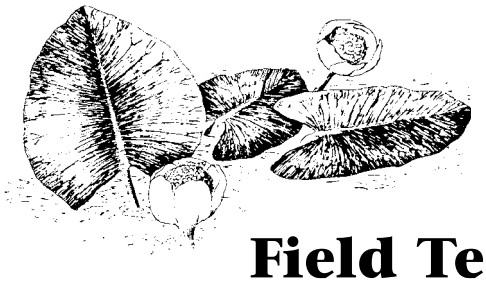
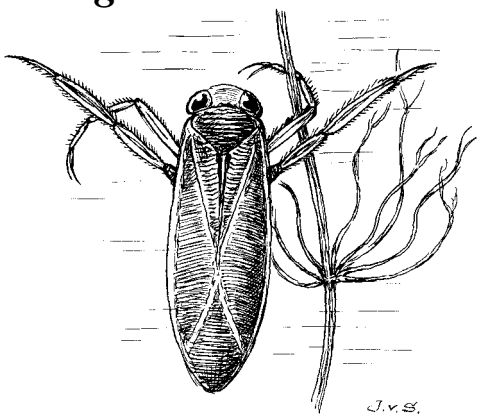


Field Testing the Wisconsin Depressional Wetland Macroinvertebrate and Plant Indices of Biological Integrity for Application by Trained Volunteers

Final Report to the U.S. Environmental Protection Agency Region V



Jennifer Hauxwell, Thomas W. Bernthal, Richard A. Lillie, Emmet J. Judziewicz, and Susan Kenney

SEPTEMBER 2004

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Final Report to USEPA – Region V
Wetland Grant #CD97565801

Jennifer Hauxwell[1], Thomas W. Bernthal[2], Richard A. Lillie[3], Emmet J. Judziewicz[4], and Susan Kenney[1, 2]

September 2004

[1] Wisconsin DNR, Bureau of Integrated Science Services, Fisheries and Aquatic Sciences Section, DNR Research Station, 1350 Femrite Drive, Monona, WI 53716
[2] Wisconsin DNR, Bureau of Fisheries Management and Habitat Protection, Lakes and Wetlands Section, P.O. Box 7921, Madison, WI 53707
[3] Wisconsin DNR, Bureau of Integrated Science Services, Ecological Inventory and Monitoring Section, DNR Research Station, 1350 Femrite Drive, Monona, WI 53716 (Retired)
[4] University of Wisconsin – Stevens Point, Department of Biology, Stevens Point, WI 54481

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Contact for Further Information

Jennifer Hauxwell
Wisconsin Department of Natural Resources
Bureau of Integrated Science Services
DNR Research Center
1350 Femrite Drive
Monona, WI 53716
(608) 221-6373
jennifer.hauxwell@dnr.state.wi.us

Contents

Executive Summary 3

Introduction 5
- Background 5
- Project Objectives 5

Methods 7
- Project Personnel and Responsibilities 7
- Volunteer Recruitment and Training 7
  - *Volunteer Recruitment*
  - *Special Training Requirements for Volunteers*
- Experimental Design 9
  - *Site Selection*
  - *Range of Disturbance*
  - *"Kettle" vs. "Prairie" Type*
  - *Design Matrix*
  - *Resulting Site Locations and Preliminary Classifications*
  - *Replicability*
- Field Collections 12
  - *Macroinvertebrates*
  - *Plants*
- Laboratory Sample Processing 13
  - *Macroinvertebrates*
  - *Plants*
- Data Analysis 17
  - *Macroinvertebrates*
  - *Plants*
- Data Quality Objectives 18

Results 19
- Macroinvertebrates 19
  - *Verification of Approach*
  - *Comparison between Volunteer and Expert Results - Overall Sources of Variability*
  - *Comparison between Volunteer and Expert Results - Specific Sources of Error*
  - *Summary of Metric Errors*
- Plants 41
  - *Discrepancies in WWPBI Scores and Summary of Metric Errors*
- Index Comparisons 54
  - *WWMBI vs. WWPBI*
  - *WWPBI vs. FQI and Mean Conservatism Values*

Recommendations for Implementation 57
- Time Spent Processing Samples 57
- Datasheets 57
- Troublesome Taxa 57
- Specimen Preservation 57
- Scores versus Ratings 57

Contents continue on next page.

Contents, continued.

Acknowledgements 58

Literature Cited 58

Appendix 1. Training Manual, Field and Laboratory Protocols and Sample Data Sheets 59

Appendix 2. Refresher Training Manual with Field and Laboratory Instructions 95

Appendix 3. Narrative Summaries of Each Site with Photographs and FQI Scores, Including Summary and Evaluation of the FQI and WWPBI. 137

Executive Summary

The Wisconsin Department of Natural Resources has developed a multi-metric Index of Biological Integrity (IBI) for isolated depressional wetlands. The composite index contains a set of metrics based on macroinvertebrates and a set of metrics based on plants. The index was developed to be employed by trained field staff, rather than requiring the advanced taxonomic skills of specialists in aquatic entomology and botany. This project tests the feasibility and reliability of deploying non-specialist field biologists to use the method after providing them with basic field and laboratory training. Specifically, we assessed whether the biologist field staff could obtain results for the macroinvertebrate and plant indices that were consistent with those of experts in the fields of aquatic entomology and botany. Additional goals of the field testing included assessing the time and cost of deploying the method, and familiarizing a group of DNR biologists with the potential application of the wetland IBIs for monitoring purposes by providing an opportunity for them to employ it.

For macroinvertebrates, we analyzed the type (i.e. cause for error categorized as mathematical, misidentified, overlooked, or other) and magnitude of errors. Overall, there were significant differences among the various levels of processing of the volunteer samples. However, volunteers always rated wetlands equal or similar (within 1 rating) to that of an expert. We determined that the only level of analysis that resulted in a significant difference from the previous level was the examination of the discarded volunteer debris (often containing significant numbers of “missed” organisms to affect the scoring). In addition, comparison of two separate samples from a given site - the “expert-level processed volunteer sample” to the “expert” sample - yielded no significant difference. These results indicate 1) that the error contributing the most to variability between volunteer and expert scores was within the discarded debris and 2) that the WWMBI adequately represented spatial heterogeneity within a site.

For plants, there was no significant difference between overall WWPBI scores for volunteers versus experts. Descriptive ratings were generally the same or varied by one level. These results indicate 1) that volunteers and experts evaluated the plant metrics between sites similarly and 2) that the WWPBI adequately represented the spatial heterogeneity within a site. Because the expert botanist was also able to determine the Floristic Quality Index and mean coefficient of conservatism for each site (both requiring species-level identifications), in addition to the WWPBI scores (requiring identification of general groups only), we had a unique opportunity to compare various plant indices. Remarkably, an index that relies on relatively coarse group-level identification of plants (WWPBI) ranked sites similarly to indices requiring species-level identifications (FQI and mean conservatism). In summary, the WWPBI is highly recommended for use within a statewide volunteer monitoring framework for 1) its ease of implementation, 2) the general ability of volunteers to accurately characterize sites (compared to an expert) with only an hour spent on-site, and 3) the concordance between WWPBI rankings of sites and that of other widely accepted plant indices (FQI and mean conservatism). Experience with an earlier volunteer monitoring methodology and the general experience of field staff for plant identification at the family level also suggests that training requirements for the plant index are less rigorous than for macroinvertebrates.

Overall, volunteers implemented the macroinvertebrate and plant IBIs with accuracy equal or similar (within 1 rating) to that of an expert. However, there are several modifications that might improve these tools for future monitoring applications, including reducing time spent processing macroinvertebrate samples, eliminating confusion with data sheets and score calculations for macroinvertebrates, and better identification of troublesome macroinvertebrate and plant taxa. Most volunteers spent at least 1 day processing each macroinvertebrate sample and often described the process as “tedious” or “frustrating.” We recommend that in the future, volunteers collect their samples, and then attend a centrally-located laboratory workshop with an expert on hand to expedite the process. This also provides the added benefit that volunteers receive immediate feedback on their accuracy, resulting in a more educational process. Confusion with filling out data sheets and calculating metric scores was a consistent source of error and one that easily may be avoided in the future by providing an automated data sheet. Sources of error for macroinvertebrates were widely distributed among the various metrics, resulting in highest percentage of errors associated with cumulative metrics (non-insect richness, total taxa richness, total insect richness, and total diversity). Sources of error for plants were also widely distributed among the various metrics. This result suggests an additional general training for macroinvertebrates and plants would be of value prior to implementation of a formal monitoring program.

Introduction

This study builds upon work conducted under previous USEPA Wetland Grants (#CD985491-01-0 and #CD975115-01-0) that resulted in the development of a biological index and classification system for Wisconsin wetlands using macroinvertebrate and plant communities (Lillie 2000 and Lillie,, et al. 2002). The purpose of this study was to assess the potential application of the Wisconsin Depressional Wetland Macroinvertebrate and Plant Indices of Biological Integrity as routine monitoring tools, and specifically to test the accuracy of trained volunteers in employing their use.

Background

The Wisconsin multi-metric Index of Biological Integrity (IBI) for isolated depressional wetlands was developed to create a quantitative measure of wetland health that can be used at the site level and is comprised of five biotic indices (including macroinvertebrates, plants, zooplankton, diatoms, and frogs) (Lillie 2000, Lillie,, et al. 2002). Its intended use is for monitoring trends on isolated, depressional sites, including assessing biological changes in natural wetlands subject to anthropogenic disturbances or tracking the development of biological conditions at wetland restoration sites. It was designed with consideration of limitations on available staff time, laboratory costs, and other constraints that affect the feasibility of field deployment. In other words, the index is intended to be useful for a wider range of users than a typical research tool, without sacrificing validity. In this study, we tested the ability of trained volunteers to apply components of the multimetric Index of Biological Integrity, specifically 1) the Wisconsin Wetland Macroinvertebrate Biotic Index (WWMBI) and 2) the Wisconsin Wetland Plant Biotic Index (WWPBI). Because the macroinvertebrate and plant metrics are based on family-level taxa discrimination, we have a high degree of confidence that any two experts applying the protocol would obtain consistent results. For this project, we tested the consistency of results when used by field staff over a broad range of disturbance conditions and the feasibility of having field staff reliably assign macroinvertebrate and plant biotic index scores for future monitoring applications.

Experience with the metrics to date leads us to expect more variation in high quality or undisturbed settings. Macroinvertebrate sampling was limited to early spring to eliminate the effect of in-migration and out-migration on the composition of the macroinvertebrate community. Experience also indicates that it is relatively easy to teach the field techniques. Because field staff typically have more experience with plant identification at the resolution required, we were more concerned with the vulnerability of the metrics to errors in macroinvertebrate identification than errors in plant identification.

Project Objectives

This project was used to help determine the feasibility of deploying the macroinvertebrate and plant indices of biotic integrity (IBI) in the field as part of a wetland monitoring program. Therefore, we needed to determine whether the existing field staff or trained volunteers that are likely to be called upon to use the method were capable of obtaining results consistent with those of specialized experts in aquatic entomology and botany. Although we tested both the macroinvertebrate and plant indices, we were particularly concerned with the ability of field staff to do the family-level macroinvertebrate identification accurately, consistently, and in a timely fashion. We needed to identify whether there were particular metrics that did not yield reliable and consistent results between field staff and a specialized expert, and determine which taxa were most difficult for field staff to identify. Potential modifications to the protocol, metrics and training materials could then also be identified through this project. Specific objectives and approaches toward addressing each question are outlined in Table 1.

Table 1. *Overall project objectives, approach, and anticipated quality of performance.*

Project Objective	**Approach and Data Quality Objective**
(1) Test the consistency of laboratory results of field staff vs. an expert with more specialized training in macroinvertebrate identification	
	Field staff will pick out at least 90% of the total number of organisms present in each sample.
	Field staff will make correct taxonomic identifications (to the level required for the metric) 90% of the time.
(2) Test consistency of field staff vs. expert results for the overall index and for each metric	
	Field staff vs. expert index results will vary by less than one rating class or if the values fall within adjacent categories, the values should be within the midpoints of the adjacent rating class.
	Individual metrics will also vary by less than one rating class.
(3) Evaluate the effect of rating class on consistency	
	Consistency is expected to be greater in lower classes (more highly disturbed wetlands).
(4) Evaluate the effect of wetland type on consistency	
	Consistency is expected to be the same in “prairie” vs. “kettle” wetlands.
(5) Evaluate practical considerations in deploying method	
	Participants will track the time spent in field and laboratory work, note difficulties, and share their opinions on the feasibility of deploying this method.

Methods

Project Personnel and Responsibilities

Project staff (non-volunteers) responsible for implementing the project and analyzing data are listed in Table 2 and are Wisconsin Department of Natural Resources employees. Additionally, Dr. Emmet Judziewicz (Botany Professor, University of Wisconsin-Stevens Point, Department of Biology) was contracted to serve as the "expert" for plant sampling.

Table 2. *Wisconsin Department of Natural Resources staff members and associated responsibilities.*

Name and Title	Project Responsibilities
Tom Bernthal, Wetland Monitoring Coordinator and Project Coordinator	Responsible for overall project direction, budgeting of EPA Grant funds, consulting on preparation of training materials, logistics of training sessions, communication with volunteer field staff. Responsible for evaluating the results as related to the implications for use of the IBI method in a wetland monitoring program, and recommendations for other uses.
Richard Lillie, Research Scientist/IBI Developer	Responsible for original research and sampling design, development and presentation of training materials, consultant for project implementation.
Jennifer Hauxwell, Research Scientist	Responsible for design and data analysis, supervision and quality control of laboratory work at the Research Center, data entry and statistical analysis and interpretation, final report preparation.
Susan Kenney, Research Technician	Responsible for "expert" laboratory work at the Research Center, preparation and custody of field samples, species identification, and data entry.

