State of Ohio
Environmental Protection Agency

Ecological Assessment Unit
Division of Surface Water

INTEGRATED WETLAND ASSESSMENT PROGRAM
Part 8: Initial Development of Wetland Invertebrate Community Index for Ohio

Ohio EPA Technical Report WET/2004-8

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Executive Summary

Initial Data Analyses of the Ohio EPA invertebrate database (1996-2003) showed relationships between several taxonomic groups and wetland quality. A mitigation study conducted in 2001 documented major differences between species richness and relative abundance for sensitive and tolerant taxa groups between mitigation sites and natural wetlands. Metrics were suggested by the mitigation study and along with other metrics from other sources (other state programs, etc) were tested for significance using parametric and nonparametric tests. A suite of metrics were chosen from the more significant results and an index was formed, the wetland invertebrate community index (WICI). Sites were scored in several different scoring schemes and one was chosen that represented a high level of discrimination and correlation with wetland quality. Additionally, a sensitivity/tolerance value was computed for the invertebrates based on the WICI scores.

This is only an initial development phase of a wetland invertebrate index for the Ohio EPA. Continued work with the sensitivity/tolerance values for the formulation of more precise metrics specifically for chironomids and other dipterans is needed for inclusion into the index. An area that may need greater taxonomic identification to family, genus, and species are the oligochaetes and microcrustaceans - cladocerans, ostracods, and copepods.

1.0 Introduction

Invertebrates have long been recognized as sensitive indicator species of environmental conditions in rivers and streams (DeShon 1995, Yoder *et al*. 1995b, Hynes 1970). The sensitivity and tolerance of invertebrate species make these organisms an excellent group to provide information on overall wetland condition. In this report, the relative abundance of different organism groups of herbivores, predators, and omnivores were sensitive to wetland perturbations compared to other groups that were tolerant of them. These sensitive and tolerant groups make up the metrics in the Wetland Invertebrate Community Index (WICI) developed from the Ohio EPA data, 1996-2002.

In earlier reports (Mack 2201b, Micacchion 2002), use of landscape attributes were used to develop initial metrics for amphibians and plants, and an overall index of wetland condition were discussed. The distributions of many of the amphibian and plant species have been described as landscape driven. The communities were affected to a large degree by anthropogenic change over the past couple of centuries. Once a mesophytic forest, the Eastern Cornbelt Plains (ECBP) has given way to a predominantly agricultural landscape. The wetland plant communities, as measured by the vegetative index of biotic integrity (VIBI), in the Erie Ontario Lake Plain score higher than in the ECBP. Although the ECBP is heavily industrialized, there are many areas of nonurban land with larger intact natural areas than in the ECBP. In the case of amphibians, the wood frog is virtually absent from the ECBP, yet thrives in the adjacent ecoregions. This species needs larger tracts of surrounding intact forest for successful habitation. Other amphibian species restricted due to human modified landscapes are salamanders and newts ((Porej *et al.* 2002).

In this report, the relative abundance of the invertebrate communities appear to be driven more by the water and soil characteristics of the wetland community. The landscape features indirectly affect these characteristics. Reduced forest canopy and open water with no groundwater surcharge will have a higher water temperature which has a direct effect on invertebrate communities. In many mitigation projects the top soil is scraped off leaving behind a nutrient poor soil for the wetland communities to sustain themselves (Fennessy, Rohosh, Mack). The relationships between rich and poor nutrients in wetland soils, plant community nutrient requirements, low and high decomposition rates, and invertebrate distributions are areas of wetland dynamics that are essential to understand to make sound environmental decisions.

