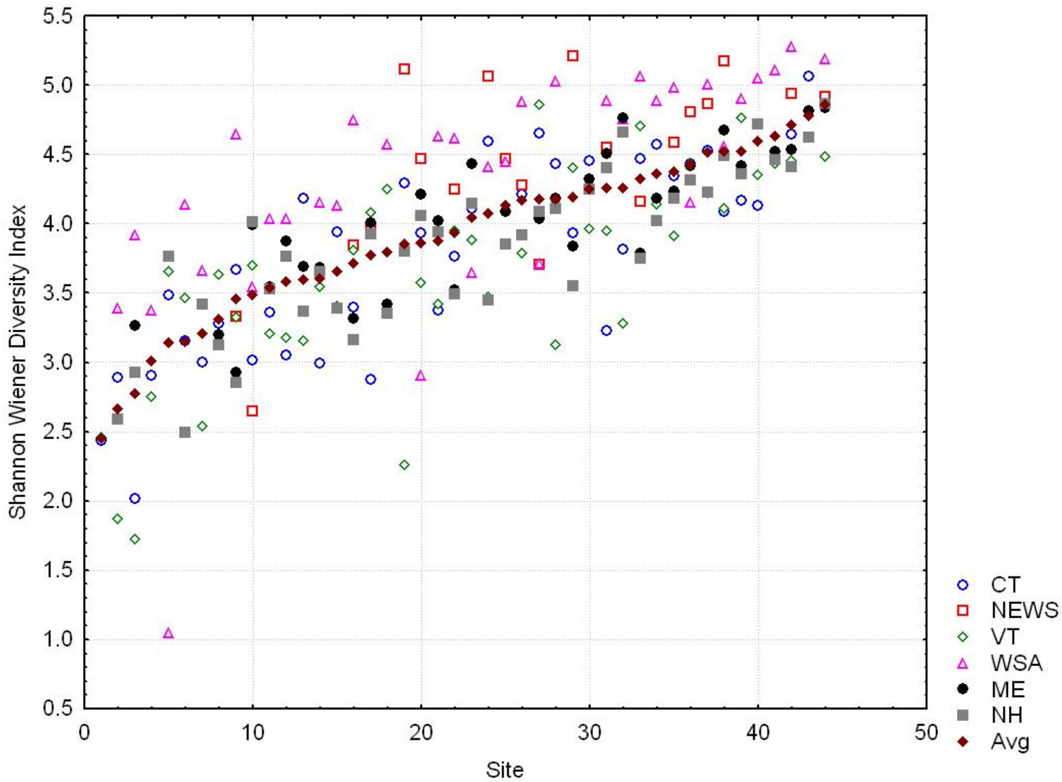
# of Trichoptera taxa
Site
CT
NEWS
VT
WSA
ME
NH
Avg