Volunteer Recruitment and Training

Volunteer Recruitment

Volunteers were selected from interested field staff to represent the range of program staff that might be involved in a future wetland monitoring program, and to include staff from the Natural Resources Conservation Service involved in monitoring wetland restoration projects (Table 3). All volunteers had a strong background or extensive training in biological science. In order to get statewide participation in testing, a minimum of one two-person team from each region was selected for training. Each team was given the option to recruit an additional team member to maximize participation. The volunteer field biologists routinely perform biological assessments in the course of their jobs. The purpose of this study was to determine whether this level of training was sufficient to obtain consistent results using the IBI protocols. For this reason, several possible candidates with specialized macroinvertebrate training were not asked to participate, because they were not reflective of the skill-level expected of most biology field staff and would bias the results.

Table 3. *Recruited teams of volunteers from different geographic regions including staff from the Wisconsin Department of Natural Resources (DNR), the Natural Resources Conservation Service (NRCS), the University of Wisconsin Extension (UWEX), and a Land Conservation Department (LCD).*

Regional Team	Name	Affiliation – Title
North Central	Jim Klosiewski	DNR Water Resources Management Specialist
	Bill Jaeger	DNR Water Resources Management Specialist
	Gary Bartz	DNR Water Resources Management Specialist
Northwest	Mike Johnson	DNR Wildlife Technician
	Jim Riemer	DNR Wildlife Biologist
	Jeremy Williamson	Polk County Land Conservation Department
Northeast	Shawn Eisch	DNR Water Management Specialist
	Eric Roers	DNR Wildlife Technician
	Laura Felda	UWEX Adopt-a-Lake Coordinator
Southeast	Joanne Kline	DNR Environmental Analysis and Review Specialist
	Cherie Wieloch	DNR Water Management Specialist
	John Masterson	DNR Water Resources Management Specialist
South Central Driftless	Tom Boos	DNR Water Management Specialist
	Cathy Bleser	DNR Environmental Analysis and Review Specialist
South Central Glaciated	Greg Kidd	NRCS Wetland Monitoring Specialist
	Bob Weihrouch	NRCS Wetland Restoration Specialist
	Tom Bernthal	DNR Wetland Monitoring Coordinator

Special Training Requirements for Volunteers

We recognized that staff would require training, not only in the sampling protocol, but also to improve their macroinvertebrate and plant identification skills. A two-day training session was provided in August of 2001 that covered the philosophy and development of the IBI, and all aspects of field sampling, laboratory analysis, calculating the metrics, and analyzing results (Appendix 1). Another half-day of training in macroinvertebrate identification and a remote, but interactive, review of the protocol was provided two to three weeks prior to field sampling (Appendix 2). The number of field staff we could train was limited by the laboratory space and equipment available and the need to maintain a reasonable instructor to trainee ratio to allow individualized attention. The training materials including sample data sheets are contained in Appendices 1 and 2.

To evaluate the effectiveness of the training we provided and to resolve potential discrepancies in performances of different volunteers, participants were asked to assess their level of skill and confidence in identifying aquatic macroinvertebrates from wetlands prior to the August 2001 training session. They were requested to assess their level of experience based on the following questionnaire (Fig. 1.

To help us document your level of expertise or familiarity with wetland macroinvertebrates, please describe your level of experience **prior to the training**, based on:

(1) Your experience in actually identifying aquatic macroinvertebrates in general, wetland species in particular, and

(2) Your exposure to looking at field guides, illustrations, looking at macroinvertebrates in the field, etc.

RATE YOURSELF USING THE FOLLOWING GUIDE:

"None" – you have no experience with macroinvertebrates in any system and have never looked at macroinvertebrates in the field.

"Low" – you have had exposure to looking at macroinvertebrates, but little or no experience with actual identification; you have little confidence in identifying to any level; you could make some of the simplest distinctions but not more difficult ones; you have not spent much time with macroinvertebrates of streams or lakes.

"Medium" – you have seen others key out macroinvertebrates and have done some identification yourself; you can recognize a few families; you have done some identification of macroinvertebrates in streams or lakes.

"High" – you have worked in streams or lakes doing macroinvertebrate identification, but you are not familiar with wetland taxa; you can key out to family level with confidence.

"Expert" – you have identified macroinvertebrates to species including those found in wetlands.

Figure 1. *Guidelines for volunteer self-ratings for experience with macroinvertebrate identification.*

Experimental Design

Site Selection

Each of the six field teams was asked to select three sites reasonably close together geographically that met the isolated, depressional wetland classification and were less than two acres in size. Two additional controls, range of disturbance and habitat type, were set to govern the type of sites selected.

Range of Disturbance

The basis of metric development was to relate biological assemblages to the degree of disturbance to the system under evaluation. To ensure that the method would be tested under the full range of disturbance conditions, we asked each field team to select wetlands that they judged to be of low, medium, and high disturbance. The goal was to avoid biasing the sample set toward either end of the disturbance gradient. Detailed criteria were not given to assess disturbance - the guidance was simply to attempt to achieve a range of disturbance across sites.

"Kettle" vs. "Prairie" Type

During IBI development two distinct types of isolated, depressional wetlands were recognized and analyzed separately; "prairie" (found in an open, grassland or agricultural setting) and "kettle" (found in forested settings). The final metrics included in the index and protocol are uniform for both types, but it is recognized that it can be useful to analyze these types separately. To avoid potential confounding effects of prairie vs. kettle type, each volunteer team was asked to select their three wetlands from only one wetland type, either kettle or prairie.

Design Matrix

Applying the site selection criteria resulted in 18 potential wetlands, distributed across six regional clusters, evenly distributed across a range of disturbance conditions and evenly distributed by type. Table 4 shows the resulting matrix:

Table 4. *Classification of wetland sites selected for study by the various regional teams of volunteers. Volunteers qualitatively assigned disturbance rating.*

Regional Team	Northwest	North Central	Northeast	Southeast	South Central: Driftless Area	South Central: Glaciated
Wetland Type and Disturbance	Prairie-Low Prairie-Med Prairie-High	Kettle–Low Kettle–Med Kettle-High	Kettle-Low Kettle-Med Kettle-High	Kettle-Low Kettle-Med Kettle-High	Prairie–Low Prairie-Med Prairie-High	Prairie–Low Prairie-Med Prairie-High

Resulting Site Locations and Preliminary Classifications

Table 5 lists the resulting site locations and their characteristics. Seventeen total sites were sampled for macroinvertebrates and plants. Appendix 3 includes additional characteristics describing each site.

Replicability

To employ a single "expert" in analyzing and verifying volunteer samples, we had to meet the assumption that different experts resulted in the same classification of a wetland. Therefore, on April 23, 2002, Dick Lillie and Jennifer Hauxwell obtained separate macroinvertebrate samples at Patrick's Marsh (Dane County, Town, Range, Section: 09N, 11E, 33). Dick Lillie and Sue Kenney subsequently analyzed them in the laboratory as described below.

For evaluating the plant index Dr. Emmet Judziewicz served as the single "expert" against which volunteer results were compared, eliminating the possibility of evaluating inter-expert variability.

Table 5. *Wetland site locations sampled by the various regional teams, with county, location, type (K = kettle, wooded; P = prairie, open; for questionable sites, the first classification in the sequence was used to assign WWPBI ratings), size (ha), perceived level of disturbance (L = low, M = medium, H = high), water duration (S = < 7.5 months, L = ≥7.5 months), the score at which volunteer teams rated themselves for macroinvertebrates (Fig. 1; N = none, L = low, M = medium, H = high, E = expert), and the approximate time spent processing the macroinvertebrate sample. If water duration was long, the modified indices for long-duration wetlands were employed for both macroinvertebrates and plants (Lillie, et al. 2002). Additional site descriptions are included in Appendix 3.*

Region and Name	County	Town, Range, Section	Latitude / Longitude	Type	Size	Level of Disturbance	Water Duration	Vol. Rating	Time
Northwest									
Tatro	Polk	T33N, R15W, S15	45°20’59”N / 92°11’51”W	P	0.30	H	L		
Standing Cedars	Polk	T32N, R19W, S29	45°14’26”N / 92°44’21”W	P	0.45	L	L		
WPA	Polk	T32N, R17W, S33	45°13’26”N / 92°28’32”W	P	1.30	M	L		
North Central									
Wetland 1 (Oneida Cty. Forest Rec. Area)	Oneida	T35N, R9E, S12	45°32’27”N / 89°18’31”W	K	0.05	L	S	M	16
Wetland 2 (Home Depot)	Oneida	T36N, R9E, S5	45°37’59”N / 89°23’25”W	K/P	0.10	H	L	M	16
Wetland 3 (US 8 and Ranch Rd)	Oneida	T36N, R9E, S23	45°35’59”N / 89°20’21”W	K/P	0.16	M	L	M	16
Northeast									
Plainfield Lakes	Waushara	T20N, R9E, S17	44°12’12”N / 89°27’53”W	K	9.00	L	L	L	8
LMR Wetland 2	Waushara	T18N, R10E, S22	44°01’29”N / 89°18’07”W	P/K	0.75	M	L	L	8
LMR Wetland 3	Waushara	T18N, R10E, S22	44°01’26”N / 89°18’01”W	P	1.25	H	L	L	8
Southeast									
OWLT	Washington	T11N, R20E, S16	43°24’51”N / 88°06’46”W	K	0.90	M	S	M	8
Beyer Pond	Ozaukee	T11N, R21E, S30	43°23’18”N / 88°01’51”W	K	0.50	L	S	M	8
Siedler Pond	Ozaukee	T10N, R21E, S21	43°18’40”N / 88°00’18”W	K	0.25	H	S	M	8
South Central – Driftless									
Tin Can Road Wetland	Green	T3N, R9E, S17	42°43’47”N / 89°27’59”W	P	0.06	M	S	M	5
Liberty Creek Sedge Meadow	Green	T3N, R9E, S2	42°46’08”N / 89°24’30”W	P	1.75	L	S	M	5
South Central – Glaciated									
Alexander Arboretum	Jefferson	T8N, R13E, S35	43°07’27”N / 88°55’05”W	P	0.15	L	S	L	20
Bork site	Dane	T7N, R11E, S20	43°03’11”N / 89°13’27”W	P	1.20	M	S	M	7
Fayeville	Jefferson	T8N, R14E, S19	43°08’46”N / 88°52’47”W	P	0.03	H	S	M	7

Field Collections

The field protocols, including an example assessment sheet, are included in Appendices 1 and 2. Field sheets were filled out in the field, as described in the protocol.

Macroinvertebrates

Two separate macroinvertebrate samples (one to be processed in the laboratory by an expert and one to be processed by volunteers and subsequently checked by an expert) were collected by volunteers from each wetland on the same date between late April to mid-May, 2002 (Fig. 2). Each sample consisted of a composite representing individual net-sweeps from three widely spaced locations within the wetland (generally representing a trisection of the wetland). The net-sweeps comprising the two samples (i.e. the set) were staggered at approximately equidistant locations about the wetland perimeter. Water depths at sampling locations may have differed depending upon the amount of standing water available in the particular wetland at the time of sampling, but depths did not exceed 60 cm. In most cases, samples were collected at the approximate midpoint (distance) between either the center of the wetland or maximum wading depth and the shoreline. Some degree of flexibility in selecting sampling locations was permitted to allow for avoiding situations where samples cannot or should not be collected. This included avoiding snags which could rip the net, too dense emergent vegetation (net would not function), dense mats of duckweed or filamentous algae (net would clog), and human disturbance. Sampling sites were chosen to be representative of typical plant communities and bottom types. Sampling within small, dense stands of plants that were very limited in their distribution within a wetland (i.e. rare or atypical to that wetland) was avoided if possible. Unvegetated areas were included in sampling if they represented a major percent of bottom area in the wetland (i.e. greater than 33%) or if a great amount of interspersion existed and sampling unvegetated areas was largely unavoidable.

Figure 2. *Volunteers Eric Roers and Laura Felda collecting macroinvertebrate samples.*

After collection, both samples (one to be processed by volunteers and subsequently checked by an expert, and one to be processed by an expert) were transferred to plastic quart jars, preserved in a 95% ethanol solution, and immediately labeled (both on the outside of the jar and with a tag placed inside with the sample), as described in the training manual (Appendices 1 and 2). “Expert” samples were delivered to the Wisconsin DNR Research Center in Monona for processing by the designated expert (Table 2). “Volunteer” samples were processed by volunteers (Table 3) at their facilities. Macroinvertebrate metric calculations are incorporated into the laboratory identification worksheet and were completed by volunteers or the expert as they processed samples (Appendices 1 and 2). Volunteers then delivered their completed data sheet, vials of labeled identified specimens, and a container holding their saved debris to the Research Center to be verified by an expert.

Plants

One round of plant sampling was conducted during the month of July for each of the 17 wetlands sampled for macroinvertebrates. Teams were asked to carry out the sampling protocol and complete field sheets for the plant index, as described in Appendices 1 and 2. Sampling instructions were provided during the original and refresher training sessions as described in Appendices 1 and 2 and included (1) a simple species list based on an informal qualitative visual survey of the wetland, and (2) a formal quantitative sampling of the wetland using transects. For the quantitative sampling, teams laid out three transects to trisect the wetland and sampled six 20 cm by 50 cm quadrats along each transect, for a total of 18 quadrats per wetland. Within each quadrat, cover estimates were made for each recognizably distinct taxon, and each distinct taxon was identified to the highest resolution possible in the field. For the plant index, taxa needed only to be recognized as distinct, and identified to the family level or as one of seven genus categories. Different unknown species within a genus were to be recognized in determining overall species richness (e.g. unknown *Carex* 1, unknown *Carex* 2, etc.), but were not necessary to identify to species level. Vouchers were to be taken when the observer was uncertain of the identification **and** where the metric score would be affected by a misidentification. Specimens of the entire plant, including roots, and inflorescences or fruits wherever possible, were to be collected, pressed and labeled (site location, team name, and date), and sent to the Research Center laboratory for correct identification.