2.0 Methods

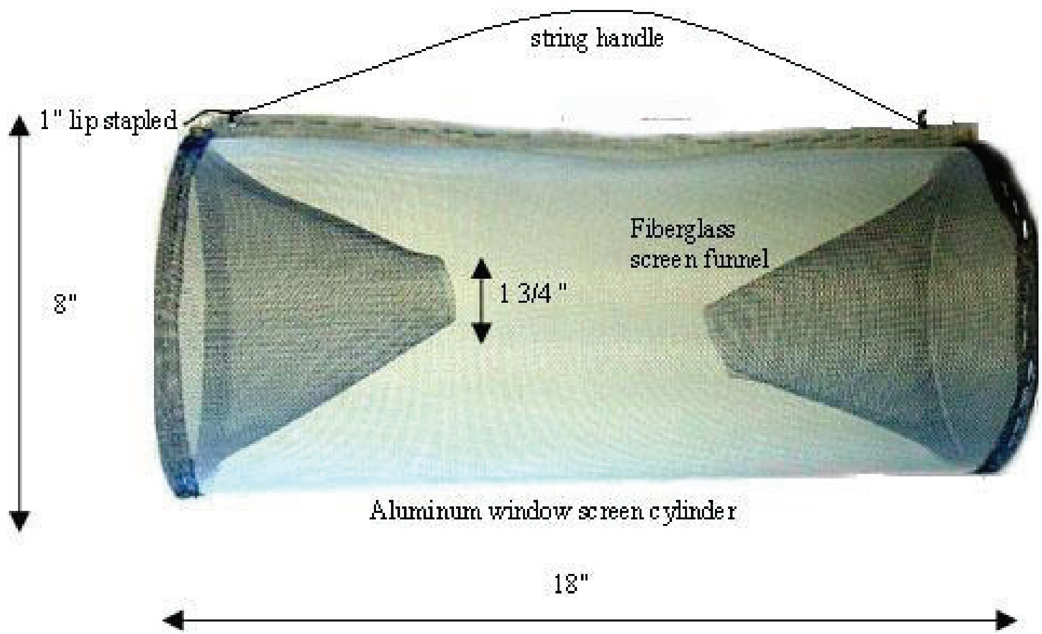
Quantitative Collection Protocol

Ohio EPA began evaluating wetland macroinvertebrate and amphibian sampling methods in 1996. A variety of sampling methods including artificial substrate samplers, several types of funnel traps, and qualitative sampling with dip nets were evaluated (see Fennessy *et al.* 1998a). The use of funnel traps as a method of sampling has been used extensively for amphibians and more recently as a protocol for macroinvertebrate collections in wetlands. A number of different kinds of funnel traps have been described ranging from modified two liter pop bottles to custom-made designs of PVC or clear acrylic plastics to using different types of metal meshes. In addition to the sampling method, the time of year to sample, the intensity, frequency, and duration of sampling were evaluated. Since 1997, field collection techniques have become standardized and the same protocols are used at each wetland sampled.

Funnel traps are constructed of aluminum window screen cylinders with fiberglass window screen funnels at each end (Figure 1). The funnel traps are similar in design to commercially available minnow traps. However, the use of window screen, with its smaller mesh, makes the traps better able to collect a wide range of sizes of larval amphibians and macroinvertebrates. Aluminum screening is used for the cylinders to provide maximum structure and fiberglass screening is used for the funnels to allow flexibility to ease funnel inversion and eversion.

For most wetland surveys, 10 funnel traps are placed evenly around the perimeter of the wetland. The perimeter around the wetland is measured by pacing. The perimeter total is then divided by 10 and a trap is placed each time that amount is paced off while traversing the perimeter for the second time. Alternatively, for large wetlands or where the placement around the entire perimeter is not feasible (slopes too steep, water too deep, etc), transects along one or several sides of the wetland are used. Care is taken to assure that all habitat types within the wetland are represented proportionally within the transect. Each funnel trap location is marked using flagging tape both at the standing water/saturated soil interface and in vegetation above or near the trap. Flagging is numbered sequentially using a permanent marker and traps are set at the same locations throughout the sampling season. When vegetation is extremely dense a hand held GPS unit can be used to record and navigate to trap locations.

Figure 1. Funnel Trap Design



Aluminum window screening 28” x 18” is rolled into a cylinder 18” long and stapled through a 1” lip to form a tube 8” in diameter. Fiberglass screening is cut out and stapled to form a funnel with an opening of 9” on the wide end and 1 ¾” on the narrow end. The narrow end of the funnel is placed inside the cylinder as indicated in the figure. The wide end of the funnel is rolled over the outside edge of the cylinder and stapled every ½”. A string handle is attached to the lip. The trap is emptied by everting the fiberglass funnel and dumping and shaking the contents into a pan.

Wetlands were typically sampled three times between March and early July spaced approximately six weeks apart. The late winter/early spring (March-early April) sample allows monitoring of adult ambystomid salamanders, early breeding frog species and macroinvertebrates such as fairy shrimp, caddisfly larvae, and other early season taxa which are often present for a limited time in some wetlands. A middle spring sample (late April-mid May) is conducted in order to collect some adult frog species entering the wetland to breed, to sample early-breeding amphibian larvae and to sample for macroinvertebrates. A late spring/early summer (early June-early July) sampling is performed to collect relatively well developed amphibian larvae and macroinvertebrates.

The traps are placed on the substrates of the wetland and the trap is almost completely submersed. Traps are placed to allow some exposure of air into the upper part of the cylinder. Placement to allow organisms access to atmospheric oxygen becomes more important as the season progresses, water temperatures rise and oxygen levels in the water decrease. Traps can be placed in shallower water as long as the funnel openings remain immersed during the sampling period. In all cases, the traps are left in the wetland for twenty-four hours in order to ensure unbiased sampling for species with diurnal and nocturnal activity patterns. Limiting trapping time to twenty-four hours also works to minimize the potential for mortality due to individuals being in the traps for extended periods.