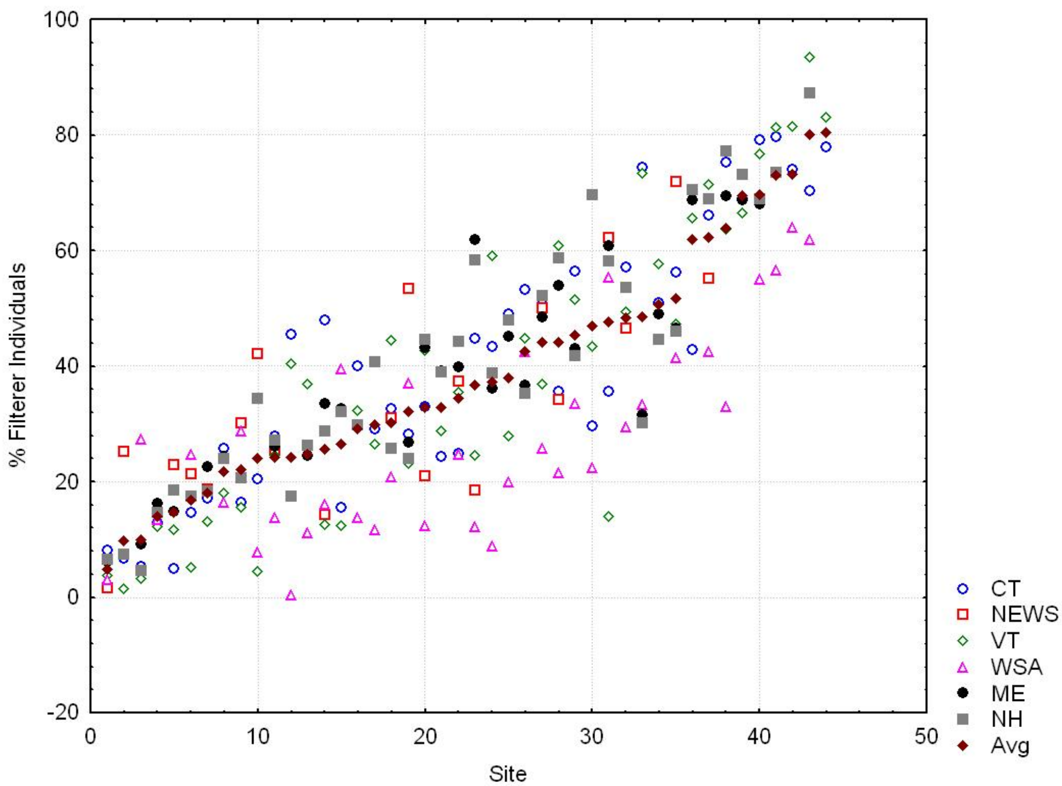


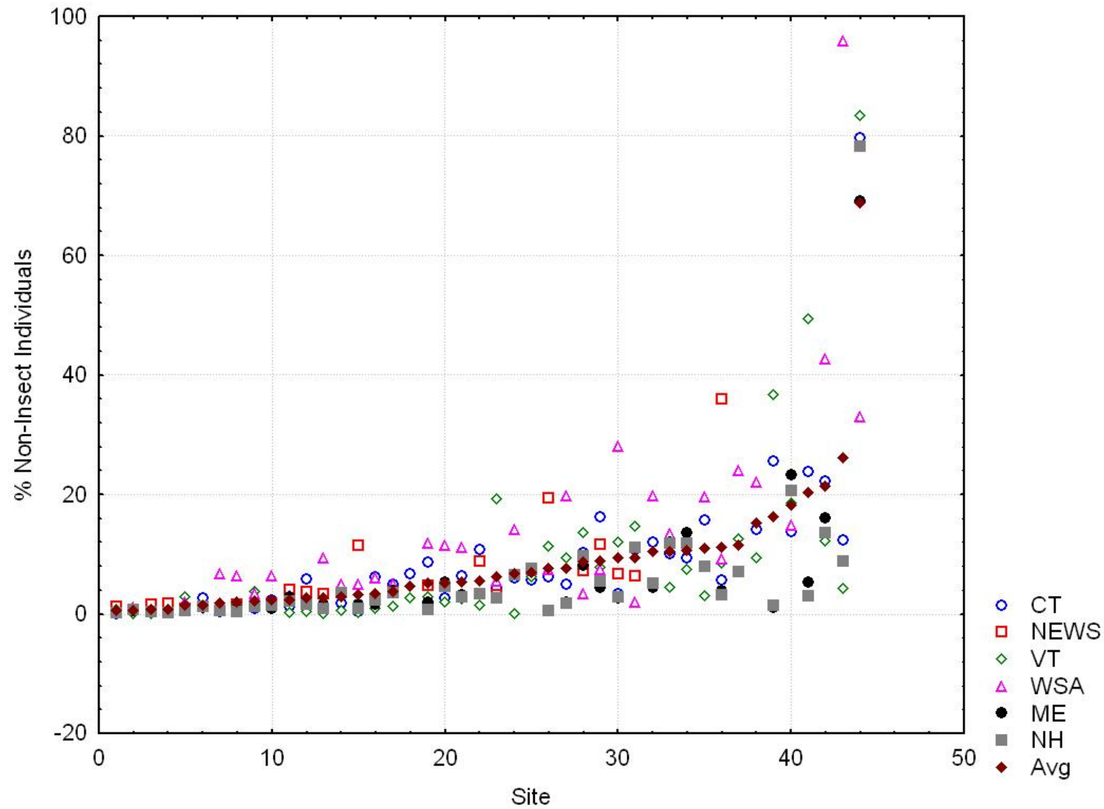
# of Chironomidae taxa
Site
CT
NEWS
VT
WSA
ME
NH
Avg


100
90
80
70
60
50
40
30
20
10
0
-10
% Chironomidae individuals
0
10
20
30
40
50
Site
CT
NEWS
VT
WSA
ME
NH
Avg