A contracted plant expert (Dr. Emmet Judziewicz, Botany Professor, University of Wisconsin-Stevens Point, Department of Biology) independently inventoried the vascular plant species at each site during late June to early July, and provided a complete species list for each site to the monitoring coordinator. He revisited each site in August and developed a complete list based on August observations and a cumulative list for both visits. During the August visit, he also conducted transect sampling as described above for volunteers.

Because the WWPBI requires a walk-through to list species not occurring in transect sampling, we were able to use Dr. Judziewicz’s results to calculate floristic quality assessment statistics (mean conservatism and floristic quality index) as well. His report, “Floristic Quality Assessment of 17 Wetland Sites in Wisconsin,” is included as Appendix 3.

Based on the field sheets (transect data plus additional species gained by the informal survey), WWPBI values were calculated by DNR Research staff.

Laboratory Sample Processing

Macroinvertebrates

The procedures for processing the laboratory samples are described in the field methods manual (Lillie 2000; Appendices 1 and 2), and were identical for experts and volunteers. Subsampling was permitted following the examination of a minimum of 3 randomly selected cells (out of 24 possible on a white tray upon which the entire sample was distributed). The total abundance of those taxa with specimen tallies reaching or exceeding 15 individuals in the 3 randomly selected cells may be estimated by extrapolation by multiplying 3-cell sums by a factor of 8. The total abundance of all other taxa were determined by a thorough examination of the entire tray. Sample results were recorded on the standard laboratory sheet designed for the study and subsequently recorded by Susan Kenney in an Excel spreadsheet. Macroinvertebrate scores were calculated using the original Wisconsin

Wetland Macroinvertebrate Biotic Index for short duration wetlands (Lillie 2000; Fig. 3) and the modified version of the index for long-duration wetlands (hydroperiod ≥ 7.5 months) (Lillie, et al. 2002; Fig. 4). Wetlands that appeared to be long-duration were identified in the field during the July plant sampling and are designated in Table 5.

METRIC SCORING FOR THE MACROINVERTEBRATE INDEX (SHORT WATER DURATION)

Taxon	Attribute	Response	Score=0	Score=1	Score=3	Score=5
Mollusks	Abundance	Decrease	0	1-10	11-99	>99
Annelids	Abundance	Decrease	-	0-10	11-25	>25
Fairy Shrimp	Abundance	Decrease	-	0-8	9-25	>25
Non-Insects	Richness	Decrease	0	1-2	3-5	>5
Damselflies	Abundance	Decrease	0	1-2	3-15	> 15
Pigmy B.S.	Abundance	Increase	0	1-2 & >100	3-5 & 11-99	6-10
Boatmen	Abundance	Decrease	0	1-4	5-10	> 10
Limnephilid	Abundance	Decrease	0	1-10	11-50	> 50
Caddisflies	Abundance	Decrease	0	1-10	11-60	> 60
Caddisflies	Percentage	Decrease	0	< 8%	8-15%	> 15%
Phantom M.	Abundance	Decrease	0	1-8	9-25	> 25
Mosquitoes	Abundance	Decrease	0	1-10	11-99	>100
Soldier Flies	Abundance	Increase	-	> 25	8-24	< 7
Total Invert	Abundance	Decrease	< 150	150-500	500-1500	> 1500
Total Taxa	Richness	Decrease	< 5	6-11	12-19	> 19

Figure 3. *Metric scoring for macroinvertebrates in short duration wetlands (Lillie 2000). Figure includes taxa and associated attributes, the response of each taxa attribute to disturbance, and assignment of metric scores based on raw values. Summed overall scores of 0-27 resulted in a "very poor" rating, 28-31 in a "poor" rating, 32-42 in a "fair" rating, 43-53 in a "good" rating, 54-58 in a "very good" rating, and ≥59 in an "excellent" rating.*

METRIC SCORING FOR THE MACROINVERTEBRATE INDEX (LONG WATER DURATION)

Taxa Group	Attribute	Adjustments	Response	Score = 0	Score = 1	Score = 3	Score = 5
Mollusks	Abundance	Low Calcium or Alkalinity*	Decrease	0	1-9	10-99	≥ 100
Pigmy backswimmers	Abundance	None	Decrease	0	1-3	4-11	≥ 12
Water Boatmen	Abundance	Low total invertebrate abundance**	Increase	≥ 12	5-11	1-4	0
Caddisflies	Abundance	None	Decrease	0	1-2	3-7	≥ 8
Soldier Flies	Abundance	None	Decrease	0	1-2	3-9	≥ 10
Non-Insects	Richness	None	Decrease	0	1-2	3-4	≥ 5
Insects	Richness	None	Decrease	< 3	3-7	8-11	≥ 12
All Macro-invertebrates	Diversity***	None	Decrease	< 1	1-2	2-3	≥ 3

* If either calcium < 5 or alkalinity < 25 occurs, then substitute average of other seven metrics.

** If boatmen abundance < 5 and total invertebrates < 100, then substitute '2'.

*** Margalef's Diversity D = (Total Taxon Richness –1)/Log_n Total

Figure 4. *Metric scoring for macroinvertebrates in long duration wetlands (Lillie 2000). Figure includes taxa and associated attributes, the response of each taxa attribute to disturbance, and assignment of metric scores based on raw values. Summed overall scores of 0-11 resulted in a "very poor" rating, 12-16 in a "poor" rating, 17-22 in a "fair" rating, 23-27 in a "good" rating, 28-30 in a "very good" rating, and ≥31 in an "excellent" rating.*

Plants

Properly collected and preserved volunteer vouchers received at the Research Center were identified by Susan Kenney. The WWPBI calls for both transect-quadrat sampling and a qualitative estimate of species dominance based on a walk-through across the entire basin. Plant scores were calculated for both volunteer and expert plant transects using the original WWPBI for short duration wetlands (Lillie 2000) and the modified version of the index for long-duration wetlands (Lillie, et al. 2002) (Table 5, Fig. 5). Total number of taxa (used in calculating the total taxa metric of the WWPBI) for each wetland was determined by combining species lists obtained from transects with the walk-through survey conducted at each site.

METRIC SCORING FOR THE PLANT INDEX

Taxon	Attribute	Response	Score=0	Score=1	Score=3	Score=5
Total Taxa	Abundance	Decrease	0-1	2-8	9-16	>16
Carex spp.	Importance Value (=IV)	Decrease	0	< 0.1	0.1 - 0.36	> 0.36
Reed Canary Grass	IV	Increase	> 0.5	> 0.05 - 0.5	> 0 - 0.05	0*
Cat-tail	IV	Increase	> 0.25	0.03 - 0.25	> 0 – 0.03	0*
Duckweed	IV	Increase	> 0.6	0.2 – 0.6	> 0 – 0.2	0
Bluejoint Grass	IV	Decrease	-	0	> 0 – 0.05	> 0.05
Good* Taxa	IV	Decrease	0	> 0 – 0.3	0.3 – 0.6	> 0.6

Deep Water Community Adjustments (1 to 5 maximum based on Pond IV & Floating-leaf / 2)

Taxon	Attribute	Response	Score=0	Score=1	Score=3	Score=5
Pondweeds	IV	Optimum	-	0	>0 - 0.12 and > 0.4	0.12 – 0.4
Floating-leaf	Percent	Decrease	-	0	> 0 – 30	> 30

- * "**Good**" includes all *Carex, Utricularia, Potamogeton, Calamogrostis, Sagittaria, Polygonum*, and *Equisetum* species.
- ** **Adjustment** If total taxa ≤ "1" and no emergents are present (or consists only of annuals) a "zero" scores as "0" points!

Figure 5. *Metric scoring for plants in short and long duration wetlands (Lillie, et al. 2002). Figure includes taxa and associated attributes, the response of each taxa attribute to disturbance, and assignment of metric scores based on raw values. For kettle wetlands, summed scores of 0-16 resulted in a "very poor" rating, 17-20 in a "poor" rating, 21-23 in a "fair" rating, 24-26 in a "good" rating, 27-29 in a "very good" rating, and ≥30 in an "excellent" rating. For prairie wetlands, summed scores of 0-11 resulted in a "very poor" rating, 12-13 in a "poor" rating, 14-16 in a "fair" rating, 17-20 in a "good" rating, 21-22 in a "very good" rating, and ≥23 in an "excellent" rating.*

Data Analysis

Macroinvertebrates

For macroinvertebrates, several potential sources of error by volunteers were determined by comparing the following data sheets ("A" and "B" refer to different samples, sample "A" was processed or corrected at 4 levels):

- (A1) the original volunteer data sheet with volunteer calculations of the WWMBI,
- (A2) a revised original volunteer data sheet (accounting for difficulty in filling out the data sheet and/or arithmetic errors in calculating the WWMBI),
- (A3) a corrected, revised volunteer data sheet (accounting for misidentifications),
- (A4) a corrected, corrected, revised data sheet (accounting for additional specimens missed in debris), and
- (B) the expert data sheet.

Figure 6 illustrates the possible comparisons and subsequent information gained (including to what to attribute errors). Please note that "A1-A4" are various levels of correction of the same sample. "B" represents another distinct sample.

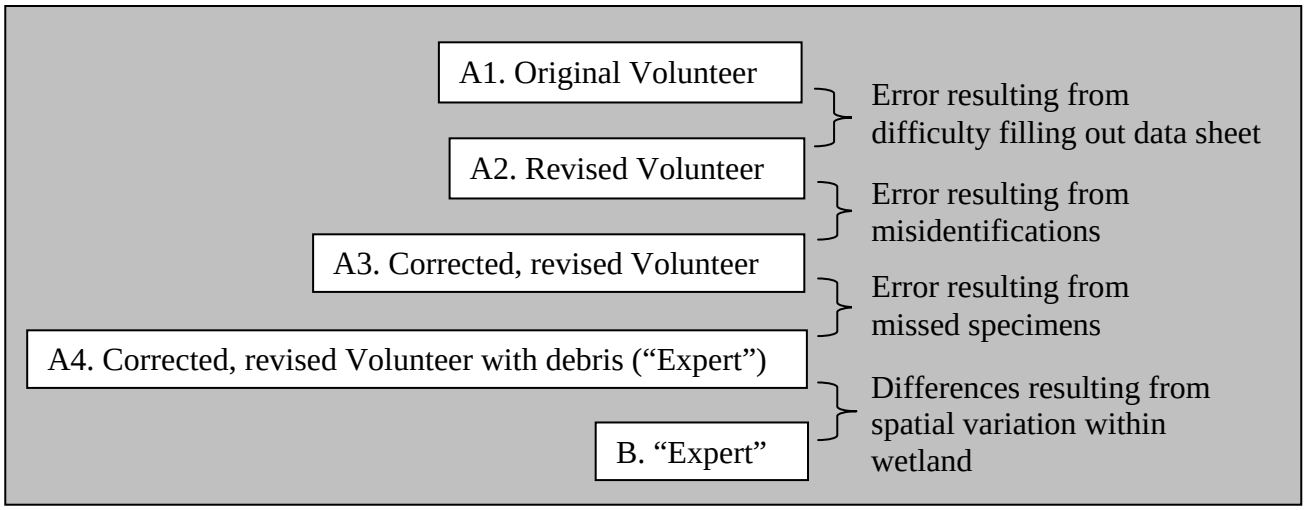

Figure 6. *The possible comparisons for macroinvertebrate data sheets and subsequent information gained (including to what to attribute errors). Please note that "A1-A4" are various levels of correction of the same sample, originally processed by the volunteers and then subsequently corrected by an expert. "B" represents another distinct sample processed only by an expert.*

We analyzed the type (i.e. cause for error categorized as mathematical, misidentified, overlooked, or other) and magnitude of errors. Troublesome taxa (consistently misidentified or overlooked) were identified in an effort to determine where improvements should be made in the training program. We also tracked the amount of time it took to process samples as a consideration in implementing this tool in a monitoring setting.

Plants

WWPBI scores were calculated by DNR Research staff based on raw data and compared between volunteers and the expert. FQI and mean conservatism values were calculated only from the expert inventory.

Data Quality Objectives

The established performance criteria for evaluating the acceptability of the field team data was somewhat arbitrary. The six qualitative habitat rating classes for the WWBI were based on the 10, 25, 50, 75, and 90 percentiles of biotic index values among 32 reference wetlands (Lillie 2000). The range of values within each rating class varies, thus prohibiting assignment of a standard percentage or standard unit as acceptable performance criteria. Consequently, we assigned the following definition for acceptability. Biotic index values computed by field staff should fall within the same qualitative habitat rating class or if the values fall within adjacent categories (e.g., excellent versus good) the values should be within the midpoints of the adjacent rating class. For example, if the field team's biotic index score fell within the upper half of the good class and the expert's score fell within the lower half of the excellent range, the team's score would be deemed acceptable.

Results

Macroinvertebrates

Verification of Approach

Preliminary testing of variation in laboratory identifications and metric results among the experts involved in the study indicated that consistent results were obtained between experts on separate macroinvertebrate samples from the same wetland (Table 6). Both expert-processed samples yielded a rating of "fair" for the test site.

