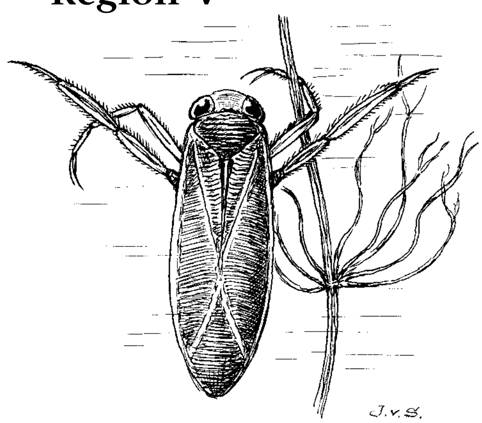
Field Testing the Wisconsin Depressional Wetland Macroinvertebrate and Plant Indices of Biological Integrity for Application by Trained Volunteers

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

The Wisconsin Department of Natural Resources developed this document under Grant No. CD-97565801 from the U.S. Environmental Protection Agency, Region 5.

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

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

This report was prepared by the Wisconsin Department of Natural Resources under Grant No. CD-97565801 from the U.S. Environmental Protection Agency, Region 5. Points of view expressed in this report do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency. Mention of trade names and commercial products does not constitute endorsement of their use.

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

Contents continue on next page.

Contents, continued.

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.

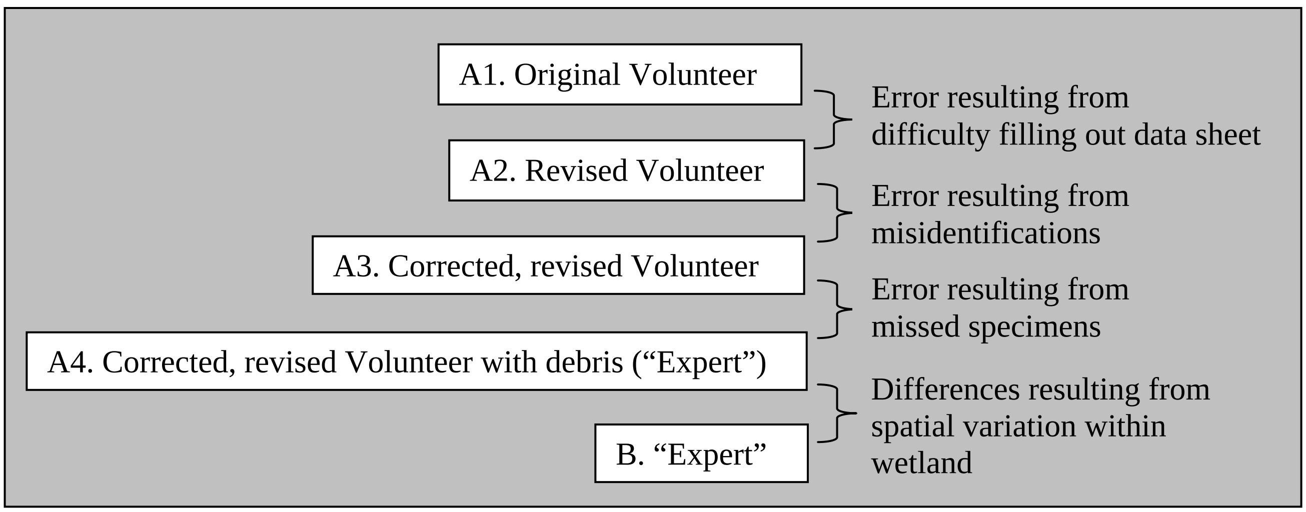


Figure 6. *The possible comparisons for macroinvertebrate data sheets and subsequent information gained (including to what to attribute errors). Please note that "A1-A4" are various levels of correction of the same sample, originally processed by the volunteers and then subsequently corrected by an expert.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

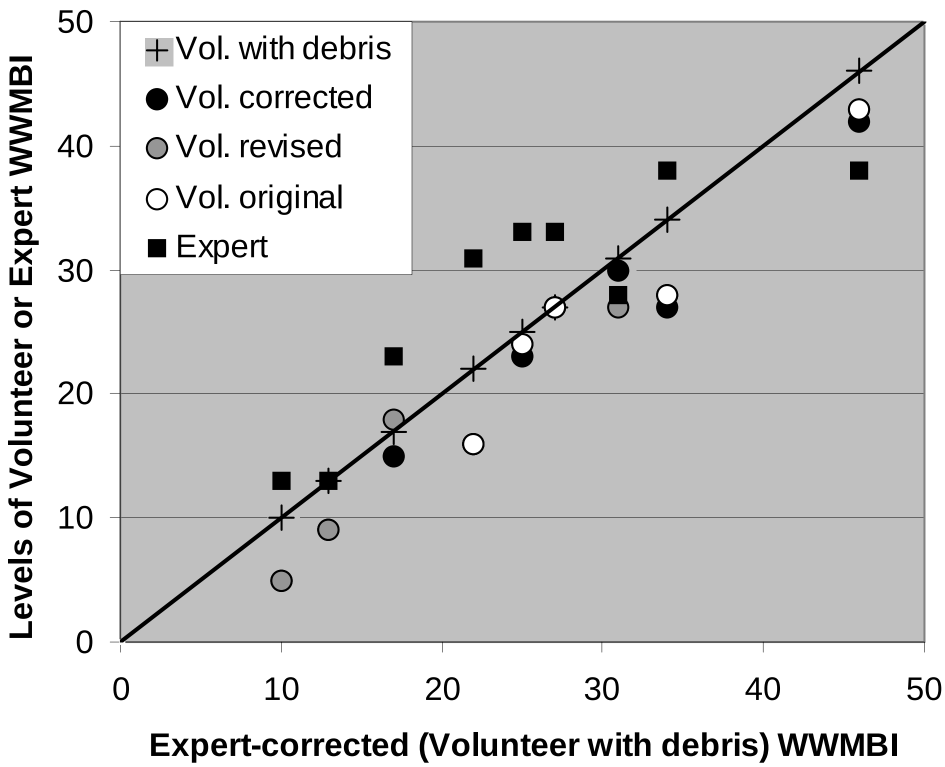


Figure 7. *Wisconsin Wetland Macroinvertebrate Biotic Index scores for the various study sites for both the expert processed sample (B) and the various levels of expert-corrected volunteer samples (A1-4) plotted against the final expert corrected scores of the volunteer sample (A4) (as in Fig. 6). The 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, $P = 0.000001$).

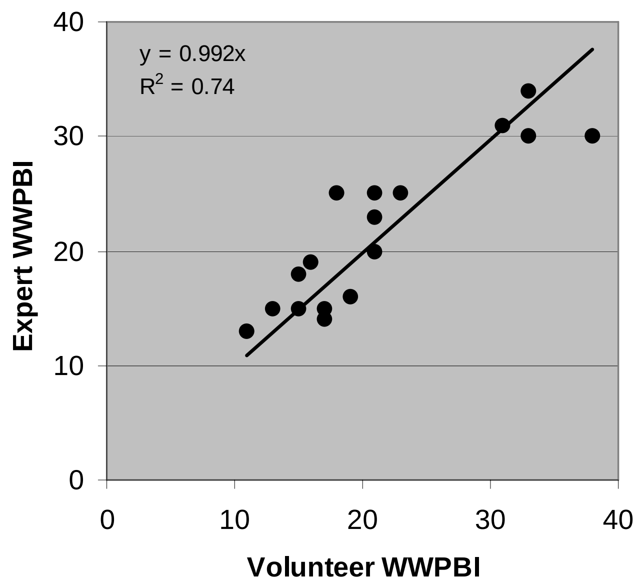


Figure 8. *Wisconsin Wetland Plant Biotic Index scores for the various study sites as determined by either the expert or the volunteers. The best-fit line is indicated.*

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).

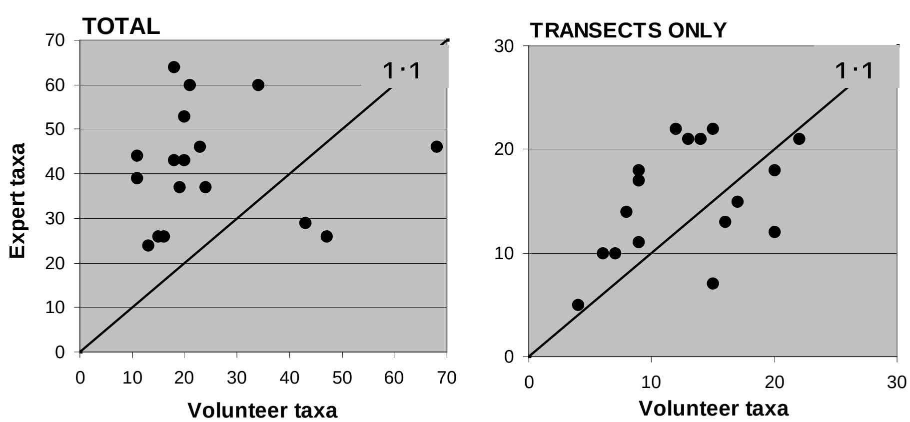


Figure 9. *Comparison between number of taxa recorded by the expert or volunteers cumulatively (left panel, sum of species recorded in walk-through and transects) or in transects only (right panel) for the various study sites. The 1:1 line is also indicated.*

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.

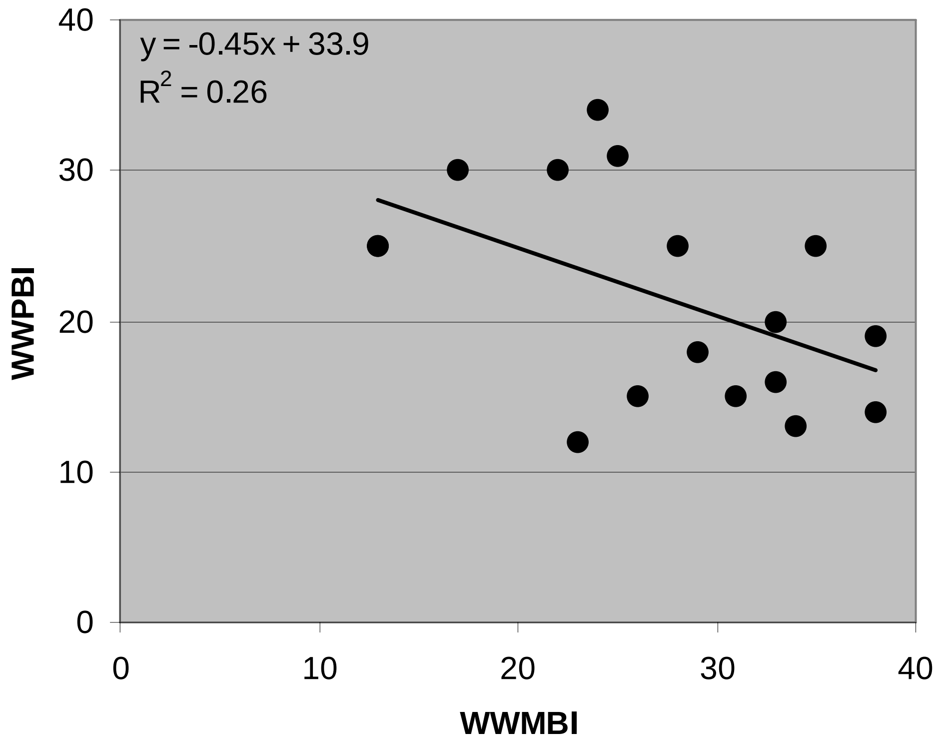


Figure 10. *Expert-determined WWMBI vs. WWPBI scores for the various study sites.*

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).

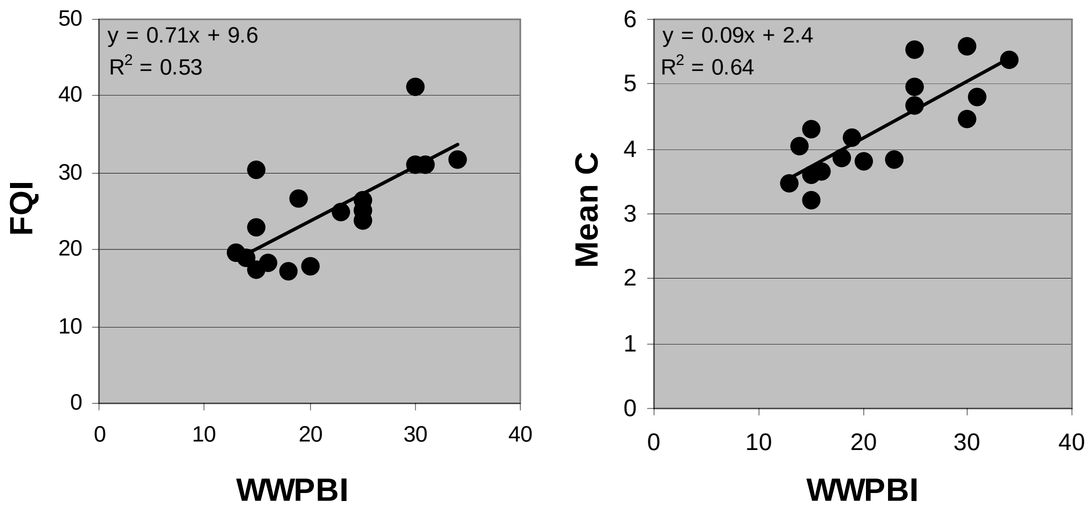


Figure 11. *Expert-determined WWPBI vs FQI (left panel) or average C (right panel) scores for the various study sites.*

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

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

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).

Acknowledgements

We thank the volunteers for their enthusiasm and effort invested in this project. We also thank Paul Rasmussen for statistical advice.

Literature Cited

Bernthal, T.W. 2003. Development of a floristic quality assessment methodology for Wisconsin. Final Report to USEPA Region V, Wetland Grant #CD97511501-0. Bureau of Integrated Science Services, Wisconsin Department of Natural Resources, Madison. (PUB-SS-986 2003). 18 pp. + appendix. Available on the worldwide web at: http://dnr.wi.gov/org/water/fhp/wetlands/documents/FQAMethodWithAcknowledgements.pdf.

Lillie, R.A. 2000. Development of a biological index and classification system for Wisconsin wetlands using macroinvertebrates and plants. Final Report to USEPA Region V, Wetland Grant #CD985491-01. Wisconsin Department of Natural Resources, Bureau of Integrated Science Services, 1350 Femrite Drive, Monona, WI 53716. 50 pp. + figures and appendices.

Lillie, R.A., P. Garrison, S.I. Dodson, R.A. Bautz, and G. LaLiberte. 2002. Refinement and expansion of wetland biological indices for Wisconsin. Final Report to USEPA Region V, Wetland Grant #CD97511501-0. Bureau of Integrated Science Services, Wisconsin Department of Natural Resources, Madison. (PUB-SS-968 2002). 132 pp. Available on the worldwide web at: http://dnr.wi.gov/org/es/science/publications/Lillie_Wetland_IBI.pdf.

Nichols, S.A. 1999. Floristic quality assessment of Wisconsin lake plant communities with example applications. *Lake and Reservoir Management* 15:133-141.

Swink, F., and G. Wilhelm. 1994. *Plants of the Chicago region* (4^{th} edition). Indiana Academy of Science, Indianapolis. 921 pp.

Appendix 1.

Training Manual, Field and Laboratory Protocols, and Sample Data Sheets
(Field and laboratory workshop conducted August 21-22, 2001)

WETLAND MONITORING TRAINING PROGRAM – BIOTIC INDICES FOR DEPRESSIONAL WETLANDS & INTRODUCING FLORISTIC QUALITY ASSESSMENT
August 21-22, 2001 at DNR Research Center, Monona, WI (1350 Femrite Dr.)