Upon retrieval, the traps are emptied by everting the funnel and shaking the contents into a white collection and sorting pan. Organisms that can be readily identified in the field (especially adult amphibians and larger and easily identified fish) are counted and recorded in the field notebook and released. The remaining organisms are transferred to wide-mouth one liter plastic bottles by washing them out of the collection and sorting tray into the bottles using a plastic squeeze bottle filled with 95% ethanol. The collection pan is then thoroughly rinsed with water from the wetland to remove any trace of alcohol that might adversely affect amphibians to be released from the next trap collection.

Laboratory analysis of the funnel trap macroinvertebrate and fish samples follows the standardized Ohio EPA procedures (Ohio EPA 1989b). Salamanders and their larvae are identified using keys in (Pfingsten and Downs 1989) and (Petranka 1998). Frogs, toads and tadpoles are identified using keys in (Walker 1946).

Qualitative Collection Protocol

Qualitative collections of macroinvertebrates and amphibians are made concurrently with funnel trapping at each wetland during the three sampling periods. Qualitative sampling involves the collection of macroinvertebrates and amphibians from all available natural wetland habitat features using triangular ring frame dip nets, collection and sorting trays and also by manual picking of substrates and woody debris with field forceps. Dip net sweeps are made in all habitat types where possible. The collection and sorting tray is often used as a repository for dip net contents to aid in examination and can itself be dipped into the water to yield a sample . Woody debris and other substrate materials are manually collected, searched and picked through with the aid of the forceps or by hand. The goal is to compile a comprehensive species/taxa inventory of macroinvertebrates and amphibians at the site

The qualitative sample is collected for a minimum of 30 minutes. The collection time lasts until the field crew determines that further sampling effort is not likely to produce new taxa. Samples are deposited in 4 ounce wide-mouth glass bottles marked as qualitative samples and preserved with 95% ethanol. The qualitative field collection and laboratory analysis of these samples for macroinvertebrates and fish will follow the standardized Ohio EPA procedures (Ohio EPA 1989).

Laboratory Methods
Upon submission to the laboratory, all funnel trap and qualitative samples are assigned a unique lab number for tracking purposes. The contents of each funnel trap are processed individually so that each site has ten quantitative samples to process for each of the three collection dates. Samples preserved in 10% formalin are washed with water under a hood and transferred to 70% ethyl alcohol before the contents are identified.

All organisms within each funnel trap sample are identified and counted. The numbers of each taxa in each trap are entered into our database along with the duration of the trapping effort so that relative abundance, number per hour of trapping, and other metrics can be calculated.

Statistical Analyses
Systat 9.0 was used to perform all statistical tests. Regression analysis, general linear models parametric test (comparable to analysis of variance and t tests), and the Kruskal-Wallace nonparametric test were used to explore and evaluate the biological attributes measured for development of a wetland invertebrate community index.

3.0 Database Structure

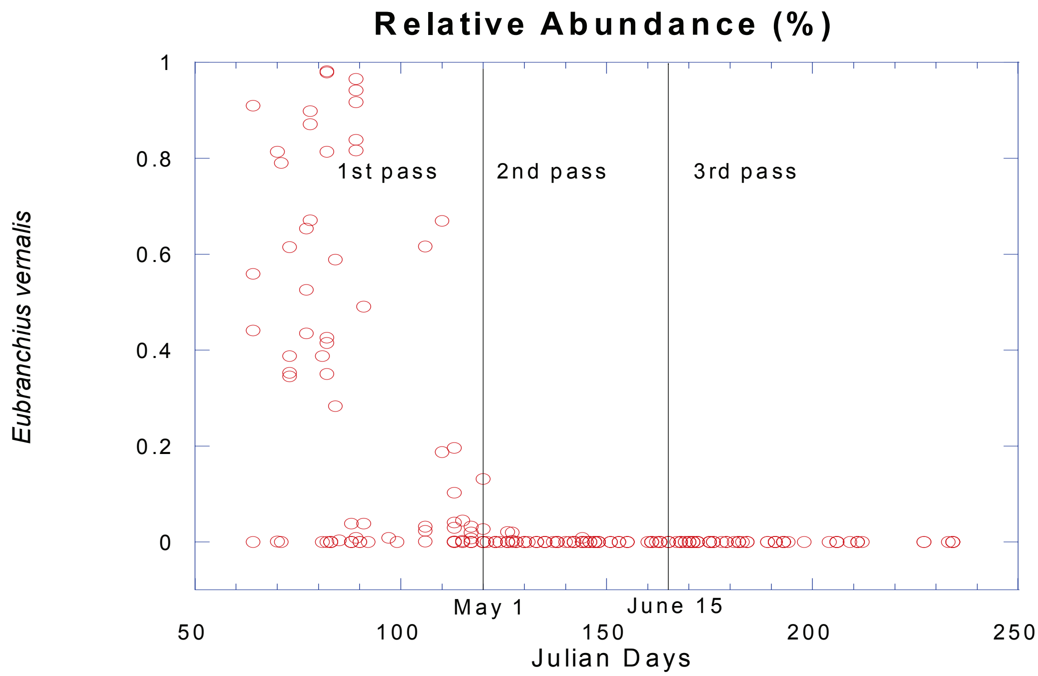
Natural wetlands spanning the range of disturbance levels, from least impacted to severely disturbed, were sampled from 1996 to 2002. Samples trapped more than 1 day or with smaller size funnel traps were excluded from analyses. First pass data (March to April) was not collected from 2001 sites. Only 2nd pass (May) and 3rd pass (June to July) data were evaluated from 2001 and 2002. Natural wetlands were selected from the three major vegetation types: forested, shrub and emergent. Metrics 2, 3e, 4a, and 4c were selected from the Ohio Rapid Assessment Method for Wetlands Version 5.0 (ORAM). These ORAM metrics were summed to gether to form a disturbance scale which was used as the dependent variable in the regression analyses. Additionally, data from 10 constructed wetland sites were collected in conjunction with the mitigation study, and were also evaluated and compared to natural wetland systems.