Table 6. *Verification that expert-processed samples yielded similar results. Samples taken at Patricks Marsh in Dane County. Expert 1 was Dick Lillie. Expert 2 was Sue Kenney. Metrics used in calculating the short water duration Wisconsin Wetland Macroinvertebrate Biotic Index scores are listed below as raw values (A = abundance, R = richness) and as metric scores.*

	Expert 1		**Expert 2**	
Taxa Group	Raw Value	Metric Score	Raw Value	Metric Score
Mollusks (A)	163	5	179	5
Annelids (A)	0	1	0	1
Fairy shrimp (A)	29	5	16	3
Non-insects (R)	9	5	9	5
Damselflies (A)	42	5	64	5
Pigmy backswimmers (A)	63	3	50	3
Water boatmen (A)	0	0	0	0
Limnephelids (A)	0	0	1	1
Caddisflies (%)	0	0	0.23	1
Caddisflies (A)	0	0	1	1
Phantom midges (A)	0	0	0	0
Mosquitoes (A)	7	1	19	3
Soldier flies (A)	16	3	11	3
Total invertebrates (A)	382	1	427	1
Total taxa (R)	22	5	22	5
Sum WWMBI (and Rating)		**34 (Fair)**		**37 (Fair)**

Comparison between Volunteer and Expert Results - Overall Sources of Variability

Experimental results for both short and long duration wetlands are shown in Table 7 (original index, Lillie 2000; modified index, Lillie, et al. 2002). Taxa that resulted in different metric scores included: non-insect richness, caddisflies abundance, insect richness, total diversity, water boatmen abundance, damselflies abundance, phantom midge abundance, total taxa richness. Overall, however, ratings were the same or varied by one level across all layers of correction. The rating for the expert sample often varied from that of the volunteer sample (even after correction by an expert) and is simply indicative of spatial heterogeneity. Detailed explanations of discrepancies are included in the following section.

Table 7. *Detailed results for macroinvertebrate samples collected by volunteers and experts for short and long duration wetlands as described in Figure 6. "Volunteer – original" indicates volunteer-written information on original data sheet. "Volunteer–revised" indicates a revised version of the original data sheet, with arithmetic errors corrected by the expert. "Volunteer–corrected" indicates a corrected version of the volunteer samples, including misidentifications and errors in counting as determined by the expert. "Volunteer–with debris" indicates "Volunteer–corrected" data in addition to specimens missed in debris and found by the expert. This equates to an expert-level volunteer sample in Figure 7. "Expert" indicates the sample was processed exclusively by the expert. Metrics used in calculating the short or long water duration WWMBI are listed below as raw values (A = abundance, R = richness, D = diversity) and as metric scores. Ratings as very poor, poor, fair, good, very good, or excellent were assigned based on metric scores for short and long water duration sites as in Lillie (2000) and Lillie, et al. (2002) and Figures 3 and 4. Blank spaces indicate situations in which an original volunteer sheet was not tallied or debris was not supplied to the expert. An asterisk (*) next to the name of a taxa group (metric) indicates an error within the volunteer data set that resulted in a different score for that metric.*

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
NW – Tatro	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)	107	5	108	5	108	5			132	5
Non-insects (R)*	4	3	5	5	4	3			6	5
Pigmy backswimmers (A)	0	0	0	0	0	0			15	5
Water boatmen (A)	6	1	6	1	6	1			0	5
Caddisflies (A)*	0	0	0	0	1	1			2	1
Soldier flies (A)	0	0	0	0	0	0			6	3
Insect richness (A)*	5	1	6	1	8	3			17	5
Total diversity (D)*	1.4	1	2.1	3	2.3	3			3.5	5
SUM (WWMBI)		**11**		**15**		**16**				**34**
RATING		**Very poor**		**Poor**		**Poor**				**Excel-lent**

Table 7 continues on the next page.

Table 7, Continued.

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
NW – Standing Cedars	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)	42	3	42	3	42	3			57	3
Non-insects (R)	4	3	4	3	3	3			7	5
Pigmy backswimmers (A)	41	5	41	5	42	5			144	5
Water boatmen (A)*	0	5	2	3	1	3			48	0
Caddisflies (A)	0	0	0	0	0	0			2	1
Soldier flies (A)	4	3	4	3	3	3			18	5
Insect richness (A)	14	5	16	5	15	5			22	5
Total diversity (D)*	2.8	3	3.5	5	3.1	5			4.3	5
SUM (WWMBI)		**27**		**27**		**27**				**29**
RATING		**Good**		**Good**		**Good**				**Very good**
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
NW – WPA	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)	62	3	63	3	63	3			10	3
Non-insects (R)	6	5	7	5	6	5			4	3
Pigmy backswimmers (A)	1	1	1	1	3	1			14	5
Water boatmen (A)	22	0	22	0	22	0			7	1
Caddisflies (A)	1	1	1	1	1	1			1	1
Soldier flies (A)	2	1	2	1	2	1			3	3
Insect richness (A)	17	5	17	5	16	5			16	5
Total diversity (D)	3.9	5	4.1	5	3.8	5			3.1	5
SUM (WWMBI)		**21**		**21**		**21**				**26**
RATING		**Fair**		**Fair**		**Fair**				**Good**

Table 7 continues on the next page.

Table 7, Continued.

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
NC – Oneida #1 (Forest Rec. Area)	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)			14	3	14	3	14	3	6	1
Annelids (A)			2	1	2	1	2	1	1	1
Fairy shrimp (A)			120	5	120	5	120	5	78	5
Non-insects (R)			3	3	4	3	4	3	3	3
Damselflies (A)*			0	0	1	1	1	1	1	1
Pigmy backswimmers (A)			0	0	0	0	0	0	0	0
Water boatmen (A)			0	0	0	0	0	0	0	0
Limnephelids (A)			7	1	7	1	9	1	2	1
Caddisflies (%)			1.83	1	1.77	1	2.18	1	0.78	1
Caddisflies (A)			7	1	7	1	9	1	2	1
Phantom midges (A)*			0	0	0	0	4	1	0	0
Mosquitoes (A)			232	5	232	5	232	5	152	5
Soldier flies (A)			0	5	0	5	0	5	0	5
Total invertebrates (A)			383	1	396	1	413	1	257	1
Total taxa (R)*			9	1	16	3	18	3	15	3
SUM (WWMBI)				**27**		**30**		**31**		**28**
RATING				**Very poor**		**Poor**		**Poor**		**Poor**
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
NC – Oneida #2 (Home Depot)	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)			53	3	53	3	55	3	68	3
Non-insects (R)			4	3	4	3	4	3	4	3
Pigmy backswimmers (A)			0	0	0	0	0	0	0	0
Water boatmen (A)			5	1	5	1	5	1	0	5
Caddisflies (A)			0	0	0	0	0	0	0	0
Soldier flies (A)			0	0	0	0	0	0	0	0
Insect richness (A)*			6	1	6	1	9	3	6	1
Total diversity (D)*			1.8	1	1.8	1	2.3	3	1.98	1
SUM (WWMBI)				**9**		**9**		**13**		**13**
RATING				**Very poor**		**Very poor**		**Poor**		**Poor**

Table 7 continues on the next page.

Table 7, Continued.

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
NC – Oneida #3 (US 8 and Ranch Rd.)	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)			0	0	0	0	0	0	7	1
Non-insects (R)*			0	0	0	0	1	1	4	3
Pigmy backswimmers (A)			0	0	0	0	0	0	0	0
Water boatmen (A)			7	1	7	1	9	1	8	1
Caddisflies (A)			0	0	0	0	0	0	0	0
Soldier flies (A)			0	0	0	0	0	0	0	0
Insect richness (A)*			10	3	10	3	13	5	13	5
Total diversity (D)*			1.4	1	1.4	1	2	3	2.5	3
SUM (WWMBI)				**5**		**5**		**10**		**13**
RATING				**Very poor**		**Very poor**		**Very poor**		**Poor**
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
NE – Plainfield Lakes	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)*			12	3	3	1			14	3
Non-insects (R)			4	3	4	3			3	3
Pigmy backswimmers (A)			0	0	0	0			6	3
Water boatmen (A)			0	5	0	5			0	5
Caddisflies (A)			3	3	3	3			1	1
Soldier flies (A)*			0	0	1	1			1	1
Insect richness (A)			6	1	6	1			9	3
Total diversity (D)			1.8	1	1.8	1			2.1	3
SUM (WWMBI)				**16**		**15**				**22**
RATING				**Poor**		**Poor**				**Fair**

Table 7 continues on the next page.

Table 7, Continued.

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
NE – LMR Wetland 2	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)			48	3	48	3			198	5
Non-insects (R)			3	3	3	3			5	5
Pigmy backswimmers (A)			0	0	0	0			3	1
Water boatmen (A)			0	5	0	5			1	3
Caddisflies (A)			0	0	0	0			6	3
Soldier flies (A)			0	0	0	0			1	1
Insect richness (A)			2	0	2	0			10	3
Total diversity (D)			.95	0	.95	0			2.3	3
SUM (WWMBI)				**11**		**11**				**24**
RATING				**Very poor**		**Very poor**				**Good**
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
NE – LMR Wetland 3	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)			80	3	80	3			47	3
Non-insects (R)			3	3	4	3			4	3
Pigmy backswimmers (A)			0	0	0	0			7	3
Water boatmen (A)			0	5	0	5			1	3
Caddisflies (A)			0	0	0	0			2	1
Soldier flies (A)			1	1	1	1			0	0
Insect richness (A)			3	1	4	1			7	1
Total diversity (D)			1.1	1	1.6	1			2.2	3
SUM (WWMBI)				**14**		**14**				**17**
RATING				**Poor**		**Poor**				**Fair**

Table 7 continues on the next page.

Table 7, Continued.

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
SE – OWLT	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)	20	3	20	3	20	3	69	3	231	5
Annelids (A)	136	5	136	5	136	5	136	5	264	5
Fairy shrimp (A)	3	1	3	1	4	1	8	1	11	3
Non-insects (R)	9	5	11	5	10	5	11	5	14	5
Damselflies (A)	8	3	8	3	7	3	29	5	12	3
Pigmy backswimmers (A)	0	0	0	0	0	0	0	0	1	1
Water boatmen (A)	0	0	0	0	0	0	0	0	0	0
Limnephelids (A)*	0	0	0	0	0	0	7	1	7	1
Caddisflies (%)*	0	0	0	0	0	0	1.33	1	0.78	1
Caddisflies (A)*	0	0	0	0	0	0	7	1	7	1
Phantom midges (A)*	4	1	4	1	0	0	0	0	1	1
Mosquitoes (A)*	7	1	7	1	7	1	52	3	44	3
Soldier flies (A)*	13	3	13	3	14	3	77	1	54	1
Total invertebrates (A)*	113	1	217	1	218	1	525	3	893	3
Total taxa (R)	23	5	24	5	22	5	28	5	29	5
SUM (WWMBI)		**28**		**28**		**27**		**34**		**38**
RATING		**Poor**		**Poor**		**Very poor**		**Fair**		**Fair**

Table 7 continues on the next page.

Table 7, Continued.

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
SE – Beyer Pond	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)	129	5	129	5	129	5	139	5	67	3
Annelids (A)	1	1	1	1	1	1	1	1	3	1
Fairy shrimp (A)	1	1	1	1	1	1	1	1	22	3
Non-insects (R)	10	5	9	5	9	5	8	5	11	5
Damselflies (A)	0	0	0	0	0	0	0	0	1	1
Pigmy backswimmers (A)	0	0	0	0	0	0	0	0	1	1
Water boatmen (A)	0	0	0	0	0	0	0	0	0	0
Limnephelids (A)	3	1	3	1	3	1	3	1	23	3
Caddisflies (%)	3	1	1.27	1	1.26	1	1.19	1	7.67	1
Caddisflies (A)	3	1	3	1	3	1	3	1	23	3
Phantom midges (A)	0	0	0	0	0	0	0	0	0	0
Mosquitoes (A)	68	3	67	3	67	3	68	3	77	3
Soldier flies (A)	0	5	0	5	0	5	0	5	1	5
Total invertebrates (A)	240	1	236	1	238	1	252	1	300	1
Total taxa (R)	17	3	16	3	18	3	19	3	19	3
SUM (WWMBI)		**27**		**27**		**27**		**27**		**33**
RATING		**Very poor**		**Very poor**		**Very poor**		**Very poor**		**Fair**

Table 7 continues on the next page.

Table 7, Continued.

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
SE – Siedler Pond	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)	231	5	231	5	111	5	143	5	167	5
Annelids (A)	0	1	0	1	0	1	0	1	7	1
Fairy shrimp (A)	27	5	27	5	27	5	29	5	7	1
Non-insects (R)	8	5	7	5	7	5	9	5	10	5
Damselflies (A)	21	5	21	5	21	5	29	5	20	5
Pigmy backswimmers (A)	0	0	0	0	0	0	0	0	0	0
Water boatmen (A)*	1	1	1	1	0	0	0	0	0	0
Limnephelids (A)	16	3	16	3	18	3	18	3	29	3
Caddisflies (%)	3.6	1	3.64	1	4.04	1	3.35	1	2.69	1
Caddisflies (A)	16	3	16	3	18	3	18	3	29	3
Phantom midges (A)	0	0	0	0	0	0	0	0	0	0
Mosquitoes (A)	121	5	121	5	122	5	139	5	58	3
Soldier flies (A)	1	5	1	5	1	5	4	5	23	3
Total invertebrates (A)*	440	1	440	1	445	1	537	3	1077	3
Total taxa (R)*	17	3	17	3	17	3	20	5	20	5
SUM (WWMBI)		**43**		**43**		**42**		**46**		**38**
RATING		**Good**		**Good**		**Fair**		**Good**		**Fair**

Table 7 continues on the next page.

Table 7, Continued.