AGENDA

DAY ONE: TUESDAY, AUGUST 21, 2001

8:00AM INTRODUCTIONS

8:10 AM OBJECTIVES – Why are we here; What do we wish to accomplish? – Bernthal

8:20 AM PROGRAM SCHEDULE AND LOGISTICS - Bernthal

8:30 AM OVERVIEW OF WETLAND MONITORING - Bernthal
- Why monitor wetlands?
- Types of assessment/monitoring methods
- Our strategy for monitoring wetlands and your role it it

8:45 AM OVERVIEW OF BIOTIC INTEGRITY RESEARCH - Lillie
- Why sample biota
- Wetlands sampled (N=104)
- Methods – general approach used
- Metric testing and development – general dose response
- Preliminary findings and limitations
- Ongoing work – new communities
- How this training program fits into the larger picture

9:00 AM MACROINVERTEBRATE BIOTIC INDEX - Lillie
- What groups are we dealing with?
- Field methodology
    - Equipment
    - When, where, and how to sample
    - Handling, processing, and preserving samples
- Laboratory processing
    - Description of process
    - Data recording
    - Data handling – Metric calculations

9:30 AM WETLAND MACROINVERTEBRATES OVERVIEW - Lillie

10:00AM AQUATIC PLANT BIOTIC INDEX - Lillie
- Level of taxonomy used
- Field methodology (Two-tiered approach)
  - Equipment
  - When, where, and how to sample
  - Vouchers and data recording
- Data manipulation – Metric calculations

10:30 AM PLANT IDENTIFICATION HINTS FOR IBI METRICS – Trochlell
- Field guides – Pat's picks
- Grasses, sedges, rushes
- Carex sedges
- Reed canary grass
- Canada Bluejoint grass
- Other "Good" aquatics – Potamogeton, Scirpus, Utricularia, Equisetum, Sagittaria, Polygonum

11:15 AM FLORISTIC QUALITY ASSESSMENT - Bernthal
- Background and development
- Coefficient of Conservatism
- Floristic Quality Index
- Sample calculation

11:45AM REVIEW
- Important Highlights
- Questions & Answer Period
- Afternoon schedule

12:00Noon –12:45 LUNCH BREAK –Sub sandwiches and beverages provided

---

1:00PM DEPART FOR FIELDTRIP & COLLECTIONS
- Assemble at RC/Monona
- Inventory and distribute equipment
- Drive to study site

1:45PM FIELD SURVEYS – MACROINVERTEBRATES
- Characterize study wetland site
- Demonstration of collection techniques
- Students collect and composite invert samples

2:30PM FIELD SURVEYS – AQUATIC PLANTS

Demonstration broad survey
Demonstration transect surveys
Demonstration plant collections
Students conduct surveys and press plants
Check of data sheets for completeness
Question & Answer?

4:00PM DEPART FIELD SITE FOR RETURN TO RC

4:30PM RETURN TO RC
Put equipment and samples away
Discuss schedule for next day
Adjourn for day (about 5PM)

WETLAND MONITORING TRAINING PROGRAM – BIOTIC INDICES FOR DEPRESSIONAL WETLANDS & INTRODUCING FLORISTIC QUALITY ASSESSMENT

August 21-22, 2001 at DNR Research Center, Monona, WI (1350 Femrite Dr.)

AGENDA

DAY TWO: WEDNESDAY, AUGUST 22, 2001

7:45AM REVIEW - Lillie
- Review schedule for day two
- Review labwork for macroinvertebrate biotic index

8:00AM INVERTEBRATE IDENTIFICATION – TAXONOMY - Lillie
- Basic identification – introduction to keys and level of ID needed
- Preserved specimens (pass around)

8:45AM PROCESS MACROINVERTEBRATE SAMPLES (move to lab) - Lillie
- Rinsing procedure
- Distribution of inverts in tray – randomization
- Picking and sub-sampling procedures
- Data recording
- QAQC checks of Ids and forms by instructors

11:00AM INVERT METRIC CALCULATIONS (in conference room) - Lillie
- Compute metric scores
- Evaluate wetland health based on findings
- Discuss problems, weaknesses, and review procedures

12:00Noon – 12:45 PM LUNCH BREAK

12:50PM More time for macroinvertebrates if needed

PLANT VOUCHERS & ID (in dry laboratory) - Trochlell
- Voucher preparation/mounting demonstration
- Complete plant Ids where required
- Verify vouchers with instructors

2:00PM PLANT METRIC CALCULATIONS & FQI DETERMINATIONS (in Conference room) - All

Compute Relative Importance Values
Compute plant metric scores
Compute FQA scores
Evaluate wetland health based on findings
Discuss problems, weaknesses, and review procedures

3:30PM COMPARE TEAM'S FINDINGS - All
Compare metric performance among teams and similarity or dissimilarity in response of the three methods – discuss.

4:00PM WRAP-UP & Q/A FOLLOW UP NEXT SPRING - All
Evaluate training program (form?)
Discuss need for a winter refresher on macroinvertebrates
Explain what is expected next spring – discuss study site selection and timing of sampling.
Distribute field equipment for next spring.
Adjourn (5PM)

Delevoped with the assistance of Wetland Grant # CD985491-01-0 and additional 106/316 funding to WDNR.

METHODS MANUAL & FIELD GUIDE FOR APPLICATION OF THE WISCONSIN WETLAND MACROINVERTEBRATE BIOTIC INDEX

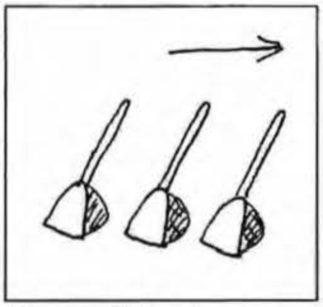
Prepared by:

Richard A. Lillie
Wisconsin Department of Natural Resources
Bureau of Integrated Science Services
Fish and Habitat Section
1350 Femrite Drive, Monona, WI 53716

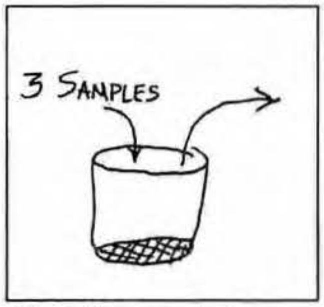
[August 2001]

OVERVIEW OF COLLECTING AND PROCESSING MACROINVERTEBRATE SAMPLES FOR CALCULATING BIOTIC IDEX SCORES

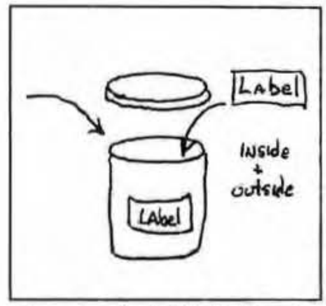
Field Collections:



Composite 3 net-sweeps



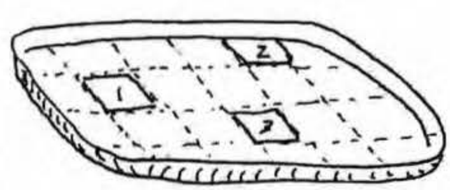
Rinse & concentrate
Into 1-quart container



Preserve in 95% Ethanol
with water-proof label

Laboratory Processing:

Tray is partioned into 24 cells:



Randomly select 3 cells. Pick and count the organisms in each cell and tally by taxon. Those taxa whose abundance are ≥ 15 (extrapolated ≥ 120) can be ignored in processing the balance of the sample. After processing the first 3 cells, continue searching the remaining 21 cells (sample can be remixed if desired) for all additional specimens. Retain all specimens in 75% ethanol. It is important not to miss the rarer or concealed cryptic taxa (e.g., caddisflies in cases, translucent midges or cased midges, pigmy backswimmers, beetle larvae). Sum up the counts, including extrapolated numbers, on the laboratory sheet; calculate percent caddisflies; and conduct taxon richness counts. Finally, using the "Metric Scoring" sheets, calculate and record the individual metric scores on the laboratory sheet in the spaces provided. The sum of these individual scores represents the Biotic Index Score for the wetland basin.

The Wisconsin Wetland Macroinvertebrate Biotic Index (WWMBI)

The Wisconsin Wetland Macroinvertebrate Biotic Index (WWMBI) was developed for the specific purpose of evaluating the biological integrity of depressional basin wetlands of Wisconsin. Its performance in evaluating other types of wetland basins is untested.

The WWMBI is derived from an examination of the macroinvertebrate community found in a composite grab sample taken from three representative areas of a wetland basin. Metrics used in the WWMBI were selected after screening the responses of 69 individual community attributes to supposed measures of human disturbance in a set of 104 wetland basins. Further details regarding the data set and rationale in developing the WWMBI are provided in the final report to USEPA. Those attributes that demonstrated a strong, unidirectional response, consistent with theoretical impact of human disturbance, were selected as metrics. The WWMBI is comprised of fifteeen component metrics, including two richness metrics (number of non-insect taxa, and total number of taxa), one percentage metric (percent of total abundance composed of caddisflies), and twelve abundance metrics. Metrics based on abundance include Mollusks (clams and snails), Annelids (worms, etc.), Fairy Shrimp (Anostraca), Damselflies (Zygoptera), Pigmy backswimmers (Pleidae), Water boatmen (Corixidae), Limnephilid caddisflies , Total caddisflies, Phantom midges (Chaoborus), Mosquitoes (Culicidae), Soldier fly larvae (Stratiomyidae), and total invertebrates. Each individual metric is assigned a score of 0, 1, 3, or 5 based on the metric's correlation with suspected levels of impact among the 104 wetland basin test set. The scores for the fifteeen metrics are then summed to derive a final WWMBI for an individual basin or sample. Each basin is assigned one of six biological integrity classifications ranging from very poor to excellent based on the WWMBI.

The biological integrity rating system was designed to compare all other wetland basins with conditions found in the reference data set. Biological integrity ranged between 19 to 61 (maximum range possible 3-75) in the 33 reference basins examined during 1998. By definition, the breakpoint separating good (and better) and fair (and worse) biological integrity was set at the median WWMBI score in the reference wetlands (i.e., 43). This approach in assigning rating values to WWMBI scores is probably conservative in that the so-called reference set included basins that undoubtedly had been impacted to some extent. Consequently, lower thresholds of the 25^{th} and 10^{th} quantiles were used to separate fair from poor and and poor from very poor, respectively. The 75^{th} and 90^{th} quantiles were used to separate good from very good and very good from excellent, respectively. A WWMBI score from another basin is compared with the reference data set as a means to evaluate relative biological integrity of the wetland in question. The sensitivity of the WWMBI has not been clearly established (ongoing studies), although field replication appears to provide classification within the same or adjacent biotic integrity class.

METRICS IN WISCONSIN WETLAND MACROINVERTEBRATE INDEX

• Mollusks	Abundance	Decreases with disturbance
• Annelids	Abundance	Decreases
• Fairy Shrimp	Abundance	Decreases (short duration basins)
• Non-Insects	Richness	Decreases
• Damselflies	Abundance	Decreases
• Pigmy Backswimmers	Abundance	Increases (longer duration basins)
• Water Boatmen	Abundance	Decreases
• Limnephelids	Abundance	Decreases
• Caddisflies	Abundance & %	Decreases
• Phantom Midges	Abundance	Decreases (longer duration basins)
• Mosquitoes	Abundance	Decreases
• Soldier Flies	Abundance	Increases
• Total Invertebrates	Abundance	Decreases
• Total Taxa	Richness	Decreases

Field Collection Procedures and Sorting & Identification

When to collect?

Dynamic shifts in macroinvertebrate community structure naturally occur within and across seasons. Wetland hydrology is complex and water levels (and more importantly water duration) may vary considerably from year to year. Periods of extended drought or wetness significantly affect macroinvertebrate community structure and abundance. The early spring community (April to early or mid-May in the north) best reflects conditions existing within the wetland during the previous year through the winter. Taxa richness and often times – abundance – highest or greatest during the early spring. Sampling in early spring reduces the confounding impact of emigration or emergence and immigration (colonization by numerous opportunists). Consequently, evaluation of wetland condition should be made only with samples collected during early spring.

> Our data show that WWMBI can change dramatically from one month to another within a wetland basin. It is not known whether the direction of these changes is similar among all types of wetlands, so it is also not clear whether sampling in summer or fall months would produce values that could be compared with a similar set of summer or fall data from least-disturbed reference basins. For the time being it is recommended that WWMBI sampling be conducted only in early spring (April-May).

Where to collect?

Sampling macroinvertebrate communities in wetlands can be difficult and, at times, dangerous. Access may be difficult, poisonous or armored plants may be encountered, bottom substrates may be slippery or soft, and floating-bog mats may be thin. Precautions should be taken before simply wading in. A wading pole or the inverted end of the D-frame net is useful in determining bottom conditions.

The WWMBI is based on the macroinvertebrate community present in a composite of three D-frame net sweep samples. The relative position of the three sample locations are somewhat dependent upon the characteristics of the wetland being assessed. In most small (less than 2 acres) wetlands, samples should be collected from shoreline areas positioned to trisect the wetland perimeter. The first site should be selected in a random fashion (or arbitrarily near the point of access) and the remaining two sites at roughly equal distances to the left and right so as to trisect the shoreline perimeter (not necessary to be exact). The objective is to attempt to collect from three representative but distant locations. In wetlands with non-wadable areas (i.e., maximum depths greater than 60 cm), samples should be collected from points approximately mid-way between shore and the 60-cm depth contour (20-40 cm). Sampling too close to shore or in water closer to the deep-water edge may influence results. In shallower wetlands (i.e., entire basin wadable), samples should be collected approximately mid-way between shore and the center of the basin. Water depth at the sites may be less than the desired 20-40 cm. In some circumstances (e.g., bogs, seeps, sphagnum mats, etc.) it may be necessary to improvise or adjust sampling as necessary in order to obtain a sample. Dense emergents, duckweed, filamentous algae, or shrubs may make dip-netting impossible or very difficult in some areas. While macroinvertebrates often display associations with various plant communities, adjusting the sampling locations slightly in order to get a "clean sweep" is acceptable if the edges of dense beds are included in the sample.

How to Collect

All samples should be collected with a D-frame net equipped with a 800 X 900 micron mesh net. Other forms of nets (e.g., rectangular dip nets) are also acceptable if equipped with suitable mesh. Use of a finer mesh net is not recommended. The WWMBI was developed based on samples collected with the standard net. A finer mesh net would collect all of the larger organisms collected by the standard net plus many smaller organisms that might substantially bias results. Also, the finer mesh net sizes would clog more rapidly in sampling most wetlands, particularly those wetlands with large volumes of coarse particulate organic matter. Samples should be collected as follows. Slowly wade out to the proper site, being careful to disturb the area as little as possible. Lower the dip net while held vertically at an arm's length though the water surface to the top of the bottom substrate. Rapidly sweep the water column at or just above the surface of the bottom in a 180-degree arc from right to left and lift the net from the water (see further precautions discussed below). This represents one net sweep sample, which will be combined with the remaining two samples to comprise the entire composite sample for the wetland. Ideally, the speed of sweeping should be uniform among samples and consistent among wetlands but speed is influenced by substrate and plant conditions present. If you 'dip' too deep into flocculent sediments, your net bag will quickly fill with solids that may or may not be able to be rinsed through the net. You want to get some of the bottom organisms, but avoid filling your net with massive amounts of sediment. Solid coverage of duckweed or long strings of filamentous algae also create serious problems in that the net may be full of plant material before even half of the sweep is completed if sweeping is conducted in the manner described. Cat-tails and other sturdy or persistent emergent stems interfere with sweeping and require either shallower sampling or variations in technique to obtain samples. The presence of woody debris (sticks, snags, etc.) or unseen barbed wire can cost you a ripped net (replacement bags $55 each!). It may be necessary to make field modifications in order to obtain an adequate sample. These modifications are justified, but one should attempt to standardize the volume of water filtered as much as possible.

The sample should be transferred to a sieving bucket or other container (five gallon pail is a good substitute) until the remaining two samples are collected. Combine the three individual sweeps in the sieving bucket and reduce the volume of sample contents by vigorously washing and rinsing a series of small handfuls of organic material to remove attached macroinvertebrates. If you don't have a sieving bucket, you can recombine the contents of the three sweeps into the D-frame net as an alternative means to rinse the sample. Each handful of material should be examined carefully before it is discarded. Continue this procedure until the volume of material and macroinvertebrates remaining in the bucket will fit easily into a one-liter container (plastic preferred, but glass may be substituted). Preserve the sample for further processing with 95% ethanol (isopropyl is an acceptable alternative) present in the sample. Some organisms should be recorded but excluded from the calculation of the WWMBI. This includes small zooplankton or water fleas (i.e., copepods and Daphnia), fish, crayfish, and amphibians (e.g., polywogs). These taxa should be listed on the tally sheet but should not be used in the calculation of the WWMBI. Record on a tally sheet (see sample in Appendix) the number of specimens of each individual taxon found within each of the first three randomly selected cells. Tally sheets should be printed on waterproof paper if available. Tally the counts in the first three cells. For those taxa that exceed a sum of 15 specimens, you may elect to extrapolate the approximated total in the entire sample by multiplying the count by a factor of 8 (assuming your tray has 24 grids). This time-savings effort accounts for the more dominant organisms in a sample. After extrapolating the numbers of the dominant organisms, continue to sort, pick, and tally the balance of the organisms present in the remaining cells. You can ignore all specimens of the dominant organisms being careful not to miss look-alike taxa resembling the dominant taxa. You can simply continue to scan and pick from the remaining 21 cells or recombine and spread the contents of the uncounted cells among all 24 cells. It is important that you search and find the rarer, less commonly occurring taxa present in the sample.