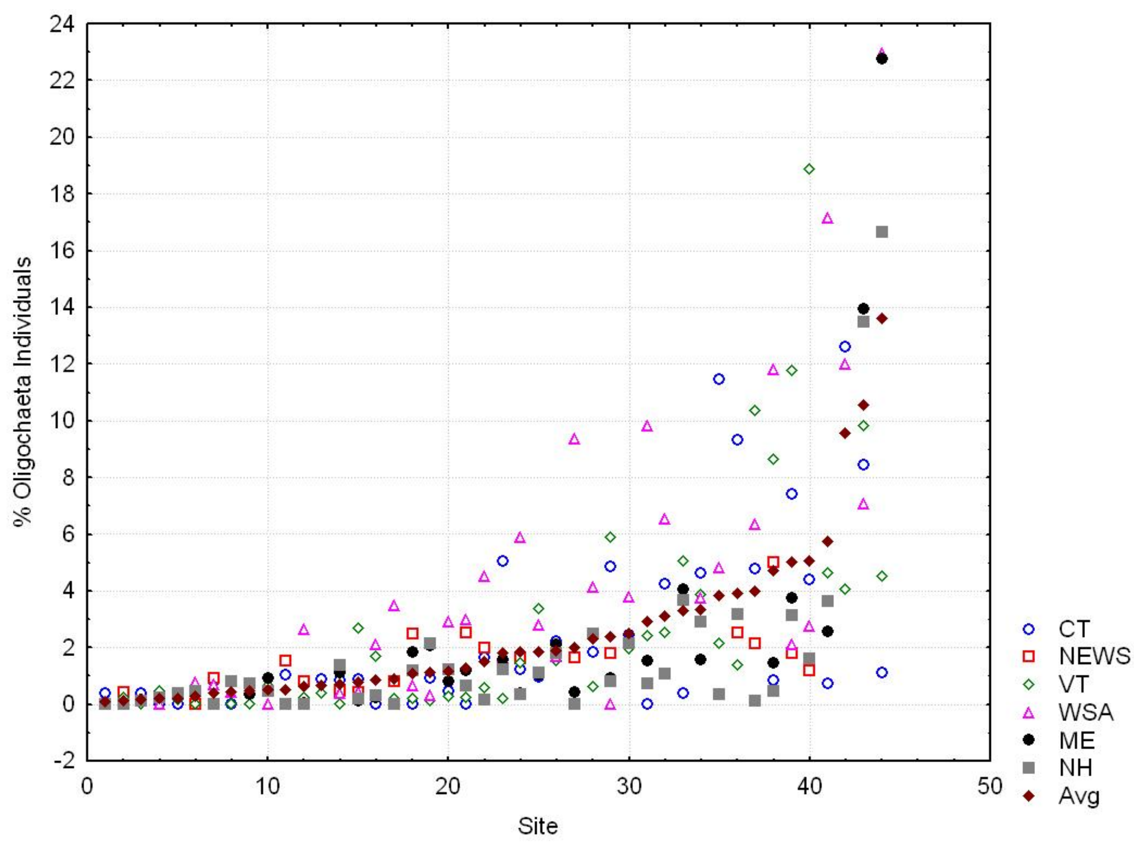

100
90
80
70
60
50
40
30
20
10
0
% Most Dominant Individuals
0
10
20
30
40
50
Site
CT
NEWS
VT
WSA
ME
NH
Avg


Shannon Wiener Diversity Index
Site
CT
NEWS
VT
WSA
ME
NH
Avg


% Filterer Individuals
Site
CT
NEWS
VT
WSA
ME
NH
Avg



100
80
60
40
20
0
-20
% Non-Insect Individuals
0
10
20
30
40
50
Site
CT
NEWS
VT
WSA
ME
NH
Avg



24
22
20
18
16
14
12
10
8
6
4
2
0
-2
% Oligochaeta Individuals
0
10
20
30
40
50
Site
CT
NEWS
VT
WSA
ME
NH
Avg

APPENDIX F

BCG - Participant Tier Assignments

Decimal rules were used when making BCG tier assignment. The rules were as follows:

1.5	middle 1
1.8	poor 1
2.2	good 2
2.5	middle 2
2.8	poor 2
3.2	good 3
3.5	middle 3
3.8	poor 3
4.2	good 4
4.5	middle 4
4.8	poor 4
5.2	good 5
5.5	middle 5

Table F1. BCG Tier assignments for each of the participants.

StationID	WaterbodyName	State	ME1	ME2	ME3	NH1	CT1	CT2	CT3	VT1	VT2	Mean	Min	Max	Max-Min
ME-REF4	Aroostook River	ME	1.8	2.5	2.5	NA**	2.2	2.5	2.8	2.8	3.2	2.5	1.8	3.2	1.4
VT-MC-05	Barney Brook	VT	3.8	4.8	4.5	4.8	4.2	5.5	5.2	4.8	4.2	4.6	3.8	5.5	1.7
NEWS04-3406	Beaver Brook***	NH	4.8	5.5	4.8	5.8	3.2	3.8	4.2	3.2	3.8	4.3	3.2	5.8	2.6
ME-MC-01	Birch Stream	ME	5.8	6.2	5.5	6.5	5.5	5.5	5.2	6.2	5.8	5.8	5.2	6.5	1.3
VT-MC-06	Bolles Brook	VT	1.5	1.5	1.8	2.5	2.5	3.2	2.8	1.8	2.2	2.2	1.5	3.2	1.7
NEWS04-1202	Carrying Place Stream	ME	2.2	2.2	1.8	2.5	3.5	2.8	2.5	3.2	2.2	2.5	1.8	3.5	1.7
NEWS04-3004	Cocheco River	NH	2.8	4.5	3.5	3.5	4.5	3.8	4.8	4.8	3.8	4.0	2.8	4.8	2
NH-01M-17	Cockermouth River	NH	2.8	3.2	3.8	4.5	4.5	4.5	3.5	3.5	3.2	3.7	2.8	4.5	1.7
NEWS04-3303	Dinsmore Pond Brook	NH	3.5*	3.5*	2.8	3.8	3.2	3.5	3.8*	3.5*	3.8*	3.3	2.8	3.8	1
NEWS04-VT01	East Branch Passumpsic River	VT	2.5	4.2	3.2	3.8	3.5	3.2	3.2	3.2	3.2	3.3	2.5	4.2	1.7
VT-MC-03	Gunner Bk	VT	3.5*	3.8	4.5	4.2*	3.5	3.8	3.8	3.8	3.2	3.8	3.2	4.5	1.3
ME-19.01	Hardy Brook	ME	1.8	2.5	1.8	3.5	1.8	2.2	2.5	4.2	2.8	2.6	1.8	4.2	2.4
ME-20.02	Higgins Brook	ME	2.2	2.5	2.2	2.5	2.2	3.5	2.5	2.2	2.2	2.4	2.2	3.5	1.3
NEWS04-2401	Indian River	NH	2.2	2.5	1.8	3.5	2.5	3.5	2.5	2.8	2.5	2.6	1.8	3.5	1.7
NEWS04-1303	Kenduskeag River***	ME	2.8	3.5	3.5	4.5	3.5	3.5	3.5	5.2	3.2	3.7	2.8	5.2	2.4
CT-65	Mad River	CT	5.5	5.5	6.2	6.5	5.8	5.5	5.5	6.2	5.5	5.8	5.5	6.5	1
ME-27.01	Medomak River	ME	2.8	3.5	3.2	3.5	3.2	3.8	3.8	4.5	3.8	3.6	2.8	4.5	1.7
ME-MC-05	Merriland River	ME	2.5	3.8	2.5	3.2	NA	NA	NA	2.8	3.5	3.1	2.5	3.8	1.3
NEWS04-2805	Mettawee River	VT	2.5	2.5	2.2	3.5	2.2	3.2	2.2	3.2	3.2	2.7	2.2	3.5	1.3
NEWS04-1801	Millers Run	VT	2.5	3.2	3.5	3.5	3.5	3.5	3.5	2.5	3.2	3.2	2.5	3.5	1
NH-00M-17	Nesenkeag Brook	NH	3.5	4.5	3.5	4.5	3.5	4.5	3.5	3.5	3.2	3.8	3.2	4.5	1.3
NEWS04-4104	Pease Brook	CT	3.2	4.5	3.8	3.8	4.5	4.8	4.2	4.2	3.8	4.1	3.2	4.8	1.6
ME-MC-03	Penjajawoc Stream	ME	4.8	5.2	4.8	5.8	4.2	5.2	4.5	5.8	4.8	5.0	4.2	5.8	1.6
CT-PR7	Pequabuck River	CT	5.2	5.8*	6.5	5.8	4.8	5.5	4.8	5.8*	5.2	5.4	4.8	6.5	1.7