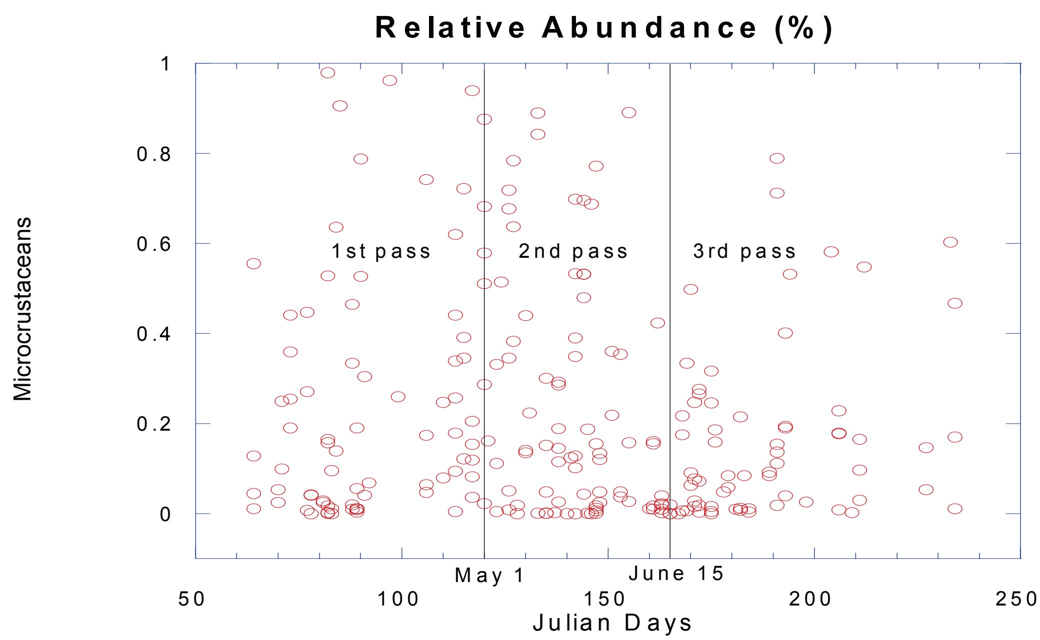
Many of the invertebrates have life cycle phases or temperature restrictions (thermoclines) which limit their presence or abundance during times of the year. Fairy shrimp were predominant in most of the forest and shrub sites in the first pass, yet were mostly absent in subsequent passes (Figure 2 on the next page). As a result metrics were developed for those organisms that were more characteristic of the 2nd and 3rd passes (eg., microcrustaceans). The first pass data was not analyzed in this report for index development.

Mitigation study database

Invertebrates studied in the mitigation study compared 10 constructed wetland sites and 9 natural sites. Invertebrates were collected from the second and third pass from each site. The nine natural sites included three nonreference sties Dever, Lake Abrams and Lodi North, and six reference sites Baker, Ballfield, Calmus, Eagle Creek Beaver, Eagle Creek Marsh, and Rickenbacker. The 10 mitigation sites were Big Island, Bluebird, JMB, Medallion, New Albany, Pizutti, Prairie Lane, Sacks, Slate Run 3, and Trotwood.

Figure 2. Relative abundance of *eubranchius vernalis* (fairy shrimp) and microcrustaceans by julian date, 1996-2002. Julian date is the day of the year measured as January 1 counted as 1 and December 31 counted as 365, in a non leap year.





Metric development database

Metric selection was based on several different subsets of the 1996-2002 data. The largest dataset used for statistical analyses was 149 records from 83 different sites, Table 1.

Table 1. Number of sites and records used for statistical analyses.