Quality Control Checks:

If you are concerned that you might have missed something; don't worry – you did! The question is was it important? Generally speaking, if you have scanned a sample thoroughly once and re-scanned it two or three times (about 2 hours), you have probably encountered 90-95% of the specimens present. The actual capture rate depends on the density and composition of the detritus and the experience of the investigator. Developing a visual search pattern takes practice. I have gone through an entire sample and later discovered that I had missed several specimens of a particular taxon that was not in my search image (e.g., dark beetles or transparent midge larvae). This is why it is important to re-scan the sample a second or third time to pick up additional taxa. Some investigators elect to use various stains or dyes that enhance discovery of cryptic taxa as a means to ensure complete coverage. I have found that dependence on dyes leads to missing taxa that do not absorb the stains; i.e., the investigator becomes too dependent upon the stain to find specimens and misses several common taxa. If you have someone willing to devote an hour or two, you could ask them to scan the sample to see what you have missed. Alternatively, return the balance of the tray contents to the original sample jar (may be easiest to pour through D-frame net to re-concentrate the sample to fit into the container), add fresh preservative (with correct label), and deliver to another lab for a quality control check. Keep in mind that unless you want to spend 4 or more hours on a sample, you are going to miss specimens (in highly organic samples). If you are consistently missing certain taxa you have a potentially serious problem. The only way you will know is to have a second person look over your sample remnants. Do not be afraid to find out! Specimens picked for the WWMBI may be preserved (in 70% ethanol and labeled) for laboratory verification, vouchers, or discarded as desired.

[See Flow chart with illustrated guide to macroinvertebrates.]

Calculation of WWMBI.

The WWMBI is calculated based on twelve abundance metrics, two richness metrics, and one percentage metric of among fifteen macroinvertebrate taxonomic groups (see Table). Scores were assigned based on the response of the various community attributes to suspected human disturbance. Abundance thresholds for mollusks, annelids, fairy shrimp, damselflies, pigmy backswimmers, water boatmen, limnephelid caddisflies, total caddisflies, phantom midges, mosquitoes, soldier flies, and total invertebrates were calculated from their response among the least-disturbed reference wetlands sampled during 1998 (see USEPA final report for further details). Richness metrics are based primarily on family-level or coarser level taxonomy. The single percentage metric based on representation by all caddisflies in a sample may be somewhat redundant, but covers those instances (e.g., in early spring) when larvae are not developed to the extent that they can be identified to a particular family.

On the tally sheet, total all organisms and taxa counts. Divide the abundance of total caddisflies by the total invertebrate abundance. Using the metric scoring sheet provided, record the appropriate metrics scores for each of the highlighted taxa (note two scores for caddisflies) and sum individual scores to derive the final WWMBI. Refer to the rating scales provided for the WWMBI to assign a biological integrity classification ranging from very poor to excellent.

Interpretation of WWMBI – reference goals, classes.

The WWMBI score can range between minimum and maximum possible scores of 2 and 75, respectively. We established a rating system for the WWMBI based on a set of 33 reference kettle wetlands (see Final report to USEPA). The reference kettles represented the least disturbed conditions in the three major ecoregions of Wisconsin. We assigned wetlands to the reference category (i.e., 'least-disturbed') on the basis of the basin's proximity to human disturbance and without regard to natural factors that may influence macroinvertebrate community composition. In retrospect, this appears to have been unwise because, although the basin may have been relatively undisturbed in terms of human disturbance, the basin may not have represented ideal conditions for supporting a diverse assemblage of macroinvertebrates. Many remote, pristine, wetland basins are naturally organically enriched with dense mats of vegetation covering the entire surface of the basin, thus limiting exchange of oxygen and other chemicals between the air and water. Such circumstances may represent very harsh environmental conditions for many groups of macroinvertebrates, which would (and does) result in a lowering of the WWMBI. Consequently, WWMBI scores may range from very high to very low despite the lack of (or low degree) of human disturbance. Truly impacted basins consistently score lower than most reference basins.

To compare your wetland with the reference wetlands, simply compute the WWMBI score and plot it on the figure based on water duration and history. The division points are given along the margin.

METRICS SCORES FOR THE WETLAND MACROINVERTEBRATE INDEX

Taxon	Attribute	Response	Score=0	Score=1	Score=3	Score=5	Adjustments
Mollusks	Abundance	Decrease	0	1-10	11-99	>99	None
Annelids	Abundance	Decrease	-	0-10	11-25	>25	None
Fairy Shrimp	Abundance	Decrease	-	0-8	9-25	>25	Duration
Non-Insects	Richness	Decrease	0	1-2	3-5	>5	Prairies?
Damselflies	Abundance	Decrease	0	1-2	3-15	> 15	Kettles?
Pigmy B.S.	Abundance	Increase	0	1-2 & >100	3-5 & 11-99	6-10	Duration
Boatmen	Abundance	Decrease	0	1-4	5-10	> 10	None
Limnephilid	Abundance	Decrease	0	1-10	11-50	> 50	?
Caddisflies	Abundance	Decrease	0	1-10	11-60	> 60	Duration?
Caddisflies	Percentage	Decrease	0	< 8%	8-15%	> 15%	Redundant?
Phantom M.	Abundance	Decrease	0	1-8	9-25	> 25	Duration
Mosquitoes	Abundance	Decrease	0	1-10	11-99	>100	Duration?
Soldier Flies	Abundance	Increase	-	> 25	8-24	< 7	Duration
Total Invert	Abundance	Decrease	< 150	150-500	500-1500	> 1500	None*
Total Taxa	Richness	Decrease	< 5	6-11	12-19	> 19	K vs. P?

* May need to incorporate an adjustment based on a dominance type metric?

NEW MODIFIED BUG INDEX FOR LONG DURATION WETLANDS

Table M7. The Modified WWMBI for long duration wetlands, with scores.

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 Macroinvertebrate abundance.

WETLAND = SAMPLE County = Type:	Date sampled: 21 AUGUST 2001 Collected By: R. LILLIE Analyzed: R. LILLIE on 21 Sep 2001			Biotic Index 51
Macroinvertebrate Name	Cells 1-3 (+16?)	Balance (X8 - Extrapolated?)	Sum	Metric Score
Snails (Gastropods)				
Snail-Type 1(Orbs)			39	
Snail-Type 2 (left)				
Snail-Type 3 (right)				
Snail-Type other?				
Clams (Pelecypods)	(20)	→	160	
Mollusks Sum =			199	A 5
Amphipods or Scuds			24	
Isopods or Sowbugs			4	
Springtails (Collembola)				
Spiders (Arachnids)			2	
Mites (Hydracarina)			8	
Worms (Annelids)				A 0
Leeches (Hirudinea)			2	
Fairy Shrimp (Anostraca)				A 1/5 discuss
Clam Shrimp (Conchostraca)			5	
Seed Shrimp (Ostracods)			1	
Other Non-insect Invertebrates				
Non-Insect Taxa			9	R 5
Mayflies (Ephemeroptera)				
Caenidae			43	
Baetidae				
Other mayflies				
Damselflies (Zygoptera)			11	A 3
Coenagrionidae			10	
Lestidae				
Other damselflies			1	
Dragonflies (Anisoptera)				
Aeshnidae			3	
Corduliidae			1	
Libellulidae				
Other dragonflies				
True Bugs (Hemiptera)				
Pigmy backswimmers (Pleidae)			51	A 3
Water boatmen (Corixidae)			15	A 5
Other bug families Notonectidae			1	
Caddisflies (Trichoptera) [2 %?]			16	A+% 3+1
Polycentropodidae				
Phryganeidae				
Limnephilidae			16	A 3
Leptoceridae				
Other families				
Beetles (Coleoptera)				
Crawling Water beetles (Haliplidae)			7	
Predaceous Diving beetles (Dytiscidae)			12	
Water Scavenger beetles (Hydrophilidae)			3	
Marsh beetles (Helodidae or Scirtidae)				
Weevils (Curculionidae)			2	
Other beetle families unidentified			1	
Flies (Diptera)				
Midges (Chironomids)	(27)	→	216	
Biting midges (Ceratapogonids)			4	
Phantom midges (Chaoborids)			33	A 5
Crane flies (Tipulids)				
Mosquitoes (Culicids)				A 0
Soldier Flies (Stratiomyidae)			2	A 5
Other families Muscidae			1	
Other Aquatic Insects				
Aquatic Insect Taxa				
Other Terrest Insects				
Total Invertebrates			667	A 3
Total Taxa			28	R 5

MACROINVERTEBRATE INDENTIFICATION

Taxonomy:

1. Designed for the non-entomologist!
2. Simplified to easily recognizable forms or groups of major organisms.
3. Includes all macroinvertebrates – insects and non-insects.
4. To compute the 15 metrics used in the WWMBI you only need to identify about a dozen important taxa. In addition you need to be able to separate non-insects to order (body form for snails) and insects to family level. Includes adults and larva.
5. Non-insect taxa list includes 14 groups.
6. Insect taxa list includes 23 families (plus miscellaneous families).

Keys to Identification:

1. Wisconsin key to **<u>Aquatic Insects</u>** by Hilsenhoff (1995). $6 each. See key to insect Orders on page 3-4. 'The" key to Wisconsin aquatic insect Genera. Designed for professional entomologist but should get you to the correct family without too much trouble.

2. **<u>Aquatic Entomology</u>** by McCafferty (1998). $55 each. Chapter 6 has key to insect Orders – pages 84-90; Non-insects presented in Chapters 5 and 21-23. Designed for layman (anglers). Easiest keys to use for Order and to insect families.

3. **<u>Aquatic Insects of North America</u>** by Merritt & Cummins (1996). Sorry, not provided!(was $75 per copy). Primary key for aquatic entomologists. Basic key to insect Orders on pages 110-112 may be useful. Many illustrations can help you confirm identifications.

4. **<u>"Key to Life in the Wetland</u>**" is the product of a joint effort between WDNR and UW-Extension. What you are getting is a 'modification' of "Key to Life in the Pond". We have taken some illustrations from other keys to build a key more suitable for use in identifying wetland fauna. Please do not copy or distribute this laminated key. This key is extremely easy to use but still sufficient to get you into the right group of organisms for calculating the biotic index. All of the major non-insect taxa commonly occurring in wetlands are illustrated. The two families of mayflies shown represent the Baetidae and Caenidae. The various families of Odonata (dragonflies and damselflies), Trichoptera (caddisflies), and Coleoptera (beetles) require further illustration (provided later) but several are illustrated in the key. The commonly occurring wetland bugs, including water boatmen (Corixidae) and the tiny pygmy backswimmer (added to the list of leathery winged taxa), are illustrated along with several of the less common water bugs (Order Hemiptera). Please note that the Coleoptera (beetles) are represented by both adult and larval forms (both live in or near the water).

Identifying Damselflies and Dragonflies to Family level

The Odonates are divided into two suborders, the Zygoptera (damselflies) and Anisoptera (dragonflies). This taxonomic division is based primarily on adult features, but luckily the larvae also exhibit clear differences. The damselflies have three broad (side-view) tail filaments referred to as caudal lamellae (Fig 1 bottom), while dragonflies have short stiff pointed valves and cerci (Fig 2 bottom). The tail filaments of the damselflies are fragile and may be missing from your specimens, so in that case you have to go on the basis of general body form. After you have examined a number of representative specimens of both suborders you should not have any difficulty in separating dragonfly nymphs from damselflies.

Among the three families of damselflies found to occur in Wisconsin, two are common in wetlands, namely Coenagrionidae and Lestes. The third, Calopterygidae, is generally confined to stream banks. To separate Coenagrionidae from Lestes, compare the length and shape of the labium (the extendable mouth part that is used to capture prey). The labium in the Coenagrionidae is relatively short and broad, while the labium in Lestes is greatly elongated and narrowed (see Fig 1 top). Of the six families of dragonflies reported for Wisconsin, only three families commonly occur in wetlands. This includes Aeshnidae, Libellulidae, and Corduliidae. Nymphs of the later two families are extremely difficult to separate except when mature. Consequently, it is only necessary to separate out the Aeshnidae. Larvae of Aeshnidae may be separated from the Libellulidae and Corduliidae on the basis of having a flat mentum, while the other two families have a spoon-shaped mentum that wraps upwards covering part of the face (Fig 2 top). A fourth family of Anisoptera, the Gomphidae, also has a flat mentum and may occasionally occur in sandy bottoms of some wetlands. The general body shape of the Aeshnidae differs from that of the other possible wetland Odonates in having an elongated, tubular abdomen (see Figure 2 bottom).

Identifying Limnephilid Caddisflies in Wisconsin Wetlands

Most keys to immature (non-adult) aquatic insects are based on mature larva. Because we are collecting wetland biotic index samples during early spring (April-early May), the caddisfly specimens that we collect may be very small and relatively undeveloped. Consequently they may be difficult if not impossible to correctly identify to the family Limnephilidae (Trichoptera). This is one reason we have retained the otherwise redundant 3 caddisfly metrics in theWWMBI (abundance and percentage total caddisflies and abundance of limnephilids). Caddisflies and limnephilids in particular seem to be more prevalent in least disturbed, wooded, depression type wetlands. Whether the limnephelids are truly dependent on good water quality and low human disturbance or are abundant in primarily wooded wetlands because of the input of coarse woody debris (leaf litter) is uncertain. Most species of limniphilids prepare their protective cases from leaf or plant fragments. The removal of trees or other sources of woody debris related to human disturbance (agriculture production or urbanization) might reduce the supply of woody debris to the wetland and thereby possibly reduce the quality of the habitat for the caddisfly.

Hilsenhoff's Trichoptera key (pages 25-33 in Hilsenhoff 1995 publication) includes many families that do not or occur infrequently in wetlands. The most likely caddisfly families that you might encounter in your wetland samples include: Polycentropodidae, Phryganeidae, Leptoceridae, and Limnephilidae. Of these the Polycentropodidae and Phryganeidae differ from the Leptoceridae and Limnephilidae based on the presence or absence of darkened sclerotized plates on the middle thoracic segment (=mesonotum). The Polycentropodidae have mesonotums that are generally entirely membranous (i.e., lacking sclerotized areas – Figure 1). Six genera of Phryganididae have entirely membranous mesonotums (Figure 2), while a few genera have mesonotums with only very small plates (Figure 3). Limnephilidae and Leptoceridae have mesonotums mostly covered with sclerotized areas (Figure 4). However, one genus of Leptoceridae that may be found in wetlands (*Ceraclea*) has a mesonotum with a pair of very narrow (but distinctive) curved or v-shaped bars on the mesonotum (Figure 5). An additional clue to separating families is the presence or absence of a case. Polycentropodidae do not live in cases. The other three families build and live in cases, but consider the fact that they may crawl outside of their cases when exposed to the preservative. Therefore do not rely on the <u>absence</u> of a case as a means to identify a specimen as a Polycentropodidae. Aside from the relatively distinctive *Ceraclea*, other genera of Leptoceridae may be told apart from Limnephilidae on the basis of the relative length of their antennae (see Figure 6). Unfortunately, examination usually requires a higher power magnification (binocular scope best). The Leptoceridae have long antennae (length > 6 times width, while Limnepilidae have short antennae (< 3 times width). Although not presented in the keys provided, the cases of the mature Leptoceridae larvae are generally narrow, long and skinny relative to Limnephilidae cases, which generally are larger and more robust. Unfortunately, small (young) Limnephilidae larval cases may be very tiny and resemble cases of Leptoceridae. Consequently, you may have to simply lump small cased caddisflies as unknown caddisflies.

Among the other families of caddisflies known to occur in Wisconsin, most are restricted to lotic waters and therefore might turn up in springs, fens, and seeps. A few others might be associated with larger wind-swept shorelines of shallow water marshes. Of these, the most likely one to encounter in wetlands might be the Hydroptilidae (micro-caddisflies), which are very small and often overlooked (see descriptions in Hilsenhoff and McCafferty's publications.