*These tier assignments were adjusted at the May 27 workshop. ME2 and CT2 were unable to participate in the workshop.
**NH1 did not feel comfortable making a tier assignment at this site due to its large drainage area.
***These are considered to be low gradient sites.

Table F1. Continued…

StationID	WaterbodyName	State	ME1	ME2	ME3	NH1	CT1	CT2	CT3	VT1	VT2	Mean	Min	Max	Max-Min
NH-99C-58	Priest Brook	NH	3.2	3.8	4.2	4.2	4.2	4.5	4.2	3.8	3.2	3.9	3.2	4.5	1.3
VT-MC-01	Rock River	VT	5.2	5.5	5.2	5.5	4.5	5.5	5.5	5.5	5.5	5.3	4.5	5.5	1
NEWS04-CT03	Salmon River	CT	2.5	3.5	3.5	3.5	3.2	3.5	3.2	3.2	3.5	3.3	2.5	3.5	1
NEWS04-CT05	Saugatuck River	CT	2.8	2.5	3.2	4.5	3.2	3.5	3.5	3.5	3.8	3.4	2.5	4.5	2
NEWS04-1302	Schoodic Brook	ME	2.2	3.2	2.5	2.8	3.5	3.5	3.5	3.5	2.8	3.1	2.2	3.5	1.3
ME-MC-04	Sheepscot River	ME	3.2	3.8	3.5	2.8	2.2	3.5	2.5	3.8	3.2	3.2	2.2	3.8	1.6
NH-01M-06	Squam Brook	NH	4.8	5.2	5.2	5.5	4.8	5.2	5.2	5.2	3.8	5.0	3.8	5.5	1.7
NEWS04-4003	Steele Brook	CT	3.2	4.2	3.2	4.2	4.2	3.8	3.8	4.2	3.8	3.8	3.2	4.2	1
CT-NR21B	Steele Brook	CT	NA	NA	NA	NA	5.8	5.5	5.5	5.5	5.5	5.6	5.5	5.8	0.3
VT-MC-04	Stevens Branch	VT	3.2	3.8	4.5	5.5	3.8	3.5	3.8	4.5	3.8	4.0	3.2	5.5	2.3
CT-SR1A	Still River	CT	NA	NA	NA	NA	5.5	5.5	5.5	5.8	5.8	5.6	5.5	5.8	0.3
NH-00M-18	Tannery Brook	NH	2.5	3.8	3.2	3.5	3.5	3.8	4.2	3.5	3.5	3.5	2.5	4.2	1.7
NEWS04-2301	Third Branch White River	VT	2.5	2.5	2.5	3.2	2.5	3.2	2.5	3.2	2.8	2.8	2.5	3.2	0.7
ME-MC-02	Trout Brook	ME	5.2	6.2	6.5	5.5	4.8	5.5	5.5	5.8	5.2	5.6	4.8	6.5	1.7
CT-58	Trout Brook	CT	5.5	5.8	5.5	6.2	5.8	5.8	5.5	6.2	5.8	5.7	5.5	6.2	0.7
VT-MC-02	W Br Ompompanoosuc	VT	5.5*	5.8	4.5	5.5	5.5*	4.8	5.5*	6.5	5.5	5.4	4.5	6.5	2
NEWS04-2907	Warren Brook	NH	2.8	2.5	3.2	4.2	3.2	3.5	2.8	3.2	2.2	3.1	2.2	4.2	2
NH-REF3	Whiteface River	NH	1.5	3.2	1.8	2.5	3.5	3.5	3.5	1.8	2.2	2.6	1.5	3.5	2
NEWS04-3603	Willimantic River	CT	2.8	2.5	3.5	3.8	3.8	3.5	4.8	3.5	3.5	3.5	2.5	4.8	2.3
NEWS04-1001	Willoughby River	VT	2.8	3.5	2.8	3.5	3.2	3.5	2.8	3.2	3.5	3.2	2.8	3.5	0.7

*These tier assignments were adjusted at the May 27 workshop. ME2 and CT2 were unable to participate in the workshop.