Wetland type	Number of sites				Number of records			
	Reference	Nonref.	Mitigaiton	**Total**	Reference	Nonref.	Mitigaiton	**Total**
Emergent	9	22	10	41	24	34	21	79
Forest	7	12	0	19	13	18	0	31
Shrub	14	9	0	23	23	16	0	39
Total	30	43	10	83	60	68	21	149

Organism and organism groups tested are listed in Appendix Table 1. This Appendix Table lists p-values for parametric and non-parametric tests showing significant differences between the reference (R), nonreference (N), and mitigation (M) sites for each of the organism groups. For the mitigation study, the 10 mitigation (M) and 9 natural (nat) sites were tested for significant differences.

The dataset used for metric calibration was 60 records from 30 reference sites collected between 1996 and 2002. Only second and third pass data was analyzed. The lower 5th and upper 95th percentiles were used as lower and upper limits for calibration.

4.0 The Mitigation Study

In 2001, 10 mitigation and 9 natural emergent wetlands were sampled. Major differences in taxa richness and relative abundance of several invertebrate groups were observed in the data set. Total number of taxa, dytiscid beetle taxa, and chironomid/dipteran taxa were significantly higher in the natural sites.

Species richness

Numbers of dytiscid beetle, dipteran/chironomid, and total taxa richness were higher at the natural sites (Figure 3). This relationship was significant with (p-value = .002) or without (p-value = .003) the total number of taxa adjusted for different numbers of traps deployed at a site.

Another significant difference was a higher number of EPT taxa at the mitigation sites. This was due mainly to the two mayfly genera Caenis and Callibaetis which were present at most of the mitigation sites, but less than half of the natural sites. These taxa are considered facultative to pollution tolerant (values of 28 and 22) in the wetland sensitivity index in Appendix Table 3.

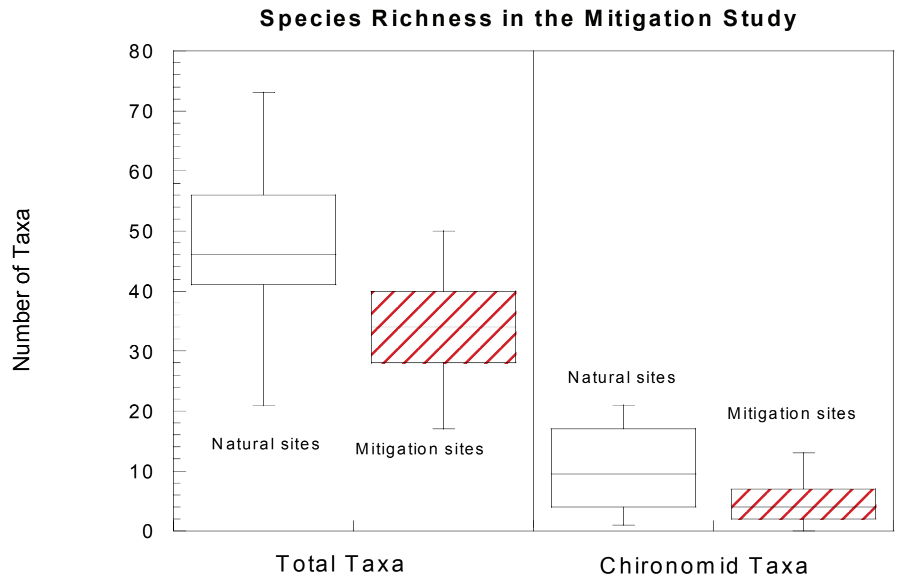
Species richness did not appear as significant with the whole dataset when compared to the results for the mitigation study alone. Whether low invertebrate diversity is characteristic of mitigation sites in general compared to natural sites should be re-evaluated from the results obtained from the Ohio EPA 2004 field survey of mitigation banks. In the 2004 survey, 26 wetland sites from 8 mitigation banks will be sampled.