Representative Polycentropodidae
No sclerite on 2nd thoracic segment
And abdominal segment no. 9 entirely membanous
No cases

Representative Phryganeidae
No sclerite on 2nd thoracic segment
And abdominal segment no. 9 with sclerite
Cases may be missing

Alternative Phryganeidae
Pair small sclerites on 2nd thoracic segment

Limnephilidae and Leptoceridae
Large sclerites on 2nd thoracic segment
Cases may be missing
Length and location of antennae important

Alternative form of Leptoceridae (*Ceraclea*)
Pair of dark bars on 2nd thoracic segment

Identifying Beetles in Wisconsin Wetlands

Beetles (both adults and larva) are common inhabitants of Wisconsin wetlands. Beetles often contribute significantly to species richness and are occasionally dominant as a group (Order level). Both adult and larval beetles are relatively difficult to identify to family. Hilsenhoff's keys (pages 44-49 for adults and pages 49-54 larvae) or McCafferty's pictoral keys (pages 208-209 adults and pages 210-211 larvae) are recommended. Adult bugs are occasionally mistaken for adult beetles, but beetles can be told apart by the presence of hardened forewings (called elytra) that meet at the midline of the body. Bugs have leathery wings that overlap near the tips.

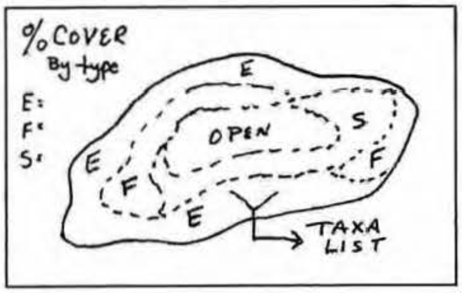
Of the 14 families of aquatic beetles represented in Wisconsin, only seven or eight occur regularly in wetland situations. These include the families Dytiscidae (Predaceous diving beetles), Gyrinidae Whirligig beetles), Haliplidae (Crawling water beetles), Chrysomelidae (Leaf beetles), Curculionidae (Weevils), Hydrophilidae (Water scavenger beetles), and Scirtidae (Marsh beetles). The family Noteridae (Burrowing water beetles) also occurs in wetlands, but specimens are often mistaken for Dytiscids. Another beetle family, the Carabidae (Ground beetles) is not keyed in Hilsenhoff's book, but it does occur in wet-soil conditions. Most of the other families are lotic.

Among the adults, weevils, whirligig beetles, and leaf beetles are relatively distinctive and are easily identified to family. The crawling water beetles have large distinctive plates covering the base (underside) of the abdomen (see illustrations in keys). Separating adult diving beetles from water scavenger beetles is perhaps the most difficult step in identifying water beetles. Following McCafferty's key (page 208), the Dytiscids can be separated from the Hydrophilids on the basis of their streamlined (bullet-shaped) body together with unclubbed antennae. Other Hydrophilids have a body form that is less streamlined with swimming hairs on the hind legs (note, some Dytiscids have swimming hairs but they have very stremalined body form). Also consider that you might have a Noteridae (consult keys).

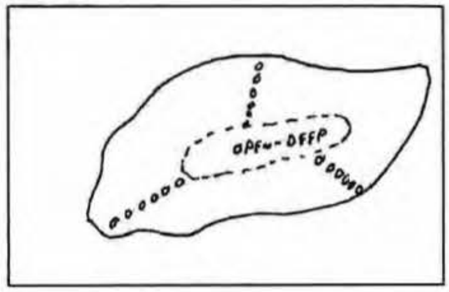
The situation with beetle larvae is even more complicated and is easier to refer directly to the keys provided in the books. Keep in mind that as you become more experienced and acquainted with the larvae, you will recognize certain familes (even genera) on sight and will not have to key everything out. Some larvae are easily recognized, such as the distinctive and somewhat common marsh beetle (Scirtidae) and larval forms of Haliplidae. The common Dytiscids and Hydrophilidae have somewhat distinctive body forms that will become more familiar to you after you have looked at several dozen specimens.

OVERVIEW OF COLLECTING AND PROCESSING PLANT DATA FOR CALCULATING PLANT BIOTIC INDEX SCORES

Field Collections:



General subjective survey



Quantitative transect surveys

Laboratory Processing:

Compute relative importance values for all taxa present in the transect surveys on the basis of relative frequency of occurrence and relative cover. Compute individual metric scores for seven taxonomic groups based on their respective importance values. Compute total taxa metric score based on combination of plants observed in the general survey and transect survey. Compute deep water adjustment metric based on combination of importance value of total pondweeds present in transect surveys and the overall percent cover of floating-leafed vegetation

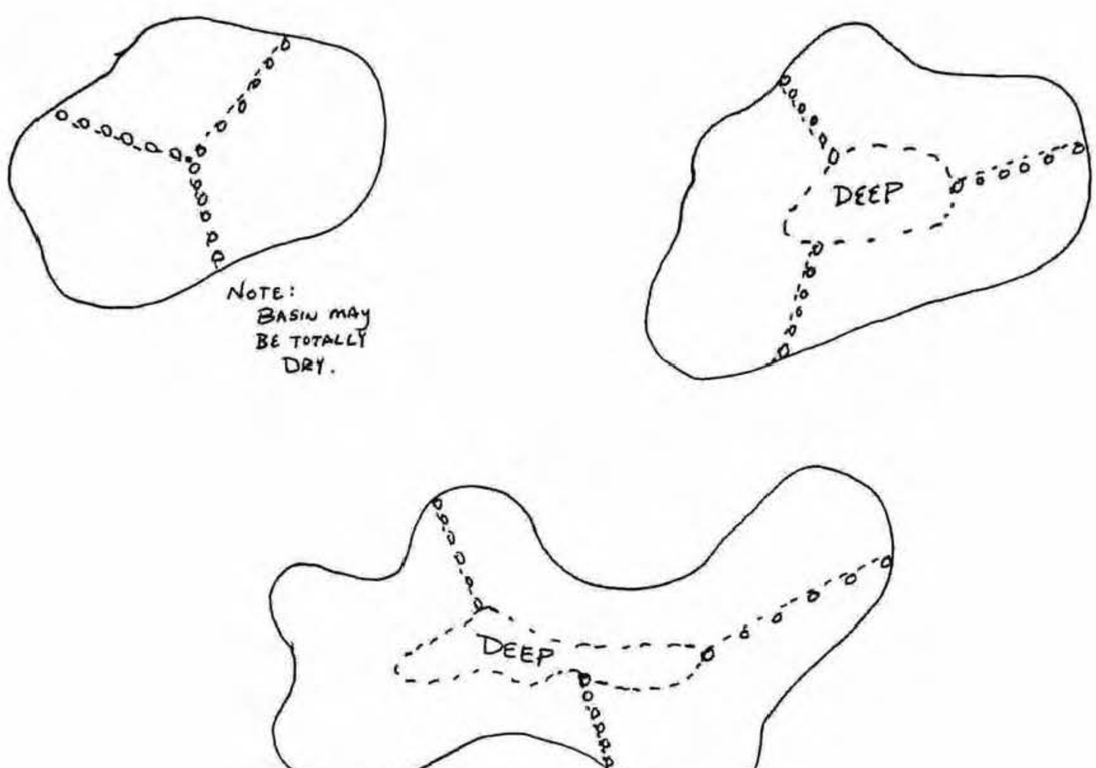
METRICS IN WISCONSIN WETLAND PLANT BIOTIC INDEX (DRAFT VERSION)

- Total Taxa — Count — Decreases with disturbance
- Carex spp. — Importance (Ivs) — Decreases
- Reed Canary Grass — Importance — Increases
- Cat-tails — Importance — Increases
- Duckweeds — Importance — Increases
- Bluejoint Grass — Importance — Decreases
- Good (7 genera) — Importance — Decreases
- --
- Deep water Community adjustment for longer duration basins:
- Pondweeds — Importance — Optimum (peak)
- Floating-leafed — Percent — Decreases

Plant Transect Survey Technique

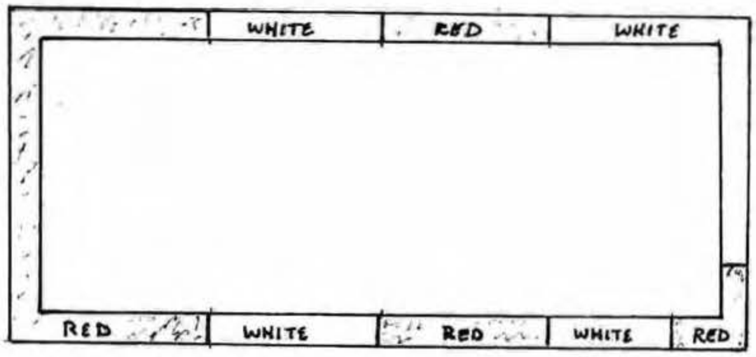
Our survey technique is based on Daubenmire's 1959 paper in the Journal Northwest Science Vol. 33, No. 1, pages 43-64 titled "A canopy-coverage method of vegetational analysis". For those of you interested in the rationale for using a transect technique with a relatively small area sampler, please consult the text of his article. We have modified his technique somewhat (e.g., we use fewer than the recommended number of quadrats) to conserve time.

We calculate relative Importance Values (IVs) as the average of relative frequency occurrence and relative percent cover in eighteeen 20 by 50 cm quadrats. Six quadrats are collected at approximately equa-distantly spaced locations along three transects in each basin. The transects are positioned to roughly trisect the basin from the center of the basin to shore (or if dry, to where the shoreline was during spring snowmelt). In large basins, the transects may be positioned parallel to one another at various intervals such that a particular region of the basin may be examined and evaluated. Uniformally spaced quads ensures gathering samples along the entire depth gradient from shore to about 60 cm (or 2 feet). Three examples of the layout of transects are shown below. Try to position transects through 'typical' areas (i.e., don't intentionally look for rarer plant types). Start at the deep end and eye-ball the position of the remaining 5 quads along the transect line (note – you don't need to use an actual line). By the deep end, we mean the 60 cm depth interval (approximately the maximum wadeable depth). However, in basins with a deep water component, record the visible plant community in that zone also.



CANOPY-COVERAGE (PERCENT COVER) METHOD. Continued.....

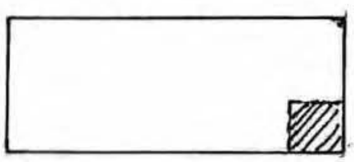
Daubenmire Rectangle 20 by 50 cm inside dimensions.



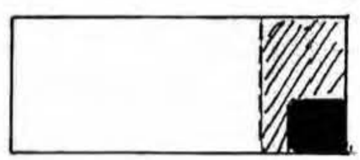
Class Code	Percentage Range covered	Percentage Midpoint
1	**0-5 (≤ 5%)**	**2.5%**
2	**5-25 (≤ 25%)**	**15%**
3	**25-50 (≤ 50%)**	**37.5%**
4	**50-75 (≤ 75%)**	**62.5%**
5	**75-95 (≤ 95%)**	**85%**
6	**95-100 (≤ 100%)**	**97.5%**

Examples:

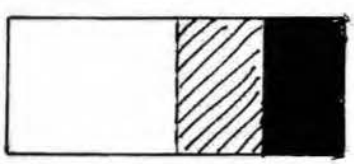
1



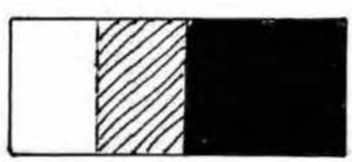
2



2



4



5

6

FIELD SHEETS

Examples shown include a 3-page form. You may wish to design your own form(s), adding or subtracting various data inputs. As a minimum, you should include either GPS coordinates or detailed T-R-Sec-Q/QQ and a map so that people can match up your data with the proper basin in future years. Data recorded on page 3 are essential to compute Importance Values and the plant biotic index scores.

Page 1. General Information – Basin description, location, map (relative to known landmarks such as roads and towns, etc.), riparian cover, plant cover type, bottom composition, and limited water quality characterization.

Page 2. Finer detail map of wetland basin outlining shape, general plant distribution, location of transects. This page is designed to record the overall occurrence of all taxa observed during the course of conducting the evaluation, including taxa observed while conducting the transect surveys and while walking about the perimeter of the basin. This information, supplemented with lab identification of unknown vouchers, can be used to compute Floristic Quality Index values. Space is provided for listing the10 most dominant plant taxa (emergent, submersed, and floating-leafed); additional taxa can be added at the bottom of the page as needed. Unknowns should be described in whatever detail is necessary or accompanied by a sketch such that you can match up the data with voucher specimens in lab. For example, use unknown # 1 (alternate leaves with tiny blue flower or finely dissected submersed # 2 with fan shaped leaflets add sketch). The "Rating" scores for estimating plant dominance refer to overall distribution in the entire basin (or portion being evaluated in the case of very large basins). The numbers 1-6 are highly subjective and may vary from one individual to another. The numbers are not used in the computation of plant biotic index scores, so it is not critical if you should forget to record all numbers. It is more important to record the presence of all taxa in the basin (without spending an inordinant amount of time doing so). The 'dominance' data recorded on this page are of historical value and will be valuable for monitoring changes in basin plant community composition over time. The data represent a very coarse 'snapshot' of the overall plant community. For guidance, reserve the use of 5s and 6s for those cases where a taxon or taxa (5s) are obviously the dominant plants in the basin and cover more than 50% of the total available vegetated area. In situations where the total plant cover in a basin may be relatively sparse and yet a particular taxon (or taxa) may clearly be dominant, I would recommend classifying those taxa as only abundant (4) or common (3) – unvegetated areas would actually represent the 'dominant'. 'Rare' (1) would represent those taxa that only appear at one or two locations in the basin (generally not found in the transects). "Occasional' (2) would represent taxa that appear more frequently (may be absent from transect quads) but are not altogether common. 'Common' (3) refers to taxa that appear relatively frequently (or may be somewhat abundant in a very small area of the basin) throughout the vegetated area of the basin, but never make a major contribution to the total abundance in the basin. 'Abundant' (4) refers to those taxa that may compete with the dominant taxa on occasion, but overall are 'secondary' plants that are generally numerous and important throughout the basin.

Page 3. Plant Transect Data form. This form is used to record taxa occurrence and percent cover among the 18 quadrats along the 3 transects for each basin. The resulting data are used to compute importance values that are the basis for assigning plant biotic index scores. Water depths are recorded at each site (up to 60 cm or about 2 feet maximum). Depth is not critical to record, so it is all right if you forget to bring a meter or yard stick. The method of estimating percent cover will be presented separately. The data for taxa beyond the wadeable depth (i.e., 'deep') is usually ignored in computing importance values in most basins. However, if the basin has experienced a recent and substantial rise in water level, the data from the 'deep' stations may be incorporated into the calculation. Irrespective of whether a basin has undergone a recent increase in water level, the taxa present in the 'deep' stations would be used in the FQI (?).

FIELD SHEET - WETLAND BIOTIC INDEX STUDY - WDNR (1998)
(Lillie, revised 7-6-1998 in pondfs.wpp)
{If Found, Please return to R. LILLIE, RESEARCH, 1350 FEMRITE DRIVE, MONONA, WI 53716; phone 608-221-6338}

Wetland Name SAMPLE Code (W1, L1, B1, etc.) L-105

County COLUMBIA Date: 21 AUG 2001 Time: 1200

Lat. 43 o 27 ' 015 " Lg. 89 o 60 ' 00 " or TN 9N RG 7E Sec 27 Qtr/qtr NE/NW

Collections By R. LILLIE

Field Measurements:
Air Temp (F/C) 85
Water Temp (F/C) 20
Clarity (in./cm) TO BOTTOM
Mx. Depth (in./cm) 40
☐ algal bloom? NONE
☐ duckweed abundant? <5 %
duckweed sp. ______
☑ **Photograph taken?**

Apparent Color Code
☐ Dark-stain
☑ Light-stain
☐ Turbid/brn
☐ Turbid/grn
☐ Clear-green
☐ Clear-blue

Biological Samples:
☐ Zooplankton collected?
☐ Diatoms (summer: sediments)?
☑ Plants (vouchers collected?)