APPENDIX G

Ratings Comparison – Maine method samples

Table G1. Maine method samples. Comparison of BCG tier assignments, CT and NEWS fuzzy model and state method results (derived from Maine's linear discriminant models, which classifies samples as A, B, C or NA (not attaining)). WSA MMI scores and ratings, which were derived from WSA method samples, are also included.

StationID	WaterbodyName	STATE	BCG Tier Assignments			Fuzzy Model		State Method	WSA	
			ME1	ME2	ME3	CT	NEWS	ME	MMI	Rating
ME-REF4	Aroostook River	ME	1	2	2	3	3	A	-	-
VT-MC-05	Barney Brook	VT	3	4	4	3	4	NA	44.3	Poor
NEWS04-3406	Beaver Brook*	NH	4	5	4	3	5	A	21.7	Poor
ME-MC-01	Birch Stream	ME	5	6	5	4	5	NA	10.3	Poor
VT-MC-06	Bolles Brook	VT	1	1	1	3	3	A	55.2	Fair
NEWS04-1202	Carrying Place Stream	ME	2	2	1	2	3	A	54.2	Fair
NEWS04-3004	Cocheco River	NH	2	4	3	3	3	A	46.4	Poor
NH-01M-17	Cockermouth River	NH	2	3	3	3	3	A	55.5	Fair
NEWS04-3303	Dinsmore Pond Brook	NH	3	3	2	3	3	A	66.3	Good
NEWS04-VT01	East Branch Passumpsic River	VT	2	4	3	3	3	A	62.3	Fair
VT-MC-03	Gunner Bk	VT	3	3	4	3	3	A	67.3	Good
ME-19.01	Hardy Brook	ME	1	2	1	2	2	A	-	-
ME-20.02	Higgins Brook	ME	2	2	2	2	3	A	-	-
NEWS04-2401	Indian River	NH	2	2	1	3	2	A	66.7	Good
NEWS04-1303	Kenduskeag River*	ME	2	3	3	3	4	A	43.6	Poor
CT-65	Mad River	CT	5	5	6	5	5	NA	20.0	Poor
ME-27.01	Medomak River	ME	2	3	3	3	3	A	-	-
ME-MC-05	Merriland River	ME	2	3	2	3	3	A	69.9	Good
NEWS04-2805	Mettawee River	VT	2	2	2	2	2	A	56.4	Fair
NEWS04-1801	Millers Run	VT	2	3	3	3	3	A	74.8	Good
NH-00M-17	Nesenkeag Brook	NH	3	4	3	3	3	A	75.3	Good
NEWS04-4104	Pease Brook	CT	3	4	3	3	4	A	59.1	Fair
ME-MC-03	Penjajawoc Stream	ME	4	5	4	3	5	C	44.0	Poor

*These are considered to be low gradient sites.

Table G1. Continued…

StationID	WaterbodyName	STATE	BCG Tier Assignments			Fuzzy Model		State Method	WSA	
			ME1	ME2	ME3	CT	NEWS	ME	MMI	Rating
CT-PR7	Pequabuck River	CT	5	5	6	5	5	NA	31.0	Poor
NH-99C-58	Priest Brook	NH	3	3	4	3	3	A	56.7	Fair
VT-MC-01	Rock River	VT	5	5	5	4	5	NA	39.5	Poor
NEWS04-CT03	Salmon River	CT	2	3	3	4	5	A	87.5	Good
NEWS04-CT05	Saugatuck River	CT	2	2	3	3	3	A	58.3	Fair
NEWS04-1302	Schoodic Brook	ME	2	3	2	3	3	A	80.9	Good
ME-MC-04	Sheepscot River	ME	3	3	3	3	3	A	-	-
NH-01M-06	Squam Brook	NH	4	5	5	3	5	B	-	-
CT-NR21B	Steele Brook	CT	NA	NA	NA	NA	NA	NA	14.9	Poor
NEWS04-4003	Steele Brook	CT	3	4	3	3	3	A	61.2	Fair
VT-MC-04	Stevens Branch	VT	3	3	4	3	4	A	55.8	Fair
CT-SR1A	Still River	CT	NA	NA	NA	NA	NA	NA	-	-
NH-00M-18	Tannery Brook	NH	2	3	3	3	3	A	66.0	Good
NEWS04-2301	Third Branch White River	VT	2	2	2	3	3	A	77.6	Good
CT-58	Trout Brook	CT	5	5	5	5	5	NA	24.2	Poor
ME-MC-02	Trout Brook	ME	5	6	6	5	5	NA	4.3	Poor
VT-MC-02	W Br Ompompanoosuc	VT	5	5	4	5	5	A	41.7	Poor
NEWS04-2907	Warren Brook	NH	2	2	3	3	3	A	60.1	Fair
NH-REF3	Whiteface River	NH	1	3	1	2	2	A	-	-
NEWS04-3603	Willimantic River	CT	2	2	3	3	5	A	65.8	Good
NEWS04-1001	Willoughby River	VT	2	3	2	3	3	A	76.1	Good

APPENDIX H

Ratings Comparison – New Hampshire method samples

Table H1. New Hampshire method samples. Comparison of BCG tier assignments, CT and NEWS fuzzy model and state method results (derived from the NH MMI). FS = fully supporting, NS=not supporting. The MMI threshold is either 54 or 65, depending on site location. WSA MMI scores and ratings, which were derived from WSA method samples, are also included.