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
SCD – Tin Can Road	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)	147	5	147	5	147	5			307	5
Annelids (A)	3	1	3	1	0	1			16	3
Fairy shrimp (A)*	0	0	0	1	0	1			0	1
Non-insects (R)	6	5	9	5	7	5			10	5
Damselflies (A)	0	0	0	0	0	0			4	3
Pigmy backswimmers (A)	0	0	0	0	0	0			0	0
Water boatmen (A)	0	0	0	0	0	0			0	0
Limnephelids (A)	0	0	0	0	0	0			2	1
Caddisflies (%)	0	0	0	0	0	0			0.4	1
Caddisflies (A)	0	0	0	0	0	0			1	1
Phantom midges (A)	0	0	0	0	0	0			1	1
Mosquitoes (A)*	0	0	0	0	1	1			11	3
Soldier flies (A)	1	5	1	5	1	5			4	5
Total invertebrates (A)	267	1	268	1	266	1			501	1
Total taxa (R)	13	3	13	3	12	3			22	5
SUM (WWMBI)		**20**		**21**		**22**				**35**
RATING		**Very poor**		**Very poor**		**Very poor**				**Fair**

Table 7 continues on the next page.

Table 7, Continued.

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
SCD – Liberty Creek Sedge Meadow	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)			47	3	47	3			145	5
Annelids (A)			0	1	0	1			5	1
Fairy shrimp (A)			0	1	0	1			0	1
Non-insects (R)*			5	3	6	5			9	5
Damselflies (A)			0	0	0	0			0	0
Pigmy backswimmers (A)			0	0	0	0			0	0
Water boatmen (A)			0	0	0	0			0	0
Limnephelids (A)			0	0	0	0			1	1
Caddisflies (%)			0	0	0	0			0.41	1
Caddisflies (A)			0	0	0	0			1	1
Phantom midges (A)			0	0	0	0			0	0
Mosquitoes (A)			0	0	0	0			2	1
Soldier flies (A)			1	5	0	5			1	5
Total invertebrates (A)			62	0	62	0			241	1
Total taxa (R)			10	1	11	1			19	3
SUM (WWMBI)				**14**		**16**				**25**
RATING				**Very poor**		**Very poor**				**Very poor**

Table 7 continues on the next page.

Table 7, Continued.

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
SCG – Alexander Arboretum	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)			7	1	8	1	8	1	11	3
Annelids (A)			4	1	0	1	1	1	10	1
Fairy shrimp (A)			0	1	0	1	0	1	0	1
Non-insects (R)*			5	3	4	3	6	5	6	5
Damselflies (A)			0	0	0	0	0	0	1	1
Pigmy backswimmers (A)			12	3	12	3	68	3	46	3
Water boatmen (A)			0	0	0	0	0	0	0	0
Limnephelids (A)			0	0	0	0	0	0	0	0
Caddisflies (%)			0	0	0	0	0	0	0	0
Caddisflies (A)			0	0	0	0	0	0	0	0
Phantom midges (A)*			1	1	0	0	0	0	0	0
Mosquitoes (A)			0	0	0	0	0	0	0	0
Soldier flies (A)*			4	5	4	5	10	3	4	5
Total invertebrates (A)			44	0	43	0	130	0	209	1
Total taxa (R)*			12	3	10	1	17	3	18	3
SUM (WWMBI)				**18**		**15**		**17**		**23**
RATING				**Very poor**		**Very poor**		**Very poor**		**Very poor**

Table 7 continues on the next page.

Table 7, Continued.

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
SCG – Bork	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)	43	3	43	3	43	3	49	3	122	5
Annelids (A)	0	1	0	1	0	1	0	1	9	1
Fairy shrimp (A)	0	1	0	1	0	1	0	1	0	1
Non-insects (R)*	5	3	5	3	5	3	6	5	7	5
Damselflies (A)	0	0	0	0	0	0	0	0	1	1
Pigmy backswimmers (A)*	2	1	2	1	2	1	3	3	13	3
Water boatmen (A)	1	1	1	1	1	1	1	1	10	3
Limnephelids (A)	0	0	0	0	0	0	0	0	0	0
Caddisflies (%)	0	0	0	0	0	0	0	0	0	0
Caddisflies (A)	0	0	0	0	0	0	0	0	0	0
Phantom midges (A)	0	0	0	0	0	0	0	0	0	0
Mosquitoes (A)	0	0	0	0	0	0	0	0	2	1
Soldier flies (A)	0	5	0	5	0	5	0	5	4	5
Total invertebrates (A)	53	0	53	0	53	0	65	0	235	1
Total taxa (R)*	10	1	10	1	10	1	14	3	23	5
SUM (WWMBI)		**16**		**16**		**16**		**22**		**31**
RATING		**Very poor**		**Very poor**		**Very poor**		**Very poor**		**Poor**

Table 7 continues on the next page.

Table 7, Continued.

	DATASET									
REGION – SITE	Volunteer-original		Volunteer-revised		Volunteer-corrected		Volunteer-with debris		Expert	
SCG – Fayeville	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score	Raw value	Metric score
Mollusks (A)	29	3	29	3	29	3	34	3	331	5
Annelids (A)	0	1	0	1	0	1	0	1	0	1
Fairy shrimp (A)	0	1	0	1	0	1	0	1	0	1
Non-insects (R)*	2	1	2	1	2	1	3	3	5	3
Damselflies (A)	22	5	22	5	22	5	35	5	29	5
Pigmy backswimmers (A)*	20	3	20	3	0	0	0	0	0	0
Water boatmen (A)*	0	0	0	0	20	5	42	5	40	5
Limnephelids (A)	0	0	0	0	0	0	0	0	0	0
Caddisflies (%)*	0.41	1	0.41	1	0	0	0	0	0	0
Caddisflies (A)*	1	1	1	1	0	0	0	0	0	0
Phantom midges (A)	0	0	0	0	0	0	0	0	0	0
Mosquitoes (A)*	8	1	8	1	0	0	0	0	0	0
Soldier flies (A)	0	5	0	5	0	5	0	5	0	5
Total invertebrates (A)	243	1	243	1	245	1	333	1	2185	5
Total taxa (R)	9	1	9	1	8	1	10	1	13	3
SUM (WWMBI)		**24**		**24**		**23**		**25**		**33**
RATING		**Very poor**		**Very poor**		**Very poor**		**Very poor**		**Fair**

Overall, there were significant differences among the various levels of processing for the volunteer sample (A1-A4 as in Fig. 6; Friedman's test, df = 3, $P = 0.01$). We used a paired sign test to test for differences between each level of analysis (Table 8), and determined that the only level of analysis that resulted in a significant difference from the previous level was the examination of the debris. In addition, comparison of 2 separate samples, the "expert-level processed volunteer sample" (A4, with debris, as in Fig. 6) to the "expert" sample, yielded no significant difference. These results indicate 1) that the error contributing the most to variability between volunteer and expert scores was within the debris, and 2) that the WWMBI adequately represented the spatial heterogeneity within a site.

Table 8. *Results of paired sign tests to assess differences in WWMBI scores at various levels of correction (A1-A2, A2-A3, A3-A4) and between different expert-level processed samples (A4-B) (as described in Fig. 6).*

Level of Processing	*P*
Volunteer original (A1)	
	0.50
Volunteer revised (A2)	
	0.99
Volunteer corrected (A3)	
	0.01
Volunteer corrected with debris (A4)	
	0.29
Expert (B)	

We plotted scores to see if there was an effect of wetland quality on scoring and found no obvious effect (Fig. 7). Throughout the range of IBI scores encountered, slopes for all levels of correction were very close to 1 (matching the 1:1 line).

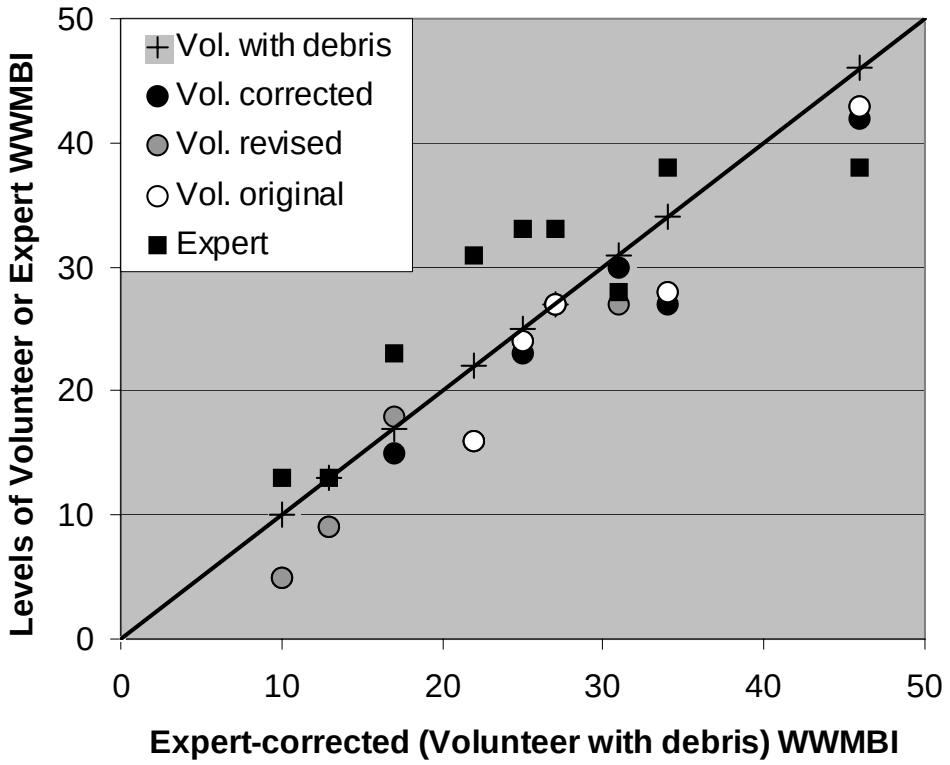

Figure 7. *Wisconsin Wetland Macroinvertebrate Biotic Index scores for the various study sites for both the expert processed sample (B) and the various levels of expert-corrected volunteer samples (A1-4) plotted against the final expert corrected scores of the volunteer sample (A4) (as in Fig. 6). The 1:1 line is indicated. Regression statistics are indicated in Table 9.*

Slopes for the various best-fit lines corresponding to data in Figure 7 are shown in Table 9 and verify the results from the paired sign tests (Table 8), where the largest difference in scores occurred with the addition of debris. The largest difference between slopes for the various levels of corrections occurred when debris was included in the analysis (m=1.00, vs m=0.90, 0.89, or 0.88 for the volunteer original, revised, and corrected scores, respectively) (Table 9).

Table 9. *Results of regressions to assess differences in WWMBI scores at various levels of correction (A1-A2, A2-A3, A3-A4) and between different expert-level processed samples (A4-B) (Fig. 7). Regression equations follow the format, y = mx.*

Level of Processing	**Slope (m)**	**Difference in Slope from 1:1 Line**	**r^2**
Volunteer original (A1)	0.90	0.10	0.91
Volunteer revised (A2)	0.89	0.11	0.94
Volunteer corrected (A3)	0.88	0.12	0.94
Volunteer corrected with debris (A4)	(1.00)	(0)	(1.00)
Expert (B)	1.06	0.06	0.60

Comparison Between Volunteer and Expert Results - Specific Sources of Error

Below we outline in detail the reasons for discrepancies in the volunteer data set for each additional layer of correction by the expert.

- *Volunteer original vs. revised.* In all cases, volunteer original scores (A1) or those adjusted for mathematical errors (A2) resulted in similar (one rating off) or identical ratings (Table 10; Fig. 6).

- *Volunteer revised vs. corrected.* In all cases, revised volunteer scores (A2) or those corrected for misidentifications (A3) resulted in similar (one rating off) or identical ratings (Table 11; Fig. 6).

- *Volunteer corrected vs addition of debris.* In all cases, volunteer corrected scores (A3) or those adjusted macroinvertebrates missed in debris (A4) resulted in similar (one rating off) or identical ratings (Table 12; Fig. 6).

Table 10. *Reasons for discrepancies between the original volunteer score (A1) and the revised volunteer score (A2) (as in Fig. 6). Since volunteers were not instructed to amend calculations for long duration sites, all explanations of discrepancies assume the volunteers followed protocol for calculating the short duration (original) index (therefore scores and explanations do not necessarily match, but do provide guidance on how to avoid future mistakes).*

Region and Name	Original Volunteer Score*	Revised Volunteer Score*	Reason for Discrepancy
Northwest			
Tatro	9	20	Original data sheet had tallies but several metric scores were left blank including both richness metric scores (non-insect and total taxa). Most of these had 0 for a balance. Even though there was a 0 balance for abundance for certain groups, this should translate into a metric score for annelids, fairy shrimp, and soldier flies of 1, 1, and 5, respectively. Total taxa metric score added incorrectly. Voucher vials did not match data sheet (e.g., one vial each marked midge larva and annelid but numbers lumped under total for "other fly families" on data sheet).
Standing Cedars	19	30	Original data sheet had tallies but 7 out of 14 metric scores were left blank including abundances and both richness metric scores (non-insect and total taxa). Fairy shrimp should have received a score of 1 even though abundance was 0. Voucher vials did not match data sheet (e.g., data sheet has "other mayflies" marked 1 but no voucher specimen; data sheet marked 1 Lestidae but 2 specimens in voucher vial; data sheet marked 2 Corduliidae but 3 in voucher vial; data sheet marked 1 Hydrophilidae but 2 in voucher vial; data sheet marked 1 other beetle families but2 in voucher vial).
WPA	23	40	Original data sheet had tallies but 6 out of 14 metric scores were left blank including abundances and both richness metric scores (non-insect and total taxa). Fairy shrimp should have received a score of 1 even though abundance was 0. Voucher vials did not match data sheet (e.g., data sheet shows 4 amphipods while voucher vial contains 7; voucher vial containing 1 clam but 0 marked on data sheet; data sheet has 1 marked under "other beetles" but no vial marked as such. No voucher vial for damselflies). Total taxa metric score added incorrectly.
North Central			
Wetland 1 (Oneida Cty. Forest Rec. Area)	n/a	27	Volunteer did not include data sheet. Expert constructed one from voucher specimens and abundances indicated on vials.
Wetland 2 (Home Depot)	n/a	24	Volunteer did not include data sheet. Expert constructed one from voucher specimens and abundances indicated on vials.
Wetland 3 (US 8 and Ranch Rd)	n/a	25	Volunteer did not include data sheet. Expert constructed one from voucher specimens and abundances indicated on vials.
Northeast			
Plainfield Lakes	n/a	18	Volunteer data sheet had tallies but no metric scores or Biotic Index Score were calculated.
LMR Wetland 2	n/a	13	Volunteer data sheet had tallies but no metric scores or Biotic Index Score were calculated.
LMR Wetland 3	n/a	14	Volunteer data sheet had tallies but no metric scores or Biotic Index Score were calculated.