Field Assessment Forms:
☐ Rapid Assessment Form? — No —

Description:

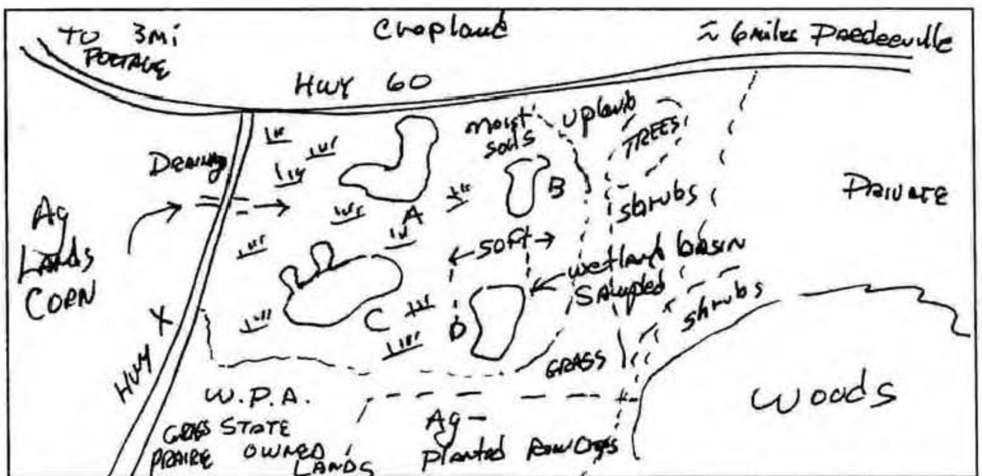


Figure 1 General cover map and shoreline details

Shade Cover % 0
100 ft buffer zone
Riparian Cover
0 % Woods
15 % Shrubs
25 % Grassland
60 % Wetland
__ % Urban
10 % Agriculture

General Measurements:
Cover by Type
15 % Emergents
50 % Submergents
75 % Floating-leaf
25 % Open water
Dominant Bottom Type
Peaty, Organic, Roots,
(Mud), silt-sand, Leafpack
Other: ______

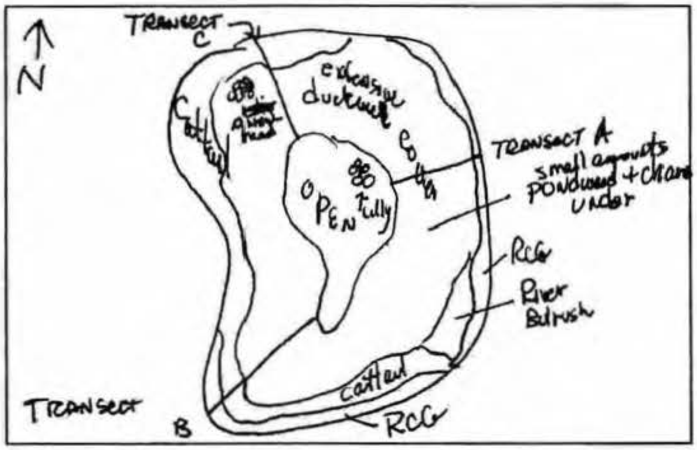
Wildlife observations:

Other Notes:
LOTS B.W. Teal
Turtles, Frogs
No direct runoff From Ag-Field to South due to berm. Some shade in early morning. (mature ...

FIELD SHEET – WETLAND BIOTIC INDEX – PLANT SURVEYS PAGE 2

Basin Name SAMPLE Code L105 County COLUMBIA
Date 21 AUG 2001 Collected By: R. LILLIE

Map sketch: (Include location of transects)



Dominance Codes:

1 = Rare

2 = Occassional

3 = Common

4 = Abundant

5 = Co-dominant

6 = Clearly Dominant

Plant Taxa Lists:

Emergents CODE – Taxon Name	Submergents CODE – Taxon Name	Floating-leafed CODE – Taxon Name
4 (1) Cat-tails	3 (1) unident. narrow-leafed Pondweed	6 (1) Lemna minor
4 (2) R.C.Grass	4 (2) Chara	2 (2) Lemna trisulca
3 (3) River Bulrush	2 (3) bladderwort (yellow)	1 (3) white water lilly
1 (4) Bluejoint	(4)	2 (4) wolffia
2 (5) arrowhead	(5)	(5)
1 (6) spikerush	(6)	(6)
2 (7) rice-cut grass	(7)	(7)
1 (8) unknown alt. leave	(8)	(8)
(9)	(9)	(9)
(10)	(10)	(10)
(11)	(11)	(11)
(12)	(12)	(12)
(13)	(13)	(13)
(14)	(14)	(14)
(15)	(15)	(15)
(16)	(16)	(16)
(17)	(17)	(17)
(18)	(18)	(18)
(19)	(19)	(19)
(20)	(20)	(20)

Describe Unknowns by leaf form, leaf orientation, size, flower color, and collect voucher for later identification.

FIELD SHEET – WETLAND BIOTIC INDEX

PLANT TRANSECT DATA (Revised 08/08/01) Page 3 of 3

Basin Name SAMPLE Code L105 County COLUMBIA

Location TRI-TRANSECTS Date 21 AUG 2001 Collected By: R. LILLIE

Percent Cover Codes: (1) = 0-5%; (2) = 5-25%; (3) = 25-50%; (4) = 50-75%; (5) = 75-95%; (6) = 95-100%

	Transect One							Transect Two							Transect Three						
Taxa List	A1	A2	A3	A4	A5	A6	AD	B1	B2	B3	B4	B5	B6	BD	C1	C2	C3	C4	C5	C6	CD
Depth (cm)	3	11	21	29	38	57	>60	5	15	20	31	47	58	>60	6	12	23	30	41	52	>60
Cattail	6	6	2	·	·	·	·	2	6	·	·	·	·	·	1	6	·	·	·	·	·
RC GRASS	·	2	·	·	·	·	·	6	1	·	·	·	·	·	6	·	·	·	·	·	·
UNKNOWN GRASS	3	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Spikerush	2	·	·	·	·	·	·	3	·	·	·	·	·	·	1	·	·	·	·	·	·
Arrowhead	·	2	1	·	·	·	·	·	·	·	·	·	·	·	·	3	·	·	·	·	·
(Galium?) Unidentified Alt-leafed forb	1	·	·	·	·	·	·	2	·	·	·	·	·	·	·	·	·	·	·	·	·
Unid. narrow-leaf pondweed	·	·	3	3	4	3	·	·	·	1	1	3	4	·	·	·	·	2	3	1	·
Chara	·	·	1	4	4	1	·	·	·	2	1	3	4	·	·	·	·	·	1	4	·
bladderwort	·	2	1	·	·	·	·	·	·	1	·	1	·	·	·	·	1	·	·	·	·
lesser duckweed	·	1	3	·	6	6	·	·	2	3	6	6	6	·	·	2	1	6	5	4	·
wolfia	·	2	·	·	·	·	·	·	1	·	·	·	1	·	·	1	·	·	·	·	·
white water lily (Note: deep H2O only)	·	·	·	·	·	·	2	·	·	·	·	·	·	1	·	·	·	·	·	·	·

CONTINUED ? [ ] Yes, see next sheet.

CALCULATING PLANT IMPORTANCE VALUES

The Plant Biotic Index consists of nine metrics, including one taxa richness, one percent cover, and seven metrics based on importance values. What are and how do you calculate importance values (Ivs)? Importance values (as we have defined them here) represent the relative importance of a taxon's contribution to the total plant community (as surveyed) based on each plant's frequency of occurrence and percent cover. Other botanists may also pay attention to stem densities or biomass, but for sake of ease in computing a relative importance value, we have stuck with occurrence and cover.

The following steps are based on the data gathered in the transect surveys (18 quadrats).
{Note: an Excel spreadsheet is available to perform these calculations if you have many wetland basins to examine}.

Step 1 – Calculate Absolute Frequency of Occurrence for each taxon as:

Absolute Frequency = # Quads taxon is present ÷ 18

Step 2 – Calculate Relative Frequency for each taxon as:

Relative Frequency = Absolute Freq. of taxon ÷ (Σ all Absolute Frequencies).

Step 3 – Calculate Total Cover for each taxon in all 18 quads:

Total Cover each taxa = Σ percent cover taxon in **1**-18 quadrats.

Step 4 – Calculate Absolute Cover as:

Absolute Cover = Total Cover each taxon ÷ (1800% {Total Cover in 18 quads})

Step 5 – Calculate Relative Cover as:

Relative Cover = Absolute Cover each taxon ÷ (Σ Absolute cover all taxa)

Step 6 – Calculate Relative Importance Value as:

IV each taxon = (Relative Frequency + Relative Cover) ÷ 2

Go to next sheet >>>>>>>>>>>>>>>>>>>>>>>>>>>

CALCULATING PLANT BIOTIC INDEX SCORES

The following steps require input data from transect survey field sheets (i.e., taxon richness, and Importance Values) and the General Field form (overall percent coverage for Floating-leafed plants).

Step 1 – Total Taxa Metric (Richness or the number of different taxa present; taxa not necessarily identified to species or even to genera in some cases). Tally all taxa on transect survey form and supplement with any additional taxa among the emergent, submergent, and floating-leafed taxa on page two of field forms. Refer to Scoring System sheet to assign scores based on the total richness.

Total ___ Score = ___

Step 2 – Relative Importance Values. (see previous sheet for instructions on how to calculate Ivs). It is essential to compute the relative frequency of occurrence and relative cover for all taxa.

	IV	Score =
Record Ivs for Carex spp.	___	___
RC-grass	___*	___*
Cat-tail	___*	___*
Duckweeds	___	___
Bluejoint grass	___	___
"Good" taxa list	___	___

and Pondweeds Ivs = ___ (use below in step 3)

Step 3 – Water Duration Adjustment. The plant biotic index has an inherent bias favoring (produces higher scores) shorter duration basins with more complex plant communities. To compensate for this bias, two additional metrics are examined that account for plant structure in basins of long water duration (i.e., basins with water persistence that borders on permanent – public waterbodies or lakes). This includes a metric based on the total percent cover of floating-leafed forms (from page 1 estimates of the entire basin) and the IV of all pondweeds (generally restricted to long duration basins). Note: the average of these two scores is applied, not both.

Percent (%) of floating-leafed plants ___% Score = ___

Pondweed Ivs from transect surveys ___ Score = ___

Average the two scores to derive the final deep-water adjustment = ____
(Note: some number between 1 – 5)

Step 4 – Calculate the Final Plant Biotic Index as the Sum of the scores in steps 1-3 = [ ]

* If total taxa count ≤ '1' and no emergents are present (or consists only of one annual) a 'zero' scores as '0' points rather than '5'. This modification is intended to account for the situation where the basin is in such sad shape that not even RCG or Cat-tail can get a foothold.

EXAMPLE OF CALCULATING IMPORTANCE VALUES

Basin 'Sample'

Taxon	Quad 1	Quad 2	Quad 3	Quad 4	Quad 5	Quad 6	Quad 7	Quad 8	Quad 9	Quad 10	Quad 11	Quad 12	Quad 13	Quad 14	Quad 15	Quad 16	Quad 17	Quad 18	Freq. Occ.	Total Cover *
Taxon A	6	3	1	0	3	6	5	2	1	0	0	2	4	4	1	0	0	3	13	550
Taxon B	3	1	1	0	1	1	0	0	3	0	1	3	1	0	0	0	0	0	9	127
Taxon C	0	2	5	2	0	0	0	0	3	2	3	0	0	0	6	4	0	0	8	365
Taxon D	2	1	0	0	1	2	2	1	0	0	0	1	1	0	0	0	5	5	0	142
Taxon E	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	5

- Based on the sum of Daubenmire's midpoint percentage values for recorded values 1-6, where for example a '3' represents 37.5% and a '6' represents 97.5%. This is where an Excel computer spreadsheet comes in handy to automatically convert your data input values (i.e., 1-6) into the proper percentage values that they represent prior to making the calculation.

The computed data are shown in the following table:

Taxon List	Absolute Frequency	Relative Frequency	Total Cover	Absolute Cover	Relative Cover	Importance Values
Taxon A	0.722	0.317	550	0.308	0.464	0.391
Taxon B	0.500	0.220	127	0.071	0.107	0.164
Taxon C	0.444	0.195	365	0.203	0.306	0.251
Taxon D	0.500	0.220	142	0.079	0.119	0.170
Taxon E	0.111	0.049	5	0.003	0.005	0.027
Sums	2.277	1.001**	1189	0.664	1.001**	1.003**

** these sums, which should approximate 1.00, should be performed as a check on your math. The small differences in this example represent inconsequential rounding errors.

If, in the above example, taxon A = Carex, taxon B = Cat-tail, taxon C = pondweeds, taxon D = duckweeds, and taxon E = arrowhead, and there were six additional taxa outside the transect quads, and total floating-leafed cover was 10%, then the Plant Biotic Index for the basin would be:

Total Taxa Metric = 5 + 6 =11 with a score of **3**; Carex IV of 0.391 scores '**5**'; RC-grass absent scores '**5**'; Cat-tail IV of 0.164 scores '**1**'; Duckweeds IV of 0.170 scores '**3**'; Bluejoint-grass absent scores as '**1**'; the "Good" taxa metric IV including the combined Ivs of Carex, Potamogeton, and Arrowhead equals 0.669 which scores as '**5**'; and the deep water adjustment metric would include pondweeds IV of 0.251 and percent floating-leafed value of less than 10% which would score as (5+3)/2 = **4**. The sum of all scores produces a biotic index score of **27**, which would result in a **VERY GOOD** rating.

Lillie Wetland Biotic Index Study

METRICS SCORES FOR THE WETLAND PLANT BIOTIC INDEX

Taxon	Attribute	Response	Score=0	Score=1	Score=3	Score=5	Adjustments
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	None
Reed Canary Grass	IV	Increase	> 0.5	> 0.05 - 0.5	> 0 - 0.05	0*	None
Cat-tail	IV	Increase	> 0.25	0.03 - 0.25	> 0 – 0.03	0*	None
Duckweed	IV	Increase	> 0.6	0.2 – 0.6	> 0 – 0.2	0	None
Bluejoint Grass	IV	Decrease	-	0	> 0 – 0.05	> 0.05	None
Good* Taxa	IV	Decrease	0	> 0 – 0.3	0.3 – 0.6	> 0.6	None

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	Adjustments
Pondweeds	IV	Optimum	-	0	➢ 0 - 0.12 ➢ and > 0.4	0.12 – 0.4	None
Floating-leaf	Percent	Decrease	-	0	> 0 – 0.3	> 0.3	None

- * **"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!

Appendix 2.

Refresher Training Manual with Field and Laboratory Instructions

Welcome to Wetland IBI Training

Please:

- Close all other applications on your computer, including email
- Mute phone when not speaking
- Ask questions as they arise
- Identify yourself by first name and location when you have a question
- Wait until end of session to print out slides with annotations

OVERVIEW OF PRESENTATION

- Objective: Present step-by-step procedure to collect, analyze, compute, and interpret wetland biotic indices.
- Part I: What, Where, When, and How to collect and process plant and bug samples and data.
- Part II: Bug Taxonomic Identification refresher & tips
- Part III: Field Level Plant Identification
- Part IV: Floristic Quality Index considerations - vouchers
- Part V: Discussion & Wrap-up.

WHERE?

- Types of Wetlands
  - Palustrine, depression, long-short temporary, seasonal, semi-permanent, and permanent without fish
  - Do not sample bogs, fens, seeps, springs, lacustrine, riverine, or wet-soils wetlands.

WHAT?

- BUGS
- PLANTS
- OTHER

WHEN?

- BUGS
  - Late April-early May
  - (minimizes emigration & immigration)

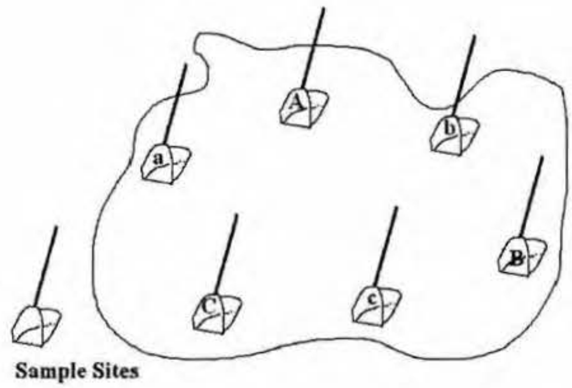
  - PLANTS
  - Late July-August
  - (easier ID, seeds, etc.)

HOW?