StationID	WaterbodyName	STATE	BCG Tier Assignment	Fuzzy Model		State Method		WSA	
			NH1	CT	NEWS	NH MMI	NH Rating	MMI	Rating
ME-REF4	Aroostook River	ME	NA	3	3	81.5	FS	-	-
VT-MC-05	Barney Brook	VT	4	4	5	69.0	FS	44.3	Poor
NEWS04-3406	Beaver Brook*	NH	5	3	5	49.3	NS	21.7	Poor
ME-MC-01	Birch Stream	ME	6	5	5	34.1	NS	10.3	Poor
VT-MC-06	Bolles Brook	VT	2	3	3	89.0	FS	55.2	Fair
NEWS04-1202	Carrying Place Stream	ME	2	2	3	88.0	FS	54.2	Fair
NEWS04-3004	Cocheco River	NH	3	3	3	68.0	FS	46.4	Poor
NH-01M-17	Cockermouth River	NH	4	3	3	44.1	NS	55.5	Fair
NEWS04-3303	Dinsmore Pond Brook	NH	3	3	3	72.2	FS	66.3	Good
NEWS04-VT01	East Branch Passumpsic River	VT	3	4	5	76.2	FS	62.3	Fair
VT-MC-03	Gunner Bk	VT	4	3	3	53.5	NS	67.3	Good
ME-19.01	Hardy Brook	ME	3	2	3	76.4	FS	-	-
ME-20.02	Higgins Brook	ME	2	2	2	90.3	FS	-	-
NEWS04-2401	Indian River	NH	3	3	2	82.8	FS	66.7	Good
NEWS04-1303	Kenduskeag River*	ME	4	3	5	50.2	NS	43.6	Poor
CT-65	Mad River	CT	6	5	5	59.0	FS	20.0	Poor
ME-27.01	Medomak River	ME	3	3	3	83.3	FS	-	-
ME-MC-05	Merriland River	ME	3	3	3	78.3	FS	69.9	Good
NEWS04-2805	Mettawee River	VT	3	2	2	91.0	FS	56.4	Fair
NEWS04-1801	Millers Run	VT	3	2	3	78.4	FS	74.8	Good
NH-00M-17	Nesenkeag Brook	NH	4	3	3	68.5	FS	75.3	Good
NEWS04-4104	Pease Brook	CT	3	4	5	65.2	FS	59.1	Fair

*These are considered to be low gradient sites.

Table H1. Continued…

StationID	WaterbodyName	STATE	BCG Tier Assignment	Fuzzy Model		State Method		WSA	
			NH1	CT	NEWS	NH MMI	NH Rating	MMI	Rating
ME-MC-03	Penjajawoc Stream	ME	5	4	5	35.6	NS	44.0	Poor
CT-PR7	Pequabuck River	CT	5	5	5	62.0	FS	31.0	Poor
NH-99C-58	Priest Brook	NH	4	3	3	74.2	FS	56.7	Fair
VT-MC-01	Rock River	VT	5	4	5	32.7	NS	39.5	Poor
NEWS04-CT03	Salmon River	CT	3	4	5	80.0	FS	87.5	Good
NEWS04-CT05	Saugatuck River	CT	4	3	3	73.9	FS	58.3	Fair
NEWS04-1302	Schoodic Brook	ME	2	3	3	81.8	FS	80.9	Good
ME-MC-04	Sheepscot River	ME	2	3	3	69.3	FS	-	-
NH-01M-06	Squam Brook	NH	5	4	5	38.4	NS	-	-
CT-NR21B	Steele Brook	CT	NA	NA	NA	NA	NA	14.9	Poor
NEWS04-4003	Steele Brook	CT	4	3	3	75.7	FS	61.2	Fair
VT-MC-04	Stevens Branch	VT	5	3	4	54.2	FS	55.8	Fair
CT-SR1A	Still River	CT	NA	NA	NA	NA	NA	-	-
NH-00M-18	Tannery Brook	NH	3	3	3	61.7	FS	66.0	Good
NEWS04-2301	Third Branch White River	VT	3	3	3	78.8	FS	77.6	Good
CT-58	Trout Brook	CT	6	5	5	47.4	NS	24.2	Poor
ME-MC-02	Trout Brook	ME	5	5	5	38.0	NS	4.3	Poor
VT-MC-02	W Br Ompompanoosuc	VT	5	5	5	69.5	FS	41.7	Poor
NEWS04-2907	Warren Brook	NH	4	2	3	62.7	FS	60.1	Fair
NH-REF3	Whiteface River	NH	2	2	2	87.5	FS	-	-
NEWS04-3603	Willimantic River	CT	3	3	4	75.7	FS	65.8	Good
NEWS04-1001	Willoughby River	VT	3	3	3	74.2	FS	76.1	Good

APPENDIX I

Ratings Comparison – Vermont method samples

Table I1. Vermont method samples. Comparison of BCG tier assignments, CT and NEWS fuzzy model and state method results (derived from the VT DEC rating system, which takes multiple metrics into account). Exc=excellent, VGood= very good, G=good. WSA MMI scores and ratings, which were derived from WSA method samples, are also included.