Table 10 continues on the next page.

Table 10, Continued.

Region and Name	Original Volunteer Score*	Revised Volunteer Score*	Reason for Discrepancy
Southeast			
OWLT	28	28	Same Biotic Index score because errors did not change score. On original score richness metric score for non-insect taxa and total invertebrate abundance added incorrectly. Daphnia (considered micro-zooplankton) and tadpoles (vertebrates) should not have been included in calculation of macroinvertebrate Biotic Index Score.
Beyer Pond	27	27	Same Biotic Index score because errors did not change score. On original score total invertebrate abundance added incorrectly. Daphnia (considered micro-zooplankton) should not have been included in calculation of macroinvertebrate Biotic Index Score.
Siedler Pond	43	43	Same Biotic Index score because errors did not change score. Daphnia (considered micro-zooplankton) and tadpoles (vertebrates) should not have been included in calculation of macroinvertebrate Biotic Index Score.
South Central – Driftless			
Tin Can Road Wetland	20	21	Original data sheet had tallies and all metric scores were complete except for abundance of fairy shrimp. Even though fairy shrimp abundance was 0, the metric score should be 1. Voucher vials do not match data sheet (e.g., data sheet says 66 isopods, voucher vial contains 70; data sheet marked 2 chironomids but no voucher vial marked as such). Richness metric score for non-insect taxa added incorrectly but metric score is the same either way.
Liberty Creek Sedge Meadow	n/a	14	Original data sheet had tallies complete but no metric scores or Biotic Index Score was calculated.
South Central – Glaciated			
Alexander Arboretum	n/a	18	Original volunteer data sheet had tallies plus mollusk sum. No metric scores or Biotic Index score was calculated.
Bork site	n/a	16	Original volunteer data sheet had tallies plus mollusk sum. No metric scores or Biotic Index score was calculated.
Fayeville	24	24	Correct – no errors detected.

*Scores tallied as if all sites were short water duration sites since volunteers received instructions for those calculations only.

Table 11. *Reasons for discrepancies between the revised volunteer score (A2, adjusted for water duration) and the corrected volunteer score (A3) that adjusted for misidentifications (as in Fig. 6).*

Region and Name	Revised Volunteer Score	Corrected Volunteer Score	Reason for Discrepancy
Northwest			
Tatro	15	16	Non-insect richness lower in corrected score due to misidentification of specimen as annelid instead of other aquatic insect taxa. Expert found a single caddisfly that volunteers missed, increasing the caddisfly metric score. Expert found 2 additional insect taxa, increasing the insect richness metric score.
Standing Cedars	27	27	Correct score - minor misidentifications did not affect metric scores.
WPA	21	21	Correct score - minor misidentifications did not affect metric scores.
North Central			
Wetland 1 (Oneida Cty. Forest Rec. Area)	27	30	The corrected volunteer score has higher metric score for damselflies (1 individual not found by volunteers) and total taxa (due to not separating unknowns into “Other families” and “Other terrestrial insects”).
Wetland 2 (Home Depot)	9	9	Correct score – no errors detected.
Wetland 3 (US 8 and Ranch Rd)	5	5	Correct score – fly pupae misidentified as phantom midges but did not affect score.
Northeast			
Plainfield Lakes	16	15	Corrected volunteer score is lower for mollusks due to misidentification of plant seeds for mollusks. Expert found 1 soldier fly missed by volunteers.
LMR Wetland 2	11	11	Correct score – no errors detected.
LMR Wetland 3	14	14	Correct score – minor misidentifications did not affect metric scores.
Southeast			
OWLT	28	27	Revised volunteer score has higher metric score for phantom midges but no phantom midges actually present.
Beyer Pond	27	27	Correct – no errors detected.
Siedler Pond	43	42	Volunteers misidentified 1 “other bug family” as a water boatman, yielding a higher metric score.
South Central – Driftless			
Tin Can Road Wetland	21	22	Expert found 1 mosquito missed by volunteers, increasing the score by 1.
Liberty Creek Sedge Meadow	14	16	Volunteers misidentified springtails as beetle larvae, resulting in lower metric score for non-insect richness.

Table 11 continues on the next page.

Table 11, Continued.

Region and Name	Revised Volunteer Score	Corrected Volunteer Score	Reason for Discrepancy
South Central – Glaciated			
Alexander Arboretum	18	15	Volunteer had higher score for phantom midges, expert found none. Expert found fewer total taxa, yielding lower score. Misidentifications of amphipods (expert found 0), annelids (expert found 0), hydrophilid beetles (water scavenger beetle mistaken for predaceous diving beetle), crane flies (expert found 0, other family), and phantom midges (expert found 0, other family).
Bork site	16	16	Correct score – no errors detected.
Fayeville	24	23	Expert had lower score for pigmy backswimmers (actually water boatmen), higher score for water boatmen, lower score for caddisfly abundance and percentage, lower score for mosquitoes.

Table 12. *Reasons for discrepancies between the corrected volunteer data set (A3) and the data set that included volunteers' debris (A4) (as in Fig. 6).*

Region and Name	Corrected Volunteer Score	Corrected Volunteer Score with Debris	Reason for Discrepancy
Northwest			
Tatro	16	n/a	Debris was discarded.
Standing Cedars	27	n/a	Debris was discarded.
WPA	21	n/a	Debris was discarded.
North Central			
Wetland 1 (Oneida Cty. Forest Rec. Area)	30	31	Expert found 4 phantom midges, increasing the score.
Wetland 2 (Home Depot)	9	13	Expert found 3 additional species of insects in debris (1 damselfly, 1 chironomid, and 1 mosquito individual representing additional species). This increased the scores for insect richness and total diversity.
Wetland 3 (US 8 and Ranch Rd)	5	10	Expert found a single additional non-insect (1 spider). Expert found 3 additional species of insects in debris (3 damselflies, 1 phantom midge, and 3 aquatic moth larvae individuals representing 3 additional species). This increased the scores for insect richness and total diversity.
Northeast			
Plainfield Lakes	15	n/a	Debris was discarded.
LMR Wetland 2	11	n/a	Debris was discarded.
LMR Wetland 3	14	n/a	Debris was discarded.
Southeast			
OWLT	27	34	Expert found additional 22 additional damselfly individuals, 7 limnephelid caddisflies (species not noted by volunteer), 45 additional mosquitoes, and over 300 additional individuals for total invertebrates, increasing the metric scores. Expert found 63 additional soldier flies, decreasing the metric score.
Beyer Pond	27	27	Same metric scores for all metrics. Addition of numbers of missed invertebrates was too small to affect score.
Siedler Pond	42	46	Expert found 3 additional taxa (1 amphipod, 2 mites, and 1 fly larva), and approximately 100 individuals of detected taxa resulting in higher metric scores for total invertebrate abundance and total taxa richness.

Table 12 continues on the next page.

Table 12, Continued.

Region and Name	Corrected Volunteer Score	Corrected Volunteer Score with Debris	Reason for Discrepancy
South Central – Driftless			
Tin Can Road Wetland	22	n/a	Debris was discarded.
Liberty Creek Sedge Meadow	16	n/a	Debris was discarded.
South Central – Glaciated			
Alexander Arboretum	15	17	Expert found 2 additional non-insect taxa (mites and worms) and 5 additional insect taxa (1 predaceous diving beetle, 3 marsh beetles, 4 diptera pupae, 5 chironomids, 3 biting midges), increasing the metric scores for richness and total abundance. Expert also found more soldier fly individuals, decreasing the metric score.
Bork site	16	22	Expert found 1 additional non-insect taxa (1 leech), increasing the metric scores for non-insect richness. Expert found 1 additional pigmy backswimmer, increasing that metric score. Expert found 3 additional insect taxa (crawling water beetles, weevils, and biting midges), increasing total taxa richness and total abundance.
Fayeville	23	25	Expert found 1 additional non-insect taxa (1 isopod), increasing the metric score. Additional discrepancies in abundances did not result in different metric scores.

Summary of Metric Errors

We tallied the number of times each specific metric resulted in a different score between volunteers and the expert (Table 13). Sources of specific errors in overall WWMBI sums were diverse. Errors resulted from a number of different taxa and were relatively evenly dispersed throughout all metrics, suggesting that further general training should be recommended. Cumulative metrics, including non-insect richness, total taxa richness, total insect richness, and total diversity received the highest percentage of errors.

Table 13. *Number and percentage of cases in which specific macroinvertebrate metric scores resulted in a discrepancy between volunteer-processed or expert-processed data sheets.*

Metric	Number of cases in which metric miscalculated	Percentage of cases in which metric miscalculated
Mollusks (A)	1	6
Annelids (A)	0	0
Fairy shrimp (A)	1	11
Non-insects (R)	6	35
Damselflies (A)	1	11
Pigmy backswimmers (A)	2	12
Water boatmen (A)	3	18
Limnephelids (A)	1	11
Caddisflies (%)	2	22
Caddisflies (A)	3	18
Phantom midges (A)	3	33
Mosquitoes (A)	3	33
Soldier flies (A)	3	18
Total invertebrates (A)	2	22
Total taxa (R)	4	44
Total insect (R)	3	38
Total diversity (D)	4	50

Plants

Experimental results for plants for both short and long duration wetlands are shown in Table 14 (original index, Lillie 2000; modified index, Lillie, et al. 2002). Overall, ratings were the same or varied by one level. In one case (Oneida County #3), the rating varied by 2 levels.

We used a paired sign test to test for differences between expert and volunteer WWPBI scores (Table 14), and determined there was no significant difference ($P = 0.80$). These results indicate 1) that volunteers and experts evaluated the plant metrics between sites similarly, and 2) that the WWPBI adequately captured the spatial heterogeneity within a site.

Table 14. *Detailed results for plant sampling conducted by volunteers and an expert for short and long duration wetlands. Metrics used in calculating the short or long water duration WWPBI are listed below as raw values (A = abundance, IV = importance value as outlined in Appendices 1 and 2) and as metric scores. Ratings as very poor, poor, fair, good, very good, or excellent were assigned based on metric scores for short and long water duration sites as in Lillie (2000) and Lillie, et al. (2002) and Figure 5. An asterisk (*) next to the name of a taxa group indicates discrepancy between data sets that resulted in a different score for that metric.*

	DATASET			
REGION – SITE (Type)	Volunteer		Expert	
NW – Tatro (Prairie)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)*	11	3	39	5
Carex spp. (IV)	0	0	0	0
Reed canary grass (IV)	0.49	1	0.42	1
Cattail (IV)	0.08	1	0.06	1
Duckweeds (IV)	0.25	1	0.26	1
Bluejoint grass (IV)	0	1	0	1
“Good” taxa (IV)	0.13	1	0.13	1
Long-duration adjustment				
% of Floating-leafed plants	5	3	15	3
Pondweed IVs from transects	0.05	3	0.05	3
Average for deep-water adjustment		3		3
SUM (WWPBI)		**11**		**13**
RATING		**Very poor**		**Poor**
REGION – SITE	Volunteer		Expert	
NW – Standing Cedars (Prairie)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)*	16	3	26	5
Carex spp. (IV)	0	0	0	0
Reed canary grass (IV)*	0.29	1	0.61	0
Cattail (IV)	0	5	0	5
Duckweeds (IV)	0.31	1	0.24	1
Bluejoint grass (IV)	0	1	0	1
“Good” taxa (IV)*	0.2	1	0.03	3
Long-duration adjustment				
% of Floating-leafed plants	40	5	50	5
Pondweed IVs from transects	0	1	0	1
Average for deep-water adjustment		3		3
SUM (WWPBI)		**15**		**18**
RATING		**Fair**		**Good**

Table 14 continues on the next page.

Table 14, Continued.

	DATASET			
REGION – SITE	Volunteer		Expert	
NW – WPA (Prairie)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)*	11	3	44	5
Carex spp. (IV)	0	0	0	0
Reed canary grass (IV)*	0.48	1	0.55	0
Cattail (IV)	0	5	0	5
Duckweeds (IV)	0.47	1	0.41	1
Bluejoint grass (IV)	0	1	0	1
“Good” taxa (IV)	0.01	1	0.03	1
Long-duration adjustment				
% of Floating-leafed plants*	0	1	15	3
Pondweed IVs from transects	0	1	0	1
Average for deep-water adjustment		1		2
SUM (WWPBI)		**13**		**15**
RATING		**Poor**		**Fair**
REGION – SITE	Volunteer		Expert	
NC – Oneida #1 (Forest Rec. Area) (Kettle)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)*	13	3	24	5
Carex spp. (IV)	0.10	3	0.29	3
Reed canary grass (IV)	0	5	0	5
Cattail (IV)	0	5	0	5
Duckweeds (IV)	0	5	0	5
Bluejoint grass (IV)	0	1	0	1
“Good” taxa (IV)	0.10	1	0.29	1
Long-duration adjustment				
% of Floating-leafed plants				
Pondweed IVs from transects				
Average for deep-water adjustment				
SUM (WWPBI)		**23**		**25**
RATING		**Fair**		**Good**

Table 14 continues on the next page.