- BUGS
  - Collection design
  - Field sweeps
  - Lab Processing
  - Identification
  - Index calculations
  - Interpretation
- PLANTS
  - Collection design
  - Transect quadrats
  - Field Identifications
  - Data recording
  - Calculating Ivs
  - Index calculations
  - Interpretation

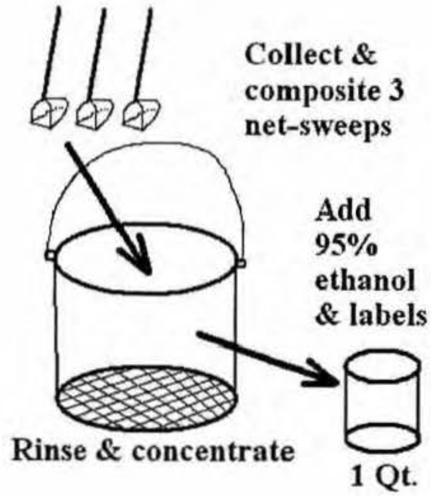
BUGS:
Where to sample within wetlands

- Sampling layouts
  - trisection
  - wadable
  - special this spring



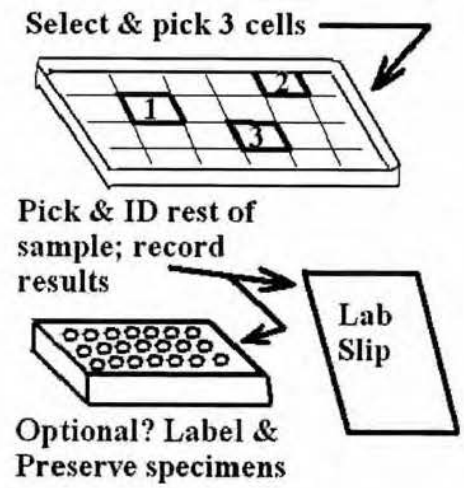
BUGS: Field collecting

- 3 net-sweeps 1m
- sieve & composite
- compact to 1 Quart
- Label inside & out
- Ethanol or isopropyl
- {Paired sampling this spring}
- Send 1 set to Madison



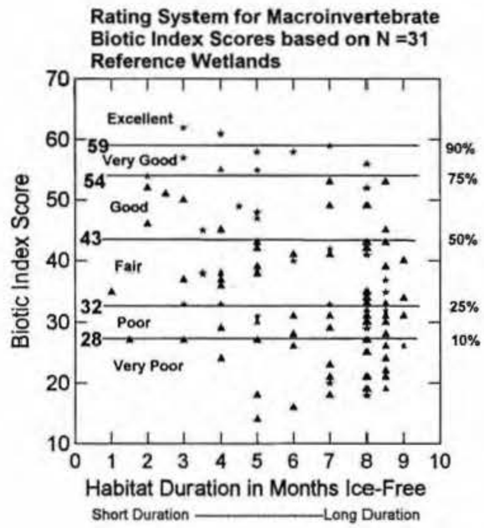
BUGS: Labwork

- Tray:Rinse & spread
- 3 random cells
- Pick & ID
- Rest of sample -
- labeling (options?)
- Lab sheet instructions
- Tallies



BUG INDEX CALCULATION

- Lab slip tallies
- Metric scoring table
- Record metric scores
- Hydroperiod Adjustments
- Sum for Final Index
- Classify?



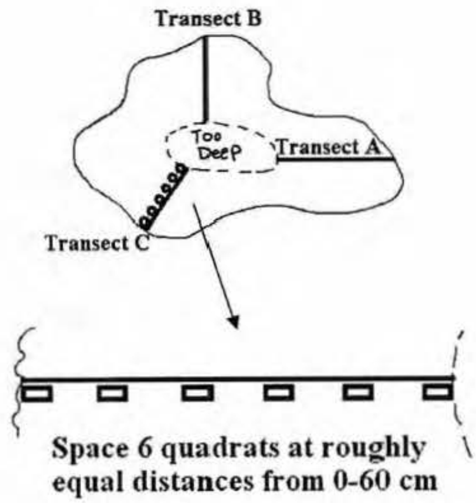
METRICS SCORES FOR THE WETLAND MACROINVERTEBRATE INDEX

Taxon	Attribute	Response	Score=0	Score=1	Score=3	Score=5	Adjustments
Mollusks	Abundance	Decrease	0	1-10	11-99	>99	None
Annelids	Abundance	Decrease	-	0-10	11-25	>25	None
Fairy Shrimp	Abundance	Decrease	-	0-8	9-25	>25	Duration
Non-Insects	Richness	Decrease	0	1-2	3-5	>5	Prairies?
Damselflies	Abundance	Decrease	0	1-2	3-15	> 15	Kettles?
Pigmy B.S.	Abundance	Increase	0	1-2 & >100	3-5 & 11-99	6-10	Duration
Boatmen	Abundance	Decrease	0	1-4	5-10	> 10	None
Limnephilid	Abundance	Decrease	0	1-10	11-50	> 50	?
Caddisflies	Abundance	Decrease	0	1-10	11-60	> 60	Duration?
Caddisflies	Percentage	Decrease	0	< 8%	8-15%	> 15%	Redundant?
Phantom M.	Abundance	Decrease	0	1-8	9-25	> 25	Duration
Mosquitoes	Abundance	Decrease	0	1-10	11-99	>100	Duration?
Soldier Flies	Abundance	Increase	-	> 25	8-24	< 7	Duration
Total Invert	Abundance	Decrease	< 150	150-500	500-1500	> 1500	None*
Total Taxa	Richness	Decrease	< 5	6-11	12-19	> 19	K vs. P?

* May need to incorporate an adjustment based on a dominance type metric?

PLANTS: Layouts

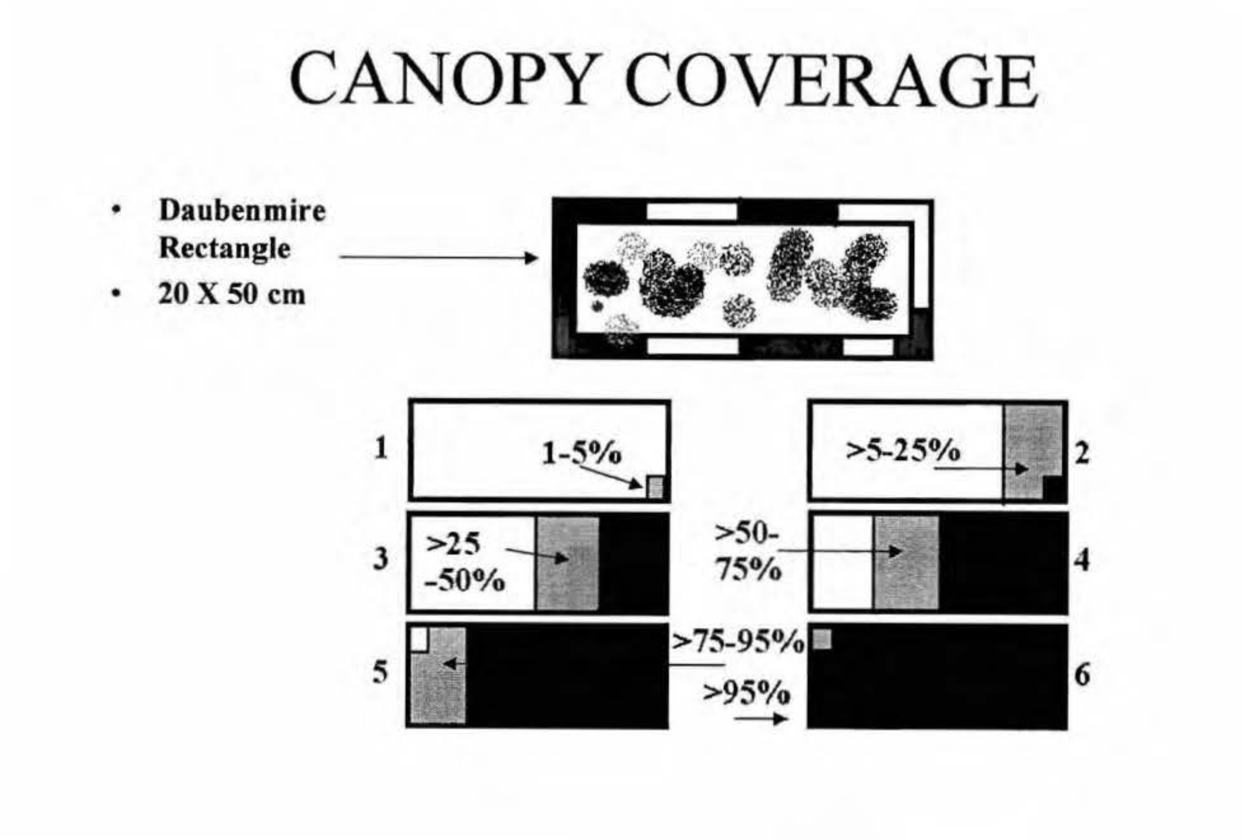
- Trisection or other
- 60 cm cutoff
- Transects - position of six quadrats



PLANTS:Fieldwork

- General cover type
- Plant dominants
- Transects
  - Depth (?)
  - Plant ID taxonomy
  - Occurrence
  - Percent Cover
  - Unknowns/vouchers

- **Dominance Codes:**
- **1 = Rare**
- **2 = Occasional**
- **3 = Common**
- **4 = Abundant**
- **5 = Co-dominant**
- **6 = Clearly Dominant**


CANOPY COVERAGE
• Daubenmire Rectangle
• 20 X 50 cm
1
1-5%
>5-25%
2
3
>25 -50%
>50- 75%
4
5
>75-95%
>95%
6

PLANT: Importance Values

- Manual
  - Absolute freq & cover
  - Relative freq & cover
  - Avg = IV
- Excel Spreadsheet
  - Data entry
  - Output columns
  - Sample

SAMPLE IV CALCULATION

- ***STEPS***
- **Absolute frequency**
- **Relative frequency**
- **Absolute cover**
- **Relative cover**
- **Importance Values**

FIELD SHEET – WETLAND BIOTIC INDEX
PLANT TRANSECT DATA (Revised 08/08/01) Page 3 of 3

Basin Name _Example Short__Code __SP1__ County: North___

Location _TN-RG-Sec_Date _April 15, 2002 Collected By: S.A.L.

Percent Cover Codes: (1) = 0-5%; (2) = 5-25%; (3) = 25-50%; (4) = 50-75%; (5) = 75-95%; (6) = 95-100%

			Transect One………………			
Taxa List	A1	A2	A3	A4	A5	A6
Depth (cm)	7	14	25	31	43	58
Pondweed	__	__	1	4	6	6
Carex sp	6	3	__	__	__	__
Smartweed	2	1	__	__	__	__
Duckweed	6	6	4	3	1	

Lillie Wetland Biotic Index Study

METRICS SCORES FOR THE WETLAND PLANT BIOTIC INDEX

Taxon	Attribute	Response	Score=0	Score=1	Score=3	Score=5	Adjustments
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	None
Reed Canary Grass	IV	Increase	> 0.5	> 0.05 - 0.5	> 0 - 0.05	0*	None
Cat-tail	IV	Increase	> 0.25	0.03 - 0.25	> 0 – 0.03	0*	None
Duckweed	IV	Increase	> 0.6	0.2 – 0.6	> 0 – 0.2	0	None
Bluejoint Grass	IV	Decrease	-	0	> 0 – 0.05	> 0.05	None
Good* Taxa	IV	Decrease	0	> 0 – 0.3	0.3 – 0.6	> 0.6	None

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	Adjustments
Pondweeds	IV	Optimum	-	0	>0 - 0.12 and > 0.4	0.12 – 0.4	None
Floating-leaf	Percent	Decrease	-	0	> 0 – 0.3	> 0.3	None

- * **"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!

PLANTS: Index calculation

- Score metrics (Table)
- Compute PBI
- Classify & Interpret

- Note: Comparisons with Bug Biotic Index -- need not agree!!
- (different responses)

BUG IDENTIFICATIONS

10 Taxa you need to recognize

- NON-INSECTS
- Snails & Clams
- Worms
- Fairy Shrimp

- INSECTS
- Damselflies
- Pigmy Backswimmers
- Water Boatmen
- Caddisflies (Limnephilids)
- Phantom Midges
- Mosquitoes
- Soldier Flies

Odonata:Zygoptera =Damselflies

- Extendable mouth-parts for grasping prey
- 3 caudal lamellae (tail parts)
- generally long, slim, skinny compared with dragonflies
- Two common families separated by shape of labium (mouthpart)

ODONATES: Family Level I.D.s

- **Use length & shape of labium (extendable mouthpart) --**
  - **Damselflies Lestes vs. Coenagrionidae**
  - **Dragonflies - 3 common families, Aeshnids (flat labium) vs. Cordulids and Libellulids (spoon-shaped labium)**

Note: ID of genera difficult in early spring because larvae generally not well developed.

Pigmy Backswimmers

- **Tiny - 3 mm range**
- **Legs folded, not visible**
- **Color varied from cream or tan to dark black**
- **Easily mistaken for plant seeds**
- **This is a smaller cousin of the larger backswimmers or Notonectids - both are Hemipterans or true bugs**
- **Common in weed beds**

CORIXIDAE: Water Boatmen

- **Fast swimmers, ranging in size from 6 to 15 mm.**
- **9 genera in Wisconsin, difficult to separate (Hesperocorixa large, other taxa smaller.**
- **Active fliers**
- **Easy to I.D. as a group.**
- **3 genera common throughout state.**
- **Most taxa are herbivorous, but prey on small animals.**
- **Increased abundance in moderately disturbed wetlands.**

TRICHOPTERA: = Caddisflies

- **Adults moth-like in appearance**
- **Larva with or without cases**
- **Long fleshy body with 3 pairs thoracic legs; often with stringy thread-like gills on abdomen**
- **Of 19 families in WI, only expect 4-5 typically in wetlands**
- **Combination of presence of scleritized plates on dorsum of thoracic segments characteristic**
- **Small size of larvae in spring makes ID difficult!**

Caddisflies Part 2 - Family ID

- **Hydroptilids - very tiny < 5 mm in purse-like cases**
- **See key McCafferty pg 242-43**

  Dorsal segment 2 with well developed plates?
  - **No - then Phryganeidae or Polycentropodidae (no cases)**
  - **Yes - then Limnephilidae or Leptoceridae (next slide)**

  Abdominal segment 1 humped with striped head?
  - **Yes - Phryganeidae**
  - **No - Polycentropodidae (also has curved body with anal prolegs**

Caddisflies Part 3 - Family ID

- **Limnephilidae and Leptoceridae have well developed plates on thoracic segment 2**
- **2nd thoracic segment with pair of distinctive dark bars?**
  - **Yes - Leptoceridae (1 genus)**
  - **No - continue…**
- **Long antenna (hard to see)?**
  - **Yes - Leptoceridae (7 genera)**
  - **No - continue**
- **Dorsal spacing tubercule on abdominal segment 1 with cases of vegetation?**
  - **Yes - Limnephilidae (several genera)**
  - **No - other families?**

DIPTERA: Chaoboridae = Phantom Midges

- **10-15 mm, thin, semi-transparent bodies**
- **Distinctive prehensile antenna**
- **3 genera easily separated by key**
- **Occurrence sensitive to fish predation; widespread**
- **Chaobrids are important predators of zooplankton**
- **More active at night**
- **Pupae! Differ from mosquitoes by having pointed respiratory horn (see also midge pupa).**

DIPTERA: CULICIDAE = Mosquitoes

- **Thoracic segments fused, bulbous, distinctive head**
- **Common everywhere without fish**
- **9 genera difficult to separate without key (don't?)**
- **Look-alike Dixid midges relatively rare and have prolegs on 1st 2 abdominal segments**
- **2 genera overwinter as larvae, but other genera exhibit fast development following spring snow-melt**
- **Pupa! See open respiratory horn**

DIPTERA: Stratiomyidae = Soldier Flies

- **Straight dark body with distinctive truncate head, no legs**
- **Usually last segment with dense plumose coronet**
- **9 genera but too difficult to try to separate (lump)**
- **larva crawl about just under the water's surface**
- **Tend to be associated with lots of aquatic vegetation**
- **Sizes vary from less than 5 mm to large, over 20 mm or more**

MOLLUSKS

Includes Gastropods and Pelecypods (Snails, bivalves or clams, including fingernail clams)

- **Small sphaerids may be mistaken for clam shrimp -see clam shrimp**
- **Three (4th possible) morphs of snails used (more possible within morphs)**
  - **shell opening to right**
  - **shell opening to left**
  - **shell coiled, flat (orbs)**
- **See Thorp & Covich's book for additional illustrations and key**
- **record all taxa found**