StationID	WaterbodyName	STATE	BCG Tier Assignments		Fuzzy Model		State Method	WSA	
			VT1	VT2	CT	NEWS	VT Rating	MMI	Rating
ME-REF4	Aroostook River	ME	2	3	3	3	VGood	-	-
VT-MC-05	Barney Brook	VT	4	4	4	5	F-Poor	44.3	Poor
NEWS04-3406	Beaver Brook*	NH	3	3	4	5	Fair	21.7	Poor
ME-MC-01	Birch Stream	ME	6	5	5	5	Poor	10.3	Poor
VT-MC-06	Bolles Brook	VT	1	2	2	3	Vg-Good	55.2	Fair
NEWS04-1202	Carrying Place Stream	ME	3	2	2	2	Good	54.2	Fair
NEWS04-3004	Cocheco River	NH	4	3	3	3	Good	46.4	Poor
NH-01M-17	Cockermouth River	NH	3	3	3	3	G-Fair	55.5	Fair
NEWS04-3303	Dinsmore Pond Brook	NH	3	3	3	3	Ex-Vgood	66.3	Good
NEWS04-VT01	East Branch Passumpsic River	VT	3	3	4	5	Vg-Good	62.3	Fair
VT-MC-03	Gunner Bk	VT	3	3	3	3	G-Fair	67.3	Good
ME-19.01	Hardy Brook	ME	4	2	5	5	Fair	-	-
ME-20.02	Higgins Brook	ME	2	2	2	2	Exc	-	-
NEWS04-2401	Indian River	NH	2	2	2	2	VGood	66.7	Good
NEWS04-1303	Kenduskeag River*	ME	5	3	4	5	VGood	43.6	Poor
CT-65	Mad River	CT	6	5	5	5	Poor	20.0	Poor
ME-27.01	Medomak River	ME	4	3	3	3	Good	-	-
ME-MC-05	Merriland River	ME	2	3	2	2	Exc	69.9	Good
NEWS04-2805	Mettawee River	VT	3	3	2	3	Ex-Vgood	56.4	Fair
NEWS04-1801	Millers Run	VT	2	3	2	3	Ex-Vgood	74.8	Good
NH-00M-17	Nesenkeag Brook	NH	3	3	3	3	Good	75.3	Good
NEWS04-4104	Pease Brook	CT	4	3	3	4	Good	59.1	Fair
ME-MC-03	Penjajawoc Stream	ME	5	4	4	5	F-Poor	44.0	Poor
CT-PR7	Pequabuck River	CT	5	5	5	5	F-Poor	31.0	Poor

*These are considered to be low gradient sites.

Table I1. Continued…

StationID	WaterbodyName	STATE	BCG Tier Assignments		Fuzzy Model		State Method	WSA	
			VT1	VT2	CT	NEWS	VT Rating	MMI	Rating
NH-99C-58	Priest Brook	NH	3	3	3	3	Vg-Good	56.7	Fair
VT-MC-01	Rock River	VT	5	5	5	5	Poor	39.5	Poor
NEWS04-CT03	Salmon River	CT	3	3	2	3	Exc	87.5	Good
NEWS04-CT05	Saugatuck River	CT	3	3	3	3	Good	58.3	Fair
NEWS04-1302	Schoodic Brook	ME	3	2	3	2	Ex-Vgood	80.9	Good
ME-MC-04	Sheepscot River	ME	3	3	3	3	Exc	-	-
NH-01M-06	Squam Brook	NH	5	3	4	5	G-Fair	-	-
CT-NR21B	Steele Brook	CT	5	5	5	5	Poor	14.9	Poor
NEWS04-4003	Steele Brook	CT	4	3	3	3	Fair	61.2	Fair
VT-MC-04	Stevens Branch	VT	4	3	4	5	Good	55.8	Fair
CT-SR1A	Still River	CT	5	5	5		Poor	-	-
NH-00M-18	Tannery Brook	NH	3	3	3	3	Ex-Vgood	66.0	Good
NEWS04-2301	Third Branch White River	VT	3	2	3	3	VGood	77.6	Good
CT-58	Trout Brook	CT	6	5	5	5	Poor	24.2	Poor
ME-MC-02	Trout Brook	ME	5	5	4	5	Poor	4.3	Poor
VT-MC-02	W Br Ompompanoosuc	VT	6	5	6	6	Poor	41.7	Poor
NEWS04-2907	Warren Brook	NH	3	2	2	2	Vg-Good	60.1	Fair
NH-REF3	Whiteface River	NH	1	2	2	2	Exc	-	-
NEWS04-3603	Willimantic River	CT	3	3	3	3	Ex-Vgood	65.8	Good
NEWS04-1001	Willoughby River	VT	3	3	3	3	Ex-Vgood	76.1	Good

APPENDIX J

Ratings Comparison – Connecticut method samples

Table J1. Connecticut method samples. Comparison of BCG tier assignments, NEWS fuzzy model results and state method results (derived from the CT MMI and CT fuzzy model). Samples for the Merriland River were removed because the CT kick method was not appropriate for the habitat at this site. The CT MMI thresholds are as follows: <45=failing, 45-55 ambiguous, >55=meeting. WSA MMI scores and ratings, which were derived from WSA method samples, are also included.