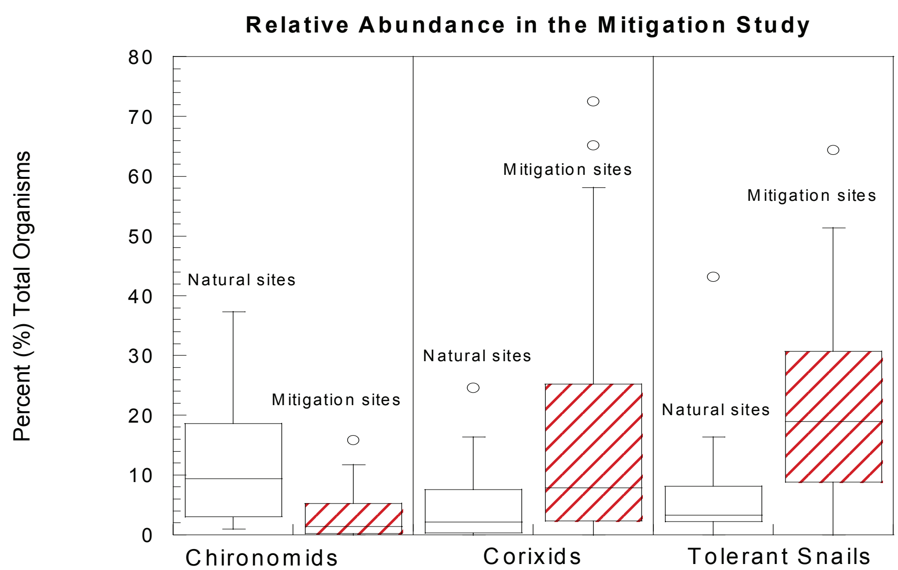
Relative abundance

The relative abundance of oligochaetes, ostracods, and chironomids/dipterans were higher in the reference sites. The oligochaetes collected by the funnel trap method in the reference sites appeared to belong to the Family Naididae. This family of oligochaetes appeared to be sensitive in wetlands compared to the *Tubifex tubifex* (Family Tubificidae) collected in high percentages from polluted rivers and streams. Ostracods also appear to be a sensitive taxa. Some varieties of ostracods are sensitive to herbicides and pesticides (Thorp *et al*. 2001).

Relative abundance of tolerant beetles, corixids, and tolerant snails were higher in the mitigation sites. The adult beetle genera Berosus, Haliplus, Peltodytes, and Tropisternus are herbivores. They are commonly found in dense mats of aquatic vegetation or algae mats. This was in opposition to the higher number of dytiscid beetle taxa found at the natural sites. The adult dytiscid beetles are predacious. Corixid abundance was higher at the mitigation sites, especially the genera *Ramphocorixa, Sigrara, and Trichocorixa*. In the reference sites only the corixid genus *Hesperocorixa* was collected in moderate numbers. The tolerant snail genera *Physella* and *Gyraulus* were more abundant at the mitigation sites.

Figure 3. Graphs of species richness and relative abundance from the mitigation study.





5.0 Metric Selection

A metric is a characteristic of an organism or an organism group that exhibits a positive or negative association with an environmental factor. Several organism groups were significant indicators of community health in the mitigation study mentioned above in Section 4.0. Previous work on the 1996 to 2000 data by the Ohio EPA (Micacchion *et al.* 2000) suggested chironomids and dytiscid beetles as possible metric candidates. Studies from other states (U.S. EPA 2002) suggested leeches, odonates, corixids, and other organism groups as metrics. From these studies and initial data analyses of major organism groups of the data, a group of approximately 40 metric candidates (Appendix Table 1) were chosen and tested with the 1996 to 2002 Ohio EPA database.

Data was grouped into one of three categories: 1) M – mitigation, 10 sites and 21 records; 2) N – nonreference natural, 43 sites and 68 records; and 3) R – reference, 30 sites and 60 records. All data analyzed was 2nd and 3rd pass (May to July). Reference and nonreference grouping was determined from the Ohio EPA wetland inventory list based upon previous studies of weland vegetative index of biotic integrity scores (VIBI), the Ohio Rapid Assessment Method (ORAM 5.0) scores of habitat quality, and the placement of wetlands into Category 1,2, or 3 for regulatory purposes. A disturbance scale using metrics 2, 3e, 4a, and 4c from ORAM 5.0 was used to test for regression analyses on organism groups for the nonreference and reference natural sites. Mitigation sites were not evaluated in the regression analyses because the ORAM 5.0 metrics apply only to natural sites.

Organisms and organism groups were tested for significant differences (p-values < .05) among the mitigation, nonreference, and reference groups. Parametric general linear models (GLM) test, which is comparable to analyses of variance (ANOVA) and the t-test, and a nonparametric Kruskal-Wallace test were used to calculate the p-values. Comparing differences between the parametric and nonparametric tests helped to alleviate some of problems due to the parametric model assumptions such as nonnormality of data and unequal variance plus aided in the identification of outliers in the dataset. Regression analyses was conducted on each of the 40 organism groups using the disturbance scale listed in the above paragraph as the x-axis.

From this analyses 6 metrics were chosen for metric scoring and calibration: relative abundance of oligochaetes, microcrustaceans, corixids (without genus Hesperocorixa), dytiscid beetles, tolerant beetles, and tolerant snails. Another negative metric, abundance of odonates, and a positive metric, sensitive snails (not including the genera Physella and Gyraulus), were also chosen for analyses on a total of 8 metrics. The addition of these metrics showed more discrimination between the 25th percentile reference and the 75th percentile nonreference sites, and showed a higher correlation (regression R^2). However, the relative abundance in the data set for odonates and sensitive snails was lower than the other organism groups used in the index. A more generalized tolerant and sensitive taxa metric may incorporate their influence more effectively than as a set of metrics on their own.