Table 14, Continued.

	DATASET			
REGION – SITE	Volunteer		Expert	
NC – Oneida #2 (Home Depot) (Kettle)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)	20	5	53	5
Carex spp. (IV)*	0	0	0.01	1
Reed canary grass (IV)	0	5	0	5
Cattail (IV)	0.48	0	0.41	0
Duckweeds (IV)	0	5	0	5
Bluejoint grass (IV)*	0	1	0.02	3
"Good" taxa (IV)	0.14	1	0.22	1
Long-duration adjustment				
% of Floating-leafed plants*	5	3	0	1
Pondweed IVs from transects	0.14	5	0.15	5
Average for deep-water adjustment		4		3
SUM (WWPBI)		**21**		**23**
RATING		**Fair**		**Fair**
REGION – SITE	Volunteer		Expert	
NC – Oneida #3 (US 8 and Ranch Rd.) (Kettle)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)*	15	3	26	5
Carex spp. (IV)	0.22	3	0.16	3
Reed canary grass (IV)	0	5	0	5
Cattail (IV)	0.02	1	0.13	1
Duckweeds (IV)*	0.04	3	0.05	1
Bluejoint grass (IV)*	0	1	0.17	5
"Good" taxa (IV)*	0.22	1	0.33	3
Long-duration adjustment				
% of Floating-leafed plants*	0	1	10	3
Pondweed IVs from transects	0	1	0	1
Average for deep-water adjustment		1		2
SUM (WWPBI)		**18**		**25**
RATING		**Poor**		**Good**

Table 14 continues on the next page.

Table 14, Continued.

	DATASET			
REGION – SITE	Volunteer		Expert	
NE – Plainfield Lakes (Kettle)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)	18	5	64	5
Carex spp. (IV)*	0.29	3	0.02	1
Reed canary grass (IV)	0.01	3	0.03	3
Cattail (IV)	0	5	0	5
Duckweeds (IV)	0	5	0	5
Bluejoint grass (IV)	0.22	5	0.29	5
“Good” taxa (IV)*	0.69	5	0.59	3
Long-duration adjustment				
% of Floating-leafed plants	0-30	3	10	3
Pondweed IVs from transects*	0	1	0.08	3
Average for deep-water adjustment		2		3
SUM (WWPBI)		**33**		**30**
RATING		**Excellent**		**Excellent**
REGION – SITE	Volunteer		Expert	
NE – LMR Wetland 2 (Prairie)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)	20	5	43	5
Carex spp. (IV)	0.56	5	0.42	5
Reed canary grass (IV)*	0	5	0.01	3
Cattail (IV)	0	5	0	5
Duckweeds (IV)	0	5	0	5
Bluejoint grass (IV)*	0	1	0.06	5
“Good” taxa (IV)*	0.63	5	0.60	3
Long-duration adjustment				
% of Floating-leafed plants	0-30	3	10	3
Pondweed IVs from transects*	0	1	0.09	3
Average for deep-water adjustment		2		3
SUM (WWPBI)		**33**		**34**
RATING		**Excellent**		**Excellent**

Table 14 continues on the next page.

Table 14, Continued.

	DATASET			
REGION – SITE	Volunteer		Expert	
NE – LMR Wetland 3 (Prairie)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)	21	5	60	5
Carex spp. (IV)*	0.37	5	0.21	3
Reed canary grass (IV)	0	5	0	5
Cattail (IV)	0	5	0	5
Duckweeds (IV)	0	5	0	5
Bluejoint grass (IV)*	0.07	5	0	1
“Good” taxa (IV)*	0.74	5	0.47	3
Long-duration adjustment				
% of Floating-leafed plants	0-30	3	10	3
Pondweed IVs from transects	0.04	3	0.09	3
Average for deep-water adjustment		3		3
SUM (WWPBI)		**38**		**30**
RATING		**Excellent**		**Excellent**
REGION – SITE	Volunteer		Expert	
SE – OWLT (Kettle)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)	68	5	46	5
Carex spp. (IV)*	0	0	0.22	3
Reed canary grass (IV)	0.17	1	0.20	1
Cattail (IV)*	0	5	0.04	1
Duckweeds (IV)	0.14	3	0.06	3
Bluejoint grass (IV)*	0	1	0.08	5
“Good” taxa (IV)	0.01	1	0.30	1
Long-duration adjustment				
% of Floating-leafed plants				
Pondweed IVs from transects				
Average for deep-water adjustment				
SUM (WWPBI)		**16**		**19**
RATING		**Very poor**		**Poor**

Table 14 continues on the next page.

Table 14, Continued.

	DATASET			
REGION – SITE	Volunteer		Expert	
SE – Beyer Pond (Kettle)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)	47	5	26	5
Carex spp. (IV)*	.01	1	0	0
Reed canary grass (IV)	0	5	0	5
Cattail (IV)	0	5	0	5
Duckweeds (IV)	0.14	3	0.11	3
Bluejoint grass (IV)	0	1	0	1
“Good” taxa (IV)	0.01	1	0.06	1
Long-duration adjustment				
% of Floating-leafed plants				
Pondweed IVs from transects				
Average for deep-water adjustment				
SUM (WWPBI)		**21**		**20**
RATING		**Fair**		**Poor**
REGION – SITE	Volunteer		Expert	
SE – Siedler Pond (Kettle)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)	43	5	29	5
Carex spp. (IV)*	0.14	3	0	0
Reed canary grass (IV)	0.26	1	0.20	1
Cattail (IV)*	0.12	1	0	5
Duckweeds (IV)*	0.03	3	0.36	1
Bluejoint grass (IV)*	0.05	3	0	1
“Good” taxa (IV)	0.19	1	0.07	1
Long-duration adjustment				
% of Floating-leafed plants				
Pondweed IVs from transects				
Average for deep-water adjustment				
SUM (WWPBI)		**17**		**14**
RATING		**Poor**		**Very poor**

Table 14 continues on the next page.

Table 14, Continued.

	DATASET			
REGION – SITE	Volunteer		Expert	
SCD – Tin Can Road (Prairie)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)	19	5	37	5
Carex spp. (IV)*	0.09	1	0.16	3
Reed canary grass (IV)	0.24	1	0.39	1
Cattail (IV)	0	5	0	5
Duckweeds (IV)	0	5	0	5
Bluejoint grass (IV)*	0	1	0.19	3
"Good" taxa (IV)	0.41	3	0.33	3
Long-duration adjustment				
% of Floating-leafed plants				
Pondweed IVs from transects				
Average for deep-water adjustment				
SUM (WWPBI)		**21**		**25**
RATING		**Very good**		**Excellent**
REGION – SITE	Volunteer		Expert	
SCD – Liberty Creek Sedge Meadow (Prairie)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)	23	5	46	5
Carex spp. (IV)	0.54	5	0.48	5
Reed canary grass (IV)*	0	5	0.05	3
Cattail (IV)	0	5	0	5
Duckweeds (IV)	0	5	0	5
Bluejoint grass (IV)*	0.01	3	0.08	5
"Good" taxa (IV)	0.60	3	0.58	3
Long-duration adjustment				
% of Floating-leafed plants				
Pondweed IVs from transects				
Average for deep-water adjustment				
SUM (WWPBI)		**31**		**31**
RATING		**Excellent**		**Excellent**

Table 14 continues on the next page.

Table 14, Continued.

	DATASET			
REGION – SITE	Volunteer		Expert	
SCG – Alexander Arboretum (Prairie)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)	34	5	60	5
Carex spp. (IV)*	0.04	1	0.15	3
Reed canary grass (IV)*	0.18	1	0.05	3
Cattail (IV)	0.11	1	0.06	1
Duckweeds (IV)*	0.15	3	0.28	1
Bluejoint grass (IV)*	0.02	3	0	1
“Good” taxa (IV)	0.12	1	0.18	1
Long-duration adjustment				
% of Floating-leafed plants				
Pondweed IVs from transects				
Average for deep-water adjustment				
SUM (WWPBI)		**15**		**15**
RATING		**Fair**		**Fair**
REGION – SITE	Volunteer		Expert	
SCG – Bork (Prairie)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)	18	5	43	5
Carex spp. (IV)	0.05	1	0.38	1
Reed canary grass (IV)	0	5	0	5
Cattail (IV)	0.17	1	0.17	1
Duckweeds (IV)*	0.13	3	0.22	1
Bluejoint grass (IV)	0	1	0	1
“Good” taxa (IV)	0.08	1	0.04	1
Long-duration adjustment				
% of Floating-leafed plants				
Pondweed IVs from transects				
Average for deep-water adjustment				
SUM (WWPBI)		**17**		**15**
RATING		**Good**		**Fair**

Table 14 continues on the next page.

Table 14, Continued.

	DATASET			
REGION – SITE	Volunteer		Expert	
SCG – Fayeville (Prairie)	Raw value	Metric score	Raw value	Metric score
Total Taxa (A)	24	5	37	5
Carex spp. (IV)	0	0	0	0
Reed canary grass (IV)*	0	5	0.01	3
Cattail (IV)*	0.02	3	0.07	1
Duckweeds (IV)	0	5	0	5
Bluejoint grass (IV)	0	1	0	1
“Good” taxa (IV)*	0	0	0.01	1
Long-duration adjustment				
% of Floating-leafed plants				
Pondweed IVs from transects				
Average for deep-water adjustment				
SUM (WWPBI)		**19**		**16**
RATING		**Good**		**Fair**

We plotted volunteer scores versus expert scores to see if there was an effect of wetland quality on scoring performance and found no obvious effect (Fig.8). Throughout the range of WWPBI scores encountered, the slope of the best fit-line was 0.99, in effect, matching that of the 1:1 line. Overall, volunteers and the expert scored sites similarly (regression analyses, $P = 0.000001$).

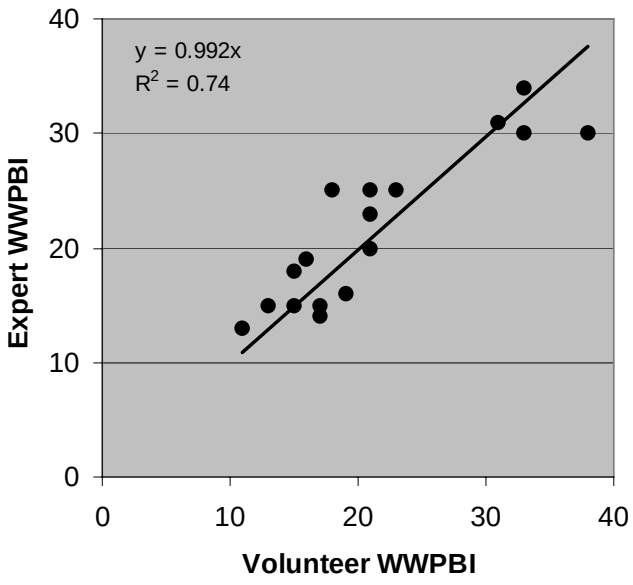

Figure 8. *Wisconsin Wetland Plant Biotic Index scores for the various study sites as determined by either the expert or the volunteers. The best-fit line is indicated.*

Discrepancies in WWPBI scores and summary of metric errors

Detailed explanations of discrepancies between volunteers and the expert are included in Table 15.

Table 15. *Reasons for discrepancies between the expert and volunteer WWPBI scores. Metric descriptions are in Figure 5.*

Region and Name	Volunteer Score	Expert Score	Reason for discrepancy
Northwest			
Tatro	11	13	Expert found 28 more species, all else in calculating score equal.
Standing Cedars	15	18	Expert found 10 more species, found more Reed Canary Grass, found more "Good" taxa.
WPA	13	15	Expert found 33 more species, found more Reed Canary Grass, found more Floating-leafed species.
North Central			
Wetland 1 (Oneida Cty. Forest Rec. Area)	23	25	Expert found 11 more species, all else in calculating score equal.
Wetland 2 (Home Depot)	21	23	Expert found 23 more species (but did not result in differences in metric score). Expert recorded Carex and Bluejoint grass, but did not note Floating-leafed species.
Wetland 3 (US 8 and Ranch Rd)	18	25	Expert found 11 more species, recorded Bluejoint grass and more "Good" taxa, more Duckweed, and recorded Floating-leafed species.
Northeast			
Plainfield Lakes	33	30	Expert found 46 more species (but did not result in differences in metric score), less Carex, fewer "Good" taxa, more Pondweeds.
LMR Wetland 2	33	34	Expert found 23 more species (but did not result in differences in metric), more Reed Canary Grass, recorded Bluejoint grass, found fewer "Good" taxa, more Pondweeds.
LMR Wetland 3	38	30	Expert found 39 more species (but did not result in differences in metric), less Carex, did not record Bluejoint grass, found fewer "Good" taxa.
Southeast			
OWLT	16	19	Expert found 22 fewer species (but did not result in differences in metric), more Carex, more Cattail, recorded Bluejoint grass.
Beyer Pond	21	20	Expert found 21 fewer species (but did not result in differences in metric), did not record Carex.
Siedler Pond	17	14	Expert found 14 fewer species (but did not result in differences in metric), did not record Carex, did not record Cattail, found more Duckweed, did not record Bluejoint grass.
South Central – Driftless			
Tin Can Road Wetland	21	25	Expert found 18 more species (but did not result in differences in metric), more Carex, recorded Bluejoint grass.
Liberty Creek Sedge Meadow	31	31	Expert found 23 more species (but did not result in differences in metric), recorded Reed Canary Grass, found more Bluejoint grass.
South Central – Glaciated			
Alexander Arboretum	15	15	Expert found 26 more species (but did not result in differences in metric), more Carex, more Duckweed, less Reed Canary Grass, did not record Bluejoint grass.
Bork site	17	15	Expert found 25 more species (but did not result in differences in metric), more Duckweed.
Fayeville	19	16	Expert found 9 more species (but did not result in differences in metric), recorded Reed Canary Grass, more Cattail, recorded "Good" taxa.