WORMS?: Includes earthworms, large oligochaetes, nematodes (Nematoda), and flatworms (Turbellaria)

- **Hodgepodge of non-insect phyla**
- **Any worm-like organism other than leeches**
- **Never very common in samples, but tend to be associated with undisturbed wetlands with plenty of organic substrates**

Non-Cladoceran Branchipods (Anostraca = Fairy Shrimp)

- **Generally limited to fishless ponds with short hydroperiods**
- **Rapid development in spring results in variation in sizes from 7-100 mm**
- **Distinctive pair of bulbous eyes**
- **11-19 pairs of thoracic legs**
- **Swims with legs up**
- **Demonstrates tolerance to salinity (some taxa); generally tolerant to low DO**
- **Key by Dodson & Frey in Thorp & Covich book**

Other Common Non-Insects

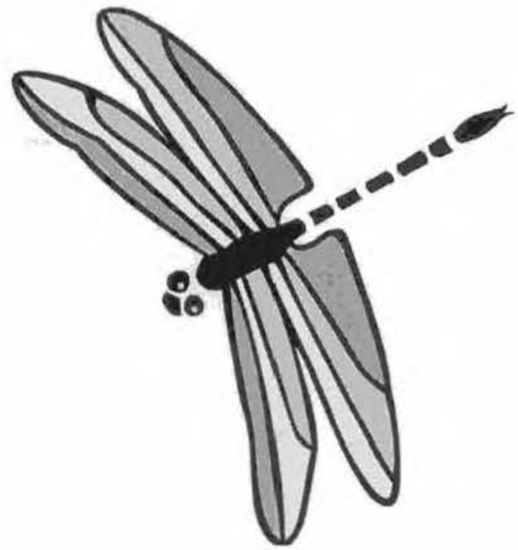
- **Amphipods**
  (Scuds)
- **Isopods**
  (Sowbugs)
- **Hydracarina**
  (Mites)
- **Collembola**
  (Springtails)

Clam Shrimp (Conchostraca) & Seed Shrimp (Ostracoda)

- **Seed Shrimp**
  - **very tiny, < 1.5 mm**
  - **some colored blue**
- **Clam Shrimp**
  - **1-4 mm**
  - **appear round like eggs**
  - **Compare with clams**

OTHER IMPORTANT AQUATIC INSECTS

- Mayflies
- Dragonflies
- Beetles
  - Primarily 5 families
- Common Midges
- Biting Midges
- Crane Flies



EPHEMEROPTERA = Mayflies

- **Most have three tails**
- **Only 2-3 families common in wetlands**
- **Caenid (squarebacks) small, 5-15 mm - very common amongst plants**
- **Baetidae (Callibaetis) some able to stand drought.**

Odonates: Anisoptera = Dragonflies

- **Generally larger more robust than damselflies**
- **Different terminal appendages**

DIPTERA: Others including Midges

- **Common midges (Chironomidae) are among the most abundant organisms occurring in wetlands**
  - **Note: proleg and shape; many different sizes.**

    Often concealed within tubes constructed of organic detritus

- **Biting midges (Ceratopogonidae)**
  - **Generally long, thin, pencil shaped**
  - **swim in snake-like motion**
  - **less common than common midges, easily overlooked**

Other Hemiptera (Bugs)

- **Many are semi-aquatic forms**
- **Fast swimmers or skaters**
- **Not shown are:**
  - **water scorpions**
  - **creeping water bugs**
  - **giant water bugs**
  - **shore bugs**
  - **short-legged striders**
  - **marsh treaders**
  - **velvet water bugs**
  - **water treaders**
  - **others**

COLEOPTERA: = Beetles (Larvae & Adults)

- **Beetle Larvae**
  - **variety shapes & sizes**
  - **many predators**
- **Aquatic Beetle adult forms**
  - **body shape**
  - **mobility (live)**
  - **See McCafferty's key pg 208-209**

Thanks for attending

Good Luck with Sampling!

Send in your site maps and driving directions to Tom Bernthal

berntt@dnr.state.wi.us
608-266-3033

Appendix 3.

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

Floristic Quality Assessment of 17 Wetland Sites in Wisconsin

28 August 2002

A report from:

Emmet J. Judziewicz
True Heritage Botanical Services
1180 Dodds Drive, Apt. 4
Plover, WI 54467

To:

Thomas Bernthal
Bureau of Fisheries Management and Habitat Protection
Wisconsin Department of Natural Resources
Madison, WI 53706

POLK COUNTY: Standing Cedars Wetlands.

Location: T32N-R19W, Sec. 29, on west side of 280th Street about 2 miles north of the St. Croix County line. GPS location: 45°14’26”N, 92°44’21”W.

Surveys: 4 July 2002 (35 minutes), 14 August 2002 (25 minutes plus 15 minutes for Wetland Biotic Index sampling).

Size of site: about 100 x 60 meters (0.45 ha).

Context of site: Within a matrix of old and currently used agricultural land to the east (on level terrain), and rugged oak forest along and within coulees of the St. Croix River to the west.

Description of site: Open natural glacial pothole wetland. Immediately surrounded by disturbed second-growth forest of willow, box elder, green ash, cottonwood, and prickly ash. The site was probably utilized by livestock sometime in the past. Standing water was present on both visits (decreasing from about 60% to 50% of the total area). The dominant plant species surrounding the pond was reed canary grass (*Phalaris arundinacea*). Emergents aquatic macrophytes included *Sagittaria graminea* and *Schoenoplectus acutus*. Common duckweed (*Lemna turionifera*) was a dominant floating aquatic.

Survey results: The surveys found 20 native species and an FQI of 17.2. The August visit increased the FQI by 1.0. The very low FQI is typical of a small natural pond with a history of “grazing” and massive invasion by reed canary grass.

POLK COUNTY: WPA (Waterfowl Production Area) Wetlands.

Location: T32N-R17W, Sec. 33, on south side of County Hwy. A, 0.2 miles east of its junction with County Hwy. CC. GPS location: 45°13’26”N, 92°28’32”W.

Surveys: 4 July 2002 (45 minutes), 14 August 2002 (20 minutes plus 15 minutes for Wetland Biotic Index sampling).

Size of site: about 150 x 125 meters (1.3 ha).

Context of site: Within a matrix of formerly and currently used agricultural land on rolling terrain.

Description of site: Open, apparently natural (not dredged?) glacial pothole wetland. Immediately surrounded by fields except for a thin fringe of box elder, green ash, and willow on the south side. Site managed for waterfowl production. Wild rice may have been planted.

Standing water was present on both visits and was apparently deep, at least 1 meter over most of the pond, which occupied 90-95% of the wetland. The dominant plant species surrounding the pond was a fringe of reed canary grass (*Phalaris arundinacea*). Emergents aquatic macrophytes were sparse.

Survey results: The surveys found 42 native species and an FQI of 22.8. The August visit left the FQI unchanged (no increase). The low FQI is typical of a pond with a narrow wetland fringe dominated by massive growths of reed canary grass. Where reed canary was not dominant there were tiny, somewhat rich pockets of native forbs that probably increased the FQI of the site by several points.

POLK COUNTY: Tatro Wetlands.

Location: T33N-R15W, Sec. 15, on west side of County Hwy. D, 2 miles NW of the village of Clayton. GPS location: 45°20’59”N, 92°11’51”W.

Surveys: 4 July 2002 (25 minutes), 14 August 2002 (20 minutes plus 20 minutes for Wetland Biotic Index sampling).

Size of site: about 60 x 60 meters (0.3 ha).

Context of site: Within a matrix of actively used agricultural land on level terrain.

Description of site: Open wetland; sign noted that it was a “restoration site” so probably has seen dredging/scraping. Standing water was present on both visits (decreasing from about 60% to 40% of the total area). The dominant plant species surrounding the pond were reed canary grass (*Phalaris arundinacea*), cattails (*Typha latifolia*), and woolgrass (*Scirpus cyperinus*). The pond had abundant submerged aquatics including bladderwort (*Utricularia*) and a weedy pondweed (*Stuckenia pectinata*). Where reed canary was not dominant there were tiny, somewhat richer pockets of native forbs that probably increased the FQI of the site by several points.

Survey results: The surveys found 35 native species and an FQI of 20.1. The August visit increased the FQI by 4.3. The very low FQI is typical of a small “restored” wetland that is partially dominated by the invasive reed canary grass.

ONEIDA COUNTY: Site 1, IBI Wetland (Forest Pond)

Location: T35N-R9E, Sec. 12. GPS location: 45°32’27”N, 89°18’31”W.

Surveys: 1 July 2002 (15 minutes), 14 August 2002 (5 minutes plus 10 minutes for Wetland Biotic Index sampling).

Size of site: about 22 x 22 meters (0.05 ha).

Context of site: Within a matrix of rolling, managed second-growth sugar maple – hemlock forest.

Description of site: Tiny, shaded glacial pothole wetland in forest. The site is seasonally wet, but no standing water was present during the 1 July 2002 survey. The dominant plant species was the sedge *Carex tuckermanii*.

Survey results: The surveys found 26 native species and an FQI of 26.5. The August visit increased the FQI by 1.3. The average co-efficient of conservatism was 5.2, the 3rd highest of all 17 sites visited. The moderately low FQI is typical of a tiny, shaded vernal woodland pond vegetated by native species, and probably does not reflect the pond’s importance to other biota such as herps.

ONEIDA COUNTY: Site 2, IBI Wetland (Home Depot Wetland).

Location: T36N-R9E, Sec. 5. GPS location: 45°37’59”N, 89°23’25”W. On the south side of Business US Hwy. 8, at the west side of the entrance to the Home Depot store.

Surveys: 1 July 2002 (20 minutes), 14 August 2002 (10 minutes plus 15 minutes for Wetland Biotic Index sampling).

Size of site: about 32 x 32 meters (0.10 ha).

Context of site: To the east and north are highways and commercially developed sites within the city of Rhinelander. To the southwest is a red pine plantation and small copse of box elder. There is a storm drain inlet leading into the site from the north (across US 8) and the site’s outlet is to the west.

Description of site: Small pothole apparently partly natural but also partly the result of construction activities. Seasonally wet, the area was about 75% standing water during the 1 July 2002 survey, decreased to 65% on 14 August. Dominant plants were the exotics reed canary grass (*Phalaris arundinacea*) and hybrid cattail (*Typha x glauca*). The native water-plantain (*Alisma triviale*) was emergent in dense beds in standing water.

Survey results: The surveys found 43 native species and a moderately low FQI of 25.8. The August visit increased the FQI by 1.8. The site also had 8 species of exotic plants including purple loosestrife and both buckthorns as well as reed canary grass. In many ways this was one of the most puzzling sites visited. The site is tiny, highly urbanized, full of the worst exotics, and perhaps scraped, yet a large number of native species are managing to hang on – so far. They will probably drop out in a few years as cattails and reed canary grass become dominant. An uncommon sedge (*Carex arcta*) was noted during the June survey.

ONEIDA COUNTY: Site 3, IBI Wetland (Pelican Ranch Road and Hwy. 8)

Location: T36N-R9E, Sec. 23. GPS location: 45°35’59”N, 89°20’21”W. At the southeast corner of US Hwy. 8 and Pelican Ranch Road.

Surveys: 1 July 2002 (20 minutes), 14 August 2002 (15 minutes plus 15 minutes for Wetland Biotic Index sampling).

Size of site: about 40 x 40 meters (0.16 ha).

Context of site: There is an aspen forest on the east side. Otherwise, the site is surrounded by high grassy embankments (the exotic grass *Bromus inermis* covers the embankments) adjacent to Highways US 8, Old US 8, and Pelican Ranch Road. There are culverts draining the wetland on the north and west sides.

Description of site: An open, sunny sedge – bluejoint meadow nearly filled with standing water during the 1 July 2002 survey (but summer has been exceptionally wet). Standing water had decreased a bit (or the emergents grown more luxuriant) by 14 August 2002. Dominant plant species were the sedge *Carex* lacustris and the grass *Calamagrostis canadensis*. One exotic shrub was present, common buckthorn (*Rhamnus cartharticus*).

Survey results: The surveys found 27 native species and a moderate FQI of 27.4. The August visit increased the FQI by 2.2. Highway construction and maintenance has had significant impact on the site’s hydrology, but the wetland is still dominated by native species. In fact the site had the highest average coefficient of conservatism (5.6) of any of the sites sampled. Perhaps exotics have a more difficult time invading a cold, acid wetland (leatherleaf is present) and that this helps maintain a relatively high FQI.

PLAINFIELD (WAUSHARA COUNTY): Site 1: Plainfield Lakes (Sherman Lake).

Location: T20N-R9E, Sec. 17. GPS location: 44°12'12"N, 89°27'53"W. On east side of Hwy. 73 about 2 miles east of village of Plainfield.

Surveys: 26 June 2002 (60 minutes), 16 August 2002 (30 minutes plus 25 minutes for Wetland Biotic Index sampling).

Size of site: about 400 x 300 meters (9 ha).

Context of site: Within a matrix of rolling, managed, sandy aspen, jack pine, and Hill's oak forest.

Description of site: Part of a State Natural Area that protects a rare community and several rare plant species, this 9-hectare pothole has a sandy-mucky bottom and widely fluctuating water levels. I visited this site in 2000 and found about 4-5 ha of open water. In 2001 there was less than 1 ha of open water. The site was about 75% covered by standing water during the 26 June 2002 survey, this increasing to 95% on 16 August when the levels were as high as I've ever seen in six visits over the last three summers. Dominant plants were sedges (*Schoenoplectus* spp., *Eleocharis* spp., *Carex* spp.) on the lake margins, floating aquatics (*Nymphaea*, *Nuphar*) and few emergents such as aquatic smartweed (*Polygonum amphibium*) in open water, and *Panicum acuminatum* and *Euthamia graminifolia* on the sandy, vegetationally zoned receding shoreline.

Survey results: The 2002 surveys found 52 native species and a moderately high FQI of 34.9. In addition, the site had 10 species of exotic plants, although none was dominant. The August visit increased the FQI by 2.8. The rather low FQI of this site was surprising given the fact that a number of rare plants were present and it is preserved as a State Natural Area. In my list of species I included four species that I had seen here in 2000 but not 2002: *Carex sychnocephala, Eleocharis compressa, E. quinquefolia, and E. olivacea*. My reasoning is that these species are doubtlessly present in the seed bank, "waiting" for low water levels. If these four native species are excluded from the survey based on their lack of emergence this year, the site's FQI would drop by 10% to 31.5.

PLAINFIELD (WAUSHARA COUNTY): LMR Site 2 (West Marsh).

Location: T18N-R10E, Sec. 22. GPS location: 44°01’29”N, 89°18’07”W. On the south side of Cumberland Lane, on the west side of Hwy. 22, about 3 miles south of Wautoma.

Surveys: 26 June 2002 (30 minutes), 16 August 2002 (20 minutes plus 20 minutes for Wetland Biotic Index sampling).

Size of site: About 100 meters in diameter (0.75 ha).

Context of site: Within a matrix of current and former agricultural fields and woodlots dominated by oak and aspen. In general the area is flat and poorly drained. A large deep, straight, north-south running drainage ditch is located a few meters west of the site and must have a significant impact on its hydrology.

Description of site: The dominant plants were tussock sedge (*Carex stricta*) with scattered to dense patches of shrubby willows, mostly *Salix petiolaris*. Open water – puddles from recent heavy rains – occupied about 10% of the site on both visits.

Survey results: The 2002 surveys found 37 native species and a moderate FQI of 31.7. The August visit increased the FQI by 1.8. Notably, in spite of nearby agricultural activities and the drainage ditch (the site was characterized as “moderately disturbed”), it had only one exotic species (bittersweet nightshade, *Solanum dulcamara*) and had numerous fairly conservative native species.

PLAINFIELD (WAUSHARA COUNTY): LMR Site 3 (East Marsh).

Location: T18N-R10E, Sec. 22. GPS location: 44°01’26”N, 89°18’01”W. On south side of Cumberland Lane; on west side of Hwy. 22 about 3 miles south of Wautoma.

Surveys: 26 June 2002 (40 minutes), 16 August 2002 (25 minutes plus 20 minutes for Wetland Biotic Index sampling).

Size of site: about 125 meters in diameter (1.25 ha).

Context of site: Within a matrix of current and former agricultural fields and woodlots dominated by oak and aspen. In general area is flat and poorly drained.