The sensitivity/tolerance index computed in section 7.0 showed that some of the metrics will need to be adjusted. Possibly the exclusion of the genus Tropisternus from the tolerant beetle metric, or rather the speciation of this genus and the subsequent testing of the different species tolerances for exclusion/inclusion in the metric. Copepod abundance shows signs of being a positive metric when comparing the mitigation sites with the natural sites, however when comparing nonreference and reference sites there is no significant difference or any slight differences detected (p-values between .090 to .107) are toward a negative metric. Identification beyond order level may be needed for cladocerans, ostracods, and copepods.

6.0 Metric Calibration

Each metric was scored on a 0, 3, 7, 10 scale for the purpose of compatibility with the other Ohio EPA wetland biotic indices the vegetative (VIBI) and amphibian (AmphIBI). Reference sites only were used for the scoring. Three different scoring strategies were used on the metrics (Table 2).

Table 2. Regression results (R^2)and WICI percentile results for the three metric scoring strategies.

Scoring Method	Regression R^2 Metric Score vs Disturbance		Metric Score Range Percentiles								
			Reference Range			Nonreference Range			Mitigation Range		
	128 Records	Outliers removed	25th	50th	75th	25th	50th	75th	25th	50th	75th
6 Metrics											
Quadrisect	.185	.336	27	33	40	17	23	33	10	10	14
30th, 70th	.274	.377	33	40	44	25	30	38	12	16	20
25th, 75th	.306	.420	23	33	37	13	20	31	6	7	13
8 Metrics											
Quadrisect	.214	.353	37	43	50	23	30	42	13	13	20
30th, 70th	.325	.359	47	53	57	33	40	47	19	26	30
25th, 75th	.367	.421	34	43	49	23	27	37	10	14	20

In the first method, reference data was quadrisected at the 95th percentile. For positive metrics the upper quadrant of relative abundance was assigned a score of 10, then 7, 3, and 0 for successive quadrants. For the negative metrics the assignment of scores was reversed (0, 3, 7, and 10) . This method showed the least discriminatory influence and lowest disturbance correlation than the other methods.

The second method ranked 60 reference sites in order of relative abundance. For positive metrics a score of 0 was assigned to values below the 5th percentile, 3 for values between the 5th and 30th, 7 for values between the 30th and 70th percentiles, and 10 for values above the 70th percentile. For negative metrics, relative abundance above the 95th was assigned a 0, then 3,7, and 10 for values above the 70th, 30th, and 5th respectively. This method was very close to assigning actual percentiles as scores. With a larger database this method could be expanded so that the score for a metric would be determined by the actual percentile of the reference database (ie. if the relative abundance was at the 63rd percentile of the reference database, a metric value of 6.3 would be assigned).

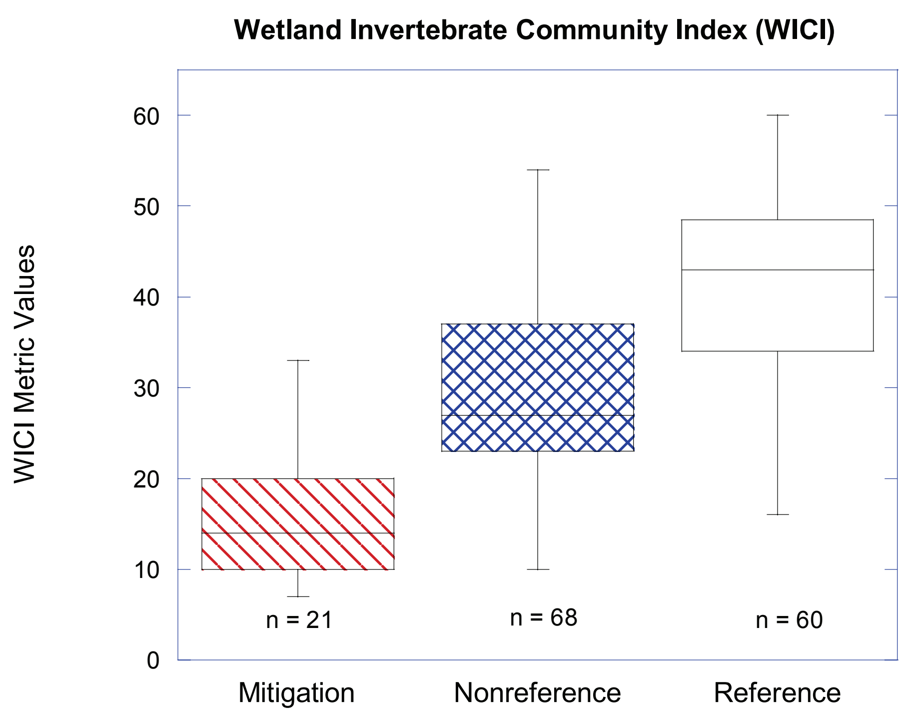
The third method ranked the database into quartiles. Similar to method three but the 5th, 25th, 75th, and 95th percentiles were used as breakpoints. Table 3 shows the exact breadpoints used for the relative abundance of organism groups. Table 2 compares the discriminatory power of these methods on the invertebrate inidices on the Ohio EPA database. This method of using the 25th and 75th percentiles with 8 metrics was chosen for the initial development of the WICI index because it represented a high level of discrimination between reference and nonreference sites and a high level of correlation with wetland quality.