StationID	WaterbodyName	STATE	BCG Tier Assignments			Fuzzy Model		State Method		WSA	
			CT1	CT2	CT3	CT	NEWS	CT MMI	CT Rating	MMI	Rating
ME-REF4	Aroostook River	ME	2	2	2	3	3	81.5	Meeting	-	-
VT-MC-05	Barney Brook	VT	4	5	5	4	5	52.0	Ambiguous	44.3	Poor
NEWS04-3406	Beaver Brook*	NH	3	3	4	3	5	63.0	Meeting	21.7	Poor
ME-MC-01	Birch Stream	ME	5	5	5	5	5	47.7	Ambiguous	10.3	Poor
VT-MC-06	Bolles Brook	VT	2	3	2	2	3	73.9	Meeting	55.2	Fair
NEWS04-1202	Carrying Place Stream	ME	3	2	2	3	2	74.4	Meeting	54.2	Fair
NEWS04-3004	Cocheco River	NH	4	3	4	3	4	55.7	Meeting	46.4	Poor
NH-01M-17	Cockermouth River	NH	4	4	3	3	4	53.3	Ambiguous	55.5	Fair
NEWS04-3303	Dinsmore Pond Brook	NH	3	3	3	3	3	83.1	Meeting	66.3	Good
NEWS04-VT01	East Branch Passumpsic River	VT	3	3	3	3	3	89.6	Meeting	62.3	Fair
VT-MC-03	Gunner Bk	VT	3	3	3	3	4	72.7	Meeting	67.3	Good
ME-19.01	Hardy Brook	ME	1	2	2	6	6	76.4	Meeting	-	-
ME-20.02	Higgins Brook	ME	2	3	2	2	3	74.1	Meeting	-	-
NEWS04-2401	Indian River	NH	2	3	2	2	2	79.7	Meeting	66.7	Good
NEWS04-1303	Kenduskeag River*	ME	3	3	3	4	5	60.2	Meeting	43.6	Poor
CT-65	Mad River	CT	5	5	5	5	5	37.6	Failing	20.0	Poor
ME-27.01	Medomak River	ME	3	3	3	3	3	72.0	Meeting	-	-
ME-MC-05	Merriland River	ME	NA	NA	NA	3	4	53.0	Ambiguous	69.9	Good
NEWS04-2805	Mettawee River	VT	2	3	2	2	3	68.6	Meeting	56.4	Fair
NEWS04-1801	Millers Run	VT	3	3	3	3	3	84.4	Meeting	74.8	Good
NH-00M-17	Nesenkeag Brook	NH	3	4	3	3	3	61.3	Meeting	75.3	Good
NEWS04-4104	Pease Brook	CT	4	4	4	3	4	66.0	Meeting	59.1	Fair

*These are considered to be low gradient sites.

Table J1. Continued…

StationID	WaterbodyName	STATE	BCG Tier Assignments			Fuzzy Model		State Method		WSA	
			CT1	CT2	CT3	CT	NEWS	CT MMI	CT Rating	MMI	Rating
ME-MC-03	Penjajawoc Stream	ME	4	5	4	4	5	51.3	Ambiguous	44.0	Poor
CT-PR7	Pequabuck River	CT	4	5	4	5	5	44.6	Ambiguous	31.0	Poor
NH-99C-58	Priest Brook	NH	4	4	4	3	3	70.1	Meeting	56.7	Fair
VT-MC-01	Rock River	VT	4	5	5	5	5	38.5	Failing	39.5	Poor
NEWS04-CT03	Salmon River	CT	3	3	3	2	3	85.8	Meeting	87.5	Good
NEWS04-CT05	Saugatuck River	CT	3	3	3	3	4	71.0	Meeting	58.3	Fair
NEWS04-1302	Schoodic Brook	ME	3	3	3	3	4	70.7	Meeting	80.9	Good
ME-MC-04	Sheepscot River	ME	2	3	2	3	3	84.3	Meeting	-	-
NH-01M-06	Squam Brook	NH	4	5	5	5	5	43.2	Failing	-	-
CT-NR21B	Steele Brook	CT	5	5	5	5	5	33.7	Failing	14.9	Poor
NEWS04-4003	Steele Brook	CT	4	3	3	2	3	85.0	Meeting	61.2	Fair
VT-MC-04	Stevens Branch	VT	3	3	3	4	5	62.0	Meeting	55.8	Fair
CT-SR1A	Still River	CT	5	5	5	5	NA	25.1	Failing	-	-
NH-00M-18	Tannery Brook	NH	3	3	4	3	3	77.0	Meeting	66.0	Good
NEWS04-2301	Third Branch White River	VT	2	3	2	2	2	79.9	Meeting	77.6	Good
CT-58	Trout Brook	CT	5	5	5	5	5	33.3	Failing	24.2	Poor
ME-MC-02	Trout Brook	ME	4	5	5	4	5	47.5	Ambiguous	4.3	Poor
VT-MC-02	W Br Ompompanoosuc	VT	5	4	5	4	5	51.8	Ambiguous	41.7	Poor
NEWS04-2907	Warren Brook	NH	3	3	2	2	3	73.9	Meeting	60.1	Fair
NH-REF3	Whiteface River	NH	3	3	3	2	2	59.3	Meeting	-	-
NEWS04-3603	Willimantic River	CT	3	3	4	3	4	72.6	Meeting	65.8	Good
NEWS04-1001	Willoughby River	VT	3	3	2	2	3	82.7	Meeting	76.1	Good