Description of site: The dominant plants were tussock sedge (*Carex stricta*), wiregrass sedge (*Carex oligosperma*), and bluejoint (*Calamagrostis canadensis*) with scattered to dense patches of shrubby willows, mostly *Salix petiolaris*. A 0.1 ha pond – apparently artificially dug as evidenced by old dredge spoils – occurs on the east edge of the site and its extent and level had not changed from 26 June to 16 August 2002.

Survey results: The site had both the highest number of native species (63) as well as the highest FQI (40.4) and 2nd highest co-efficient of conservatism (5.22) of any of the sites sampled. The August visit increased the FQI by 1.6. Notably, in spite of nearby agricultural activities and the dredged pond, the site had only two exotic species, neither common: reed canary grass (*Phalaris arundinacea*) and bittersweet nightshade (*Solanum dulcamara*) and had numerous fairly conservative native species. On the margins of the site was a tiny, somewhat richer pocket of native wetland forbs (including the beakrush *Rhynchospora capitellata*) that probably increased the FQI of the site by several points.

GREEN COUNTY: Brooklyn-Albany Road Wetland (Liberty Creek Sedge Meadow).

Location: T3N-R9E, Sec. 2. GPS location: 42°46’08”N, 89°24’30”W. On south side of Brooklyn-Albany Road ca. miles west of the Rock County line, just west of Liberty Creek.

Surveys: 27 June 2002 (70 minutes), 8 August 2002 (30 minutes plus 25 minutes for Wetland Biotic Index sampling).

Size of site: about 150 meters in diameter (1.75 ha).

Context of site: Within a matrix of current and former agricultural fields. In general the area is flat and poorly drained. Streams in immediate vicinity including Liberty Creek do not appear to have been ditched.

Description of site: An open sedge-grass meadow. During the 27 June 2002 survey, the dominant plants were tussock sedge (*Carex stricta*) and bluejoint (*Calamagrostis canadensis*). There were also scattered to dense patches of shrubby willows, mostly *Salix petiolaris*. No open water was evident on either visit.

Survey results: The 2002 surveys found 49 native species and a moderately high FQI of 34.1. The August visit increased the FQI by 0.5. Notably, in spite of nearby agricultural activities, the site had only one exotic species, reed canary grass (*Phalaris arundinacea*), and that was uncommon. The record of northern green orchid (*Platanthera huronensis*) was the first for Green County.

GREEN COUNTY: Tin Can Alley Wetland.

Location: T3N-R9E, Sec. 17. GPS location: 42°43’47”N, 89°27’59”W. On the east side of Tin Can Road just south of the Sugar River hike-bike trail.

Surveys: 27 June 2002 (35 minutes), 8 August 2002 (15 minutes plus 20 minutes for Wetland Biotic Index sampling).

Size of site: About 40 x 20 meters (0.06 ha).

Context of site: Within a matrix of current and former agricultural fields and floodplain woods in the floodplain of the Sugar and Little Sugar Rivers. In general the area is flat and poorly drained. Construction and maintenance of the former railroad and (east-west) and town road (north-south) appear to have impeded drainage and formed or deepened this wetland.

Description of site: A thick stand of reed canary grass (*Phalaris arundinacea*), common cattail (*Typha latifolia*), and bur-reed (*Sparganium eurycarpum*) with about one foot of standing water on 27 June 2002. The water had dried by 8 August 2002.

Survey results: The 2002 surveys found 30 native species and a moderately low FQI of 25.9. The August visit increased the FQI by 1.0. The site had two exotic species, the dominant reed canary grass (*Phalaris arundinacea*), and also *Solanum dulcamara*. The FQI was relatively low, reflecting the disturbed hydrological regime of the site and the dominance of an exotic species.

DANE COUNTY: Hope Road Wetlands (Bork).

Location: T7N-R11E, Sec. 20. GPS location: 43°03’11’12”N, 89°13’27”W. On south side of Brooklyn-Albany Road ca. miles west of the Rock County line, just west of Liberty Creek.

Surveys: 29 June 2002 (25 minutes), 2 August 2002 (45 minutes plus 20 minutes for Wetland Biotic Index sampling).

Size of site: about 100 x 150 meters (1.2 ha).

Context of site: Within a matrix of current and former agricultural fields. In general the area is flat and poorly drained, between drumlins to the NW and SE.

Description of site: The site is a cattail marsh dominated by hybrid (*Typha x glauca*) and native (*T. latifolia*) species. It may be partly artificially dug and is perhaps fertilized with run-off from adjacent agricultural fields. About 0.1 ha of the site is open water in June. This has dried to mud by August.

Survey results: The 2002 surveys found 29 native species and a very low FQI of 17.3. The August visit increased the FQI by 3.3. In addition to the exotic cattail, exotic reed canary grass (*Phalaris arundinacea*) was also present. The site was species-poor because of its disturbed nature and the dominance of cattails.

JEFFERSON COUNTY: Fayeville Prairie Scrape.

Location: T8N-R14E, Sec. 19. GPS location: 43°08’46”N, 88°52’47”W. At the end of Prairie Lane, less than a mile west of the Crawfish River.

Surveys: 28 June 2002 (30 minutes), 2 August 2002 (25 minutes plus 15 minutes for Wetland Biotic Index sampling).

Size of site: About 20 x 20 meters (0.03 ha).

Context of site: Within a matrix of unplowed prairie (to the north) and former agricultural fields (to the south). In general the area is flat and poorly drained.

Description of site: The site is a tiny shallow pond that is the result of a recent bulldozer scrape. The pond is surrounded by cattails (the exotic hybrid *Typha x glauca* and native *T. latifolia*. Spikerushes and bulrushes of various species are the dominants. The pond had dried up by the August visit.

Survey results: The 2002 surveys found 26 native species and a very low FQI of 17.1. The August visit increased the FQI by 2.3. Five species of exotic plants are present including reed canary grass (*Phalaris arundinacea*) and purple loosestrife (*Lythrum salicaria*). The FQI is low as expected because of the artificial nature of this wetland.

JEFFERSON COUNTY: Diedrich-Alexander Wetland.

Location: T8N-R13, Sec. 35. GPS location: 43°07’27”N, 88°55’05”W.

Surveys: 28 June 2002 (25 minutes), 2 August 2002 (25 minutes plus 20 minutes for Wetland Biotic Index sampling).

Size of site: About 75 x 25 meters (0.15 ha).

Context of site: Within a matrix of current and former agricultural fields on rolling drumlinal terrain (to the east) and extensive wetlands including tamarack swamp (to the west). In general the area is flat and poorly drained.

Description of site: The site is at the eastern margin of an extensive wetland complex. The dominant plants are cattails (*Typha latifolia*) along with various tussock sedges such as *Carex stricta*. About 80% of the area surveyed was open water over muck. This was reduced to a few puddles by August.

Survey results: The 2002 surveys found 43 native species and a moderately low FQI of 27.6. The August visit increased the FQI by 4.8. Three species of exotic plants are present including reed canary grass (*Phalaris arundinacea)*. On the margins of the site was a tiny, somewhat richer pocket of native wetland forbs that probably increased the FQI of the site by several points.

WASHINGTON COUNTY: WIBI SER Site 1 - Myra Wetland (Ozaukee County Land Trust) (OWLT)

Location: T11N-R20E, Sec. 16. GPS location: 43°24’51”N, 88°06’46”W.

Surveys: 29 June 2002 (35 minutes), 20 August 2002 (25 minutes plus 20 minutes for Wetland Biotic Index sampling).

Size of site: About 150 x 75 meters (0.9 ha).

Context of site: Within a matrix of active agricultural fields (planted to clover for hay) and suburban residences on rolling.

Description of site: The site is a pothole vegetated by a mix of sedges (*Carex lacustris*), grass (the native *Calamagrostis canadensis* and exotic *Phalaris arundinacea*), and shrubby willows (*Salix petiolaris* is commonest). There was standing water throughout much of the site during the 29 June 2002 survey; this was all gone by the 20 August visit.

Survey results: The 29 June 2002 survey found 39 native species and a moderately low FQI of 26.9. Five species of exotic plants are present. The August visit reduced the FQI by 0.2 to 26.7. The FQI is somewhat low, probably because of both invasion by reed canary grass, and nutrient-laden run-off from adjacent agriculture.

WASHINGTON COUNTY: WIBI SER Site 2 – Byer's Pond

Location: T11N-R21E, Sec. 30. GPS location: 43°23'18"N, 88°01'51"W.

Surveys: 29 June 2002 (30 minutes), 20 August 2002 (25 minutes plus 20 minutes for Wetland Biotic Index sampling).

Size of site: About 200 x 30 meters (0.5 ha).

Context of site: The site is within a matrix of a woodlot of second-growth sugar maple, beech, basswood, and white ash on rolling morainal land adjacent to the UW-Milwaukee Field Station.

Description of site: The site is a shaded pothole supporting a vernal pond that on 29 June 2002 was almost entirely open water. The commonest emergents are occasional trees of green ash (*Fraxinus pennsylvanica*). Many old dead tree trunks, probably American elm, occur in the pond, and many herbaceous species occur only on the downed rotting trunks. Dominant aquatic macrophytes in the pond include yellow water buttercup (*Ranunculus flabellaris*), forked duckweed (*Lemna trisulca*), and eastern manna grass (*Glyceria septentrionalis*). On 20 August, there was no standing water.

Survey results: The 29 June 2002 survey found 20 native species and a very low FQI of 18.1. Three species of exotic plants are present including reed canary grass (*Phalaris arundinacea*) but none are dominant. The August visit decreased the FQI by 0.2 to 17.9. The FQI is very low, probably because site was at one time essentially a wooded swamp with few herbaceous species. It "opened up" when the American elm died.

WASHINGTON COUNTY: WIBI SER Site 3 – Seidler Farms on Hwy. 181

Location: T10N-R21E, Sec. 21. GPS location: 43°18’40”N, 88°00’18”W.

Surveys: 29 June 2002 (25 minutes), 20 August 2002 (25 minutes plus 20 minutes for Wetland Biotic Index sampling).

Size of site: About 60 x 50 meters (0.25 ha).

Context of site: The site is within a matrix of a woodlot of second-growth green ash and American elm. Hwy. 181 forms the site’s eastern boundary. Surrounding the woodlot is residential and agricultural land.

Description of site: The site is a shaded pothole supporting a vernal pond that on 29 June 2002 was almost entirely open water. The commonest emergents are occasional trees of green ash (*Fraxinus pennsylvanica*) and the manna grass *Glyceria septentrionalis*. Many old dead tree trunks, probably American elm, occur in the pond. On 20 August the standing water was gone and reed canary grass, manna grass, and river bulrush (*Bulboschoenus fluviatilis*) were dominant.

Survey results: The 29 June 2002 survey found 22 native species and a very low FQI of 14.1. Five species of exotic plants are present but none are dominant. The August visit increased the FQI by 5.5 to 19.6. This was the largest increase in FQI in any site. The reason for this may be that species that were submerged in the June survey became evident when the waters dried over the summer. The FQI is low, but this is natural since the site was a vernal pond dominated by just a few emergent species (manna grass and bulrush).

Summary and Evaluation of the Floristic Quality Assessment and Index of Biotic Integrity
(Based on Visits to 17 Wisconsin Wetlands, June-August 2002)

Emmet J. Judziewicz
True Heritage Botanical Services, 1180 Dodds Drive, Apt. 4, Plover, WI 54467
30 August 2002

An evaluation of the Floristic Quality Assessment and Index of Biotic Integrity of 17 selected Wisconsin wetlands was conducted from 26 June to 20 August 2002 and its results are summarized as:

1) An overall evaluation and summary of the utility of the Floristic Quality Assessment (FQA) and Index of Biotic Integrity (IBI) methods of survey (below).
2) An illustrated narrative for each site;
3) Three Excel Spreadsheets documenting the FQI of 17 Wisconsin Wetlands during late June surveys, August surveys, and combined June and August surveys (plus an 18th very high quality wetland of my choice).

1. Overall Evaluation of the Adequacy of the Floristic Quality Assessment (FQA) to Characterize the Integrity of the Plant Community at Wetland Sites

In general, a site's Floristic Quality Assessment (FQI) corresponded well to the site's natural area significance. Swink & Wilhelm (Flora of the Chicago Region, 4th ed., 1994: 18) note that FQI values of less than 20 denote a site with no significance whatever, while those of 35 or higher are at least marginally significant; while sites with FQA values of 50 or more probably deserve protection as natural areas. The 17 sites I surveyed had FQIs ranging from 17 to 40. Below 40, there were two sites with FQIs approaching 35, and one has already been designated as a State Natural Area (Sherman-Plainfield Lake).

One exception is that the FQA system does not work well for small, high-quality vernal ponds such as the two Ozaukee County sites (Byers and Seidler Ponds) and the Oneida County forest pond. Both Ozaukee sites had FQIs of less than 20, yet they were clearly fairly undisturbed and probably had important values for other biota such as herps and aquatic invertebrates that are not reflected in their low FQIs…. By contrast, a pond of similar size with a rich fen mat and numerous obligate calciphiles (and probably also a high quality fauna, too) such as "Site 18" (Ponsegrau Lake, Oconto County) had an FQI of over 80, or 4 times as high as the southern Wisconsin vernal ponds.

Some of the aspects of FQI that impressed me were the following:

Some species have coefficients of conservatism that appear to be inflated. Examples include but are not limited to *Campanula aparinoides* (7), *Lysimachia terrestris* (7), and *Triadenum fraseri* (8). Even in degraded sites one will often find one or a few individuals of these species. It would probably be useful at some point in the future to review FQI values for all of these native species.

The species that "suffer" most from a "late-season-only" survey are the more delicate species of sedges such as *Carex brunnescens* (C = 7), and *C. interior* (7). These species tend not to keep their perigynia for as long as some of the larger, coarser sedges, and moreover they tend to be more conservative taxa with higher Cs than the late season species. Also, late season-flowering species such as *Aster* and *Bidens* species generally tend to be coarser and weedier, with lower C values that decrease the FQI values at a site.

With regard to an optimum time for surveys, the following are summations of the values for the 17 sites visited:

	June	August	June + August	Increase by adding an August survey
Mean co-efficient of conservatism	4.41	4.30	4.31	- 2.5 %
Mean number of native species	28.9	33.9	36.2	+ 25.3%
Mean FQA value for site	23.5	24.9	25.6	+ 8.9 %

Small, rich pockets of “high-C’ species tend increase the FQI of certain sites. These microsites generally occur on the margins of more extensive wetland where, by chance, larger coarse, often invasive species such as reed canary grass have failed to become dominant.

The late season (August) surveys found significantly more species (34) than the June surveys (29). This is probably due to the more numerous species that appear, flower, and fruit after water levels have dropped as the summer progresses – examples are the smartweeds (*Polygonum* species) and beggar-ticks (*Bidens* species).

In summary, a single visit to a site to obtain an FQI is probably sufficient. This visit could be scheduled any time from mid-June to the end of August. Two visits (early and late) will probably not, in general, increase the FQI by any more than about 10%. If the choice is between an early or late visit, a late visit is slightly preferable.

2. Summary of Observations on the Feasibility and Utility of the Sampling Methodology Employed in the Plant Biotic Index (Index of Biotic Integrity, IBI)

First of all, the results of IBI are not comparable to those of FQA because the entire site is not surveyed. In the August surveys, I found an aggregate total of 238 “species-records” in 17 sites in the IBI transects, while 577 species-records were found in the same 17 sites. So IBI picked up 238/577 or 41% of the species-records at a given site. On the other hand, IBI was clearly more quantitative in that an estimate of percent cover at each quadrat was recorded, plus a correlation with water depth and species-cover was recorded.
Because water levels vary from season to season and from year to year, it will be difficult to get even approximately comparable IBI transect data from the same site. Also, different transect routes will be run by different surveyors.

Another problem that I had with IBI was that, in practice, littoral zones tend to be abrupt, going from deep water to dry land in only a few meters. Or, there is no standing water at all late in the season. That necessitates transects with sampling intervals of only 1 or in some cases only 0.5 meters. Rare was the wetland with a long gradual gradient from deep water to shore so that transect intervals could be, say five meters in length.

That said, IBI is a useful, fast way to get quantitative data on the dominant vegetation at a given site. While a useful FQI value can be gotten from a single visit to a site, I think that two or three IBI visits – during periods of high, medium, and low water --- would be more useful.

Printed on
recycled paper.

Wisconsin Department of Natural Resources
Bureau of Integrated Science Services
PO Box 7921, Madison WI 53707

PUB-SS-1017 2005