We tallied the number of times each specific plant metric resulted in a different score between volunteers and the expert (Table 16). Sources of specific errors in overall WWPBI sums were diverse. Errors resulted from a number of different taxa and were relatively evenly dispersed throughout all metrics, suggesting a further general training might be beneficial. Difficulty with enumerating the Bluejoint grass metric resulted in the highest percentage of errors.

Table 16. *Number of cases in which specific plant metric scores resulted in a discrepancy between volunteer-processed or expert-processed data sheets.*

Metric	Number of cases in which metric miscalculated	Percentage of cases in which metric miscalculated
Total Taxa (A)	5	36
Carex spp. (IV)	8	47
Reed canary grass (IV)	6	43
Cattail (IV)	3	18
Duckweeds (IV)	4	24
Bluejoint grass (IV)	9	53
“Good” taxa (IV)	6	43
% of Floating-leafed plants	3	38
Pondweed IVs from transects	2	25

Though the metric score for total taxa was often correct (for example, if >16 species, all resulted in a metric score of 5), the expert consistently found many more species than the volunteers (Fig. 9, left). If we exclude data from the southeast region team (which happened to contain an “expert” volunteer botanist), the expert found, on average, 23 more species per site than volunteers. We further explored the source of discrepancy for tallies of total taxa between the expert and volunteers (Fig. 9). Volunteers had total taxa numbers similar to that of the expert when sampling similar areas using transects (standing water areas) (Fig. 9, right). However, the expert greatly augmented his taxa list (relative to the volunteers) when surveying plants in the walk-through (Fig. 9, left). This may be a result of 1) the expert’s ability to recognize more taxa, and/or 2) inconsistency in guidelines regarding how extensively to search for additional taxa (*i.e.* the expert may have searched a larger area than volunteers).

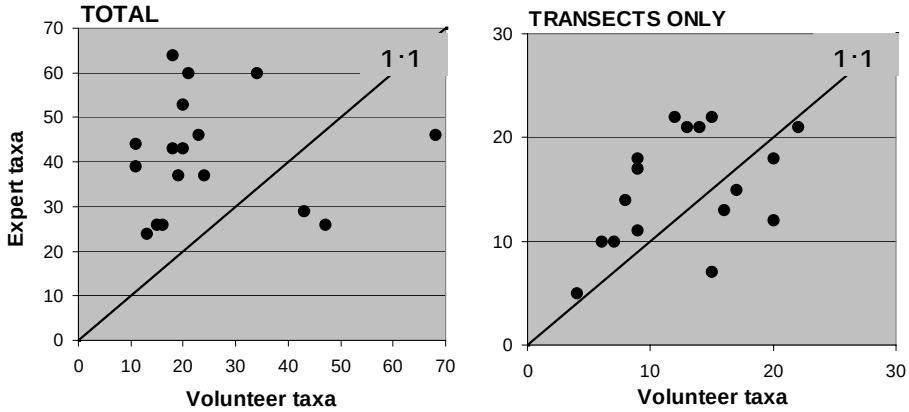

Figure 9. *Comparison between number of taxa recorded by the expert or volunteers cumulatively (left panel, sum of species recorded in walk-through and transects) or in transects only (right panel) for the various study sites. The 1:1 line is also indicated.*

Index Comparisons

Different taxa groups often respond differently to the various types of human disturbances. Despite this expectation, we were interested in whether the different indices measured in this study ranked sites similarly or differently. In the following sections, we compare results from the WWMBI (macroinvertebrates) to those of the WWPBI (plants). Because our expert botanist was able to determine the Floristic Quality Index (Bernthal 2003) and average coefficient of conservatism for each site, in addition to the WWPBI scores, we also had a unique opportunity to compare various plant indices.

WWMBI vs. WWPBI

We anticipated that plant biotic index results may differ slightly from macroinvertebrate index results, because plants and macroinvertebrates respond to different habitat conditions and disturbances. In Figure 10, we plotted expert-determined WWMBI and WWPBI scores, and found a significant negative relationship (regression analysis; $P = 0.04$). This indicates that within this study, different IBIs ranked sites not only differently, but oppositely. Further investigation of this result is warranted.

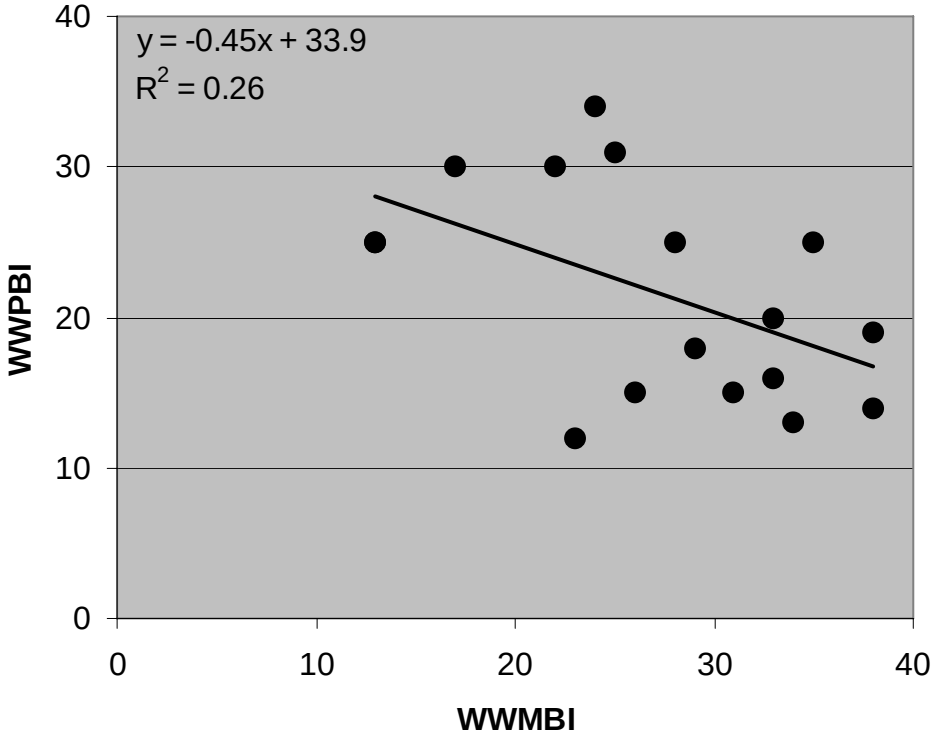

Figure 10. *Expert-determined WWMBI vs. WWPBI scores for the various study sites.*

WWPBI vs. FQI and mean conservatism

The Floristic Quality Index (FQI) (Swink and Wilhelm 1994, Nichols 1999, Bernthal 2003) was designed to provide a relatively rapid assessment of how closely the aquatic vegetation in a given area matches that of undisturbed conditions[1]. The FQI takes into account species richness of the assemblage of plants in a site and the sensitivity of each individual plant species to environmental conditions. Determination of the FQI for a site requires botanical expertise, as all plant taxa need to be identified to the species level. The Wisconsin Floristic Quality Assessment (WFQA) is an adapted version of the FQI designed to provide an intensive measure of wetland biotic integrity within plant communities encountered in Wisconsin. It includes a characterization of sites by both FQI scores and mean conservatism values (Bernthal 2003), because FQI may be biased by size of the assessed area and increased overall diversity resulting from disturbance and subsequent invasion of weedy species on a portion of a site.

In Figure 11 (left panel), we plotted expert-determined FQI and WWPBI scores and found a significant positive relationship (regression analysis; $P = 0.0009$). Regressing mean conservatism scores versus WWPBI scores also yielded a significant positive relationship ($P = 0.0003$) with slight improvement in the coefficient of determination (r^2, the proportion of the variation in the y axis that is explained by variation in WWPBI).

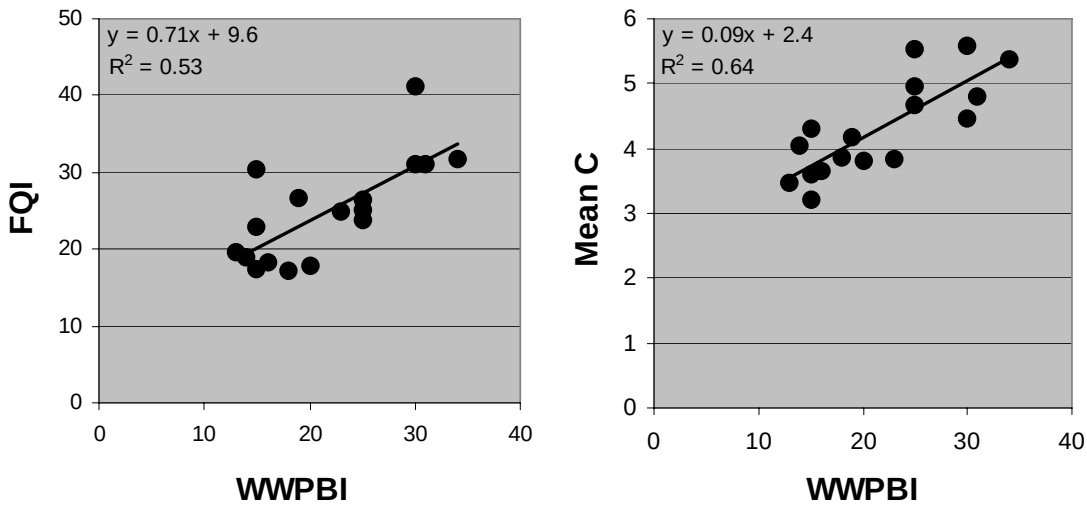

Figure 11. *Expert-determined WWPBI vs FQI (left panel) or average C (right panel) scores for the various study sites.*

[1] For a given site, the FQI is calculated as:

$$FQI = (\overline{C})(\sqrt{N})$$, where

N = the total number of native species, and

$\overline{C}$ = the average coefficient of conservatism (conservatism is defined as the estimated probability that a plant is likely to occur in a landscape that is believed to be relatively unaltered from presettlement conditions (Nichols 1999), determined by dividing the sum of coefficient of conservatism values for all native species by the total number of native species. Conservatism values, ranging from 0 (most tolerant) to 10 (most sensitive), were assigned to 1788 species native to Wisconsin in Bernthal (2003).

Remarkably, an index that relies on relatively coarse group-level identification of plants (WWPBI), ranked sites similarly to indices requiring species-level identifications (FQI and mean conservatism). Though the WWPBI includes a total taxa metric generated from in-water transect surveys and a general walk-through that includes wetland areas without standing water, the index scoring is heavily weighted by species found in the standing water portion of wetland sites. FQI and mean conservatism scores are generated by species lists for the entire wetland. Concordance between the WWPBI and the other indices suggests that species found in the wetted portion of wetland sites (e.g., containing standing water) may adequately indicate overall wetland quality.

In summary, the WWPBI is highly recommended for use within a statewide volunteer monitoring framework for 1) its ease of implementation, 2) the general ability of volunteers to accurately characterize sites (compared to an expert, Fig. 8) with only an hour spent on-site, and 3) the concordance between WWPBI rankings of sites and that of other widely accepted plant indices (Fig. 11; FQI and mean conservatism).

Recommendations for Implementation

Overall, volunteers implemented the macroinvertebrate and plant IBIs with accuracy equal or similar (within 1 rating) to that of an expert. However, there are several modifications that could be implemented to refine this tool for future monitoring by field staff and trained volunteers. In this section we outline some of the problems encountered throughout this exercise and our recommendations for improvements.

Time Spent Processing Samples

We should note that most volunteers spent at least 1 day processing each macroinvertebrate sample (Table 5), and that the process was often described as “tedious” or “frustrating” for them. Rather than having volunteers sort and identify samples on their own, we recommend that in the future, volunteers collect their samples when convenient, but then attend a centrally-located laboratory workshop where everyone processes samples together, with an expert on hand to expedite the process. This also gives the added benefit that volunteers receive immediate feedback on their accuracy, resulting in a more educational process.

Time spent conducting plant surveys was reasonable, usually under 1 hour.

Datasheets

Confusion with filling out data sheets and calculating metric scores was a consistent source of error for macroinvertebrates (Table 10) and one that may easily be avoided in the future. We recommend providing volunteers with an automated data sheet for both macroinvertebrates and plants, in which they provide abundance information for various taxa, but in which calculations of species richness, diversity, metric scores, and final IBI scores are automated.

Troublesome Taxa

Sources of error for macroinvertebrates were widely distributed among the various metrics, resulting in the highest percentage of errors associated with cumulative metrics (non-insect richness, total taxa richness, total insect richness, and total diversity). Sources of error for plants were also widely distributed among the various metrics, and error rates were higher than expected for some taxa. This result suggests an additional general training for macroinvertebrates and plants would be of value (Tables 13 and 16).

Specimen Preservation

Given the potential error associated with volunteer monitoring, we do recommend preservation and archiving of samples, so that an expert may conduct quality assurance checks for any future monitoring data. Vouchering of unknown plant specimens is also recommended.

Scores versus Ratings

For a future monitoring program, we recommend emphasizing IBI numeric scores in tracking changes within a site over time or in comparing different sites. Descriptive ratings (very poor to excellent) are somewhat arbitrary and in many cases, a difference of only 1 in IBI scores, resulted in a level different rating of systems. Though volunteer versus expert descriptive ratings often varied for individual sites, overall, volunteers closely matched experts in scoring sites for both macroinvertebrates and plants (Figs. 7 and 8).

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Wisconsin Department of Natural Resources
Bureau of Integrated Science Services
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