Table 3. Metric score values (0, 3, 7, 10) assigned to relative abundance of organism groups using a 25th and 75th percentile scoring strategy.

	Metric score value assigned			
	0	3	7	10
Oligochaetes	< .006	< .026	< .085	≥ .085
Microcrustaceans	< .050	< .154	< .354	≥ .354
Dytiscids	< .019	< .047	< .120	≥ .120
Sensitive Snails	< .008	< .022	< .060	≥ .060
Corixids	> .0059	> .0005	< .00025	≤ .00025
Tolerant Beetles	> .036	> .014	> .001	≤ .001
Tolerant Snails	> .0522	> .0182	> .0031	≤ .0031
Odonates	> .023	> .009	> .001	≤ .001

The database of 149 records and 83 sites were scored with the metric score values of Table 3. The total WICI index and individual metric scores for these sites are presented in Appendix Table 2. Figure 4 show the boxplots of the WICI index scores for mitigation, nonreference and reference sites.

Figure 4. Wetland Invertebrate Community Index (WICI) scores by wetland type for the Ohio EPA database, 1996-2002.



7.0 Initial Invertebrate Index for the1996-2002 Data

An invertebrate sensitivity/tolerant list was formulated from the initial scoring of sites. Sites were ranked by WICI index score. Organism average relative abundance for ranges 0-10, 11-20, …, 51-60, were calculated and multiplied by the midpoint of the range. This sum was divided by the sum of the average relative abundances. As an example, Eubanchius bundii was only collected at sites in the 51-60 range of scores. The average relative abundance of the 51-60 range multiplied by the midpoint of 55, then divided by the total of the average abundances for all ranges (which in this case is the same number as the average relative abundance at 51-60 since it wasn't found in any of the other ranges) is 55. This method was used to keep the bias due to ranges of unequal sample size to a minimum. Organisms with values less than or equal to 20 are considered tolerant. Those with values greater than or equal to 40 are considered sensitive. Another sensitivity/tolerance list was calculated based upon the disturbance scale. These sensitivity/tolerance lists along with ranks from lowest to highest are presented in Appendix Table 3.

The results from this sensitive/tolerance analyses need to be analyzed further. Some species may have only occurred at a miminal number of sites which could affect the sensitivity/tolerance value (*Eubranchius bundyii* mentioned above). Some of the tolerant organisms groups, specifically Tanytarsini tribe and the Spheariidae family were on the tolerant list. These two groups are general, in that identification is usually taken down to the genus level. However in this case they may have been immature stages and were not able to be taken down further. One possible explanation is that in degraded sites only the immature stages exist and these organisms do not reach more mature stages. Or again, it could be do to a small sample size that happens to be in the lower index range.

Although chironomids and dipteran taxa were more species rich and more abundant at natural sites compared to the mitigation sites, these metrics did not show significant differences between reference and nonreference sites. The sensitivity/tolerance list is a good starting point to separate out the sensitive species from the tolerant ones. Future revisions to the WICI index will incorporate these important organism groups by their sensitivity/tolerance characters.

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Appendix Table 1. Table 1 lists p-values for parametric and nonparametric test on subsets of the database. The general linear models (GLM) test is comparable to a t-test when there are only two groups compared. The nonparametric test used was Kruskal-Wallace. Additionally, p-values are given for regression analyses against a disturbance scale. Wetland types used for comparisons were emergent (E), forest (F), and shrub(S). Groups tested for significant differences were mitigation (M), nonreference natural (N), and reference (R) sites. Generally numbers less than .05 can be considered as significant differences between groups

	Mitigation Study		Tests of Significance on 1996-2002 data						Disturbance Scale	
	Param	NonPar	Parametric Tests			Non parametric			Regression	
	E	E	EFS	EFS	ES	EFS	EFS	ES	EFS	ES
Organism Groups	**M-nat**	**M-nat**	**MNR**	**NR**	**NR**	**MNR**	**NR**	**NR**	**NR**	**NR**
TOTAL TAXA	0.002	0.003	0.695	0.834	0.159	0.751	0.744	0.438	0.058	0.916
TOT 10 TRAP TX	0.001	0.002	0.574	0.956	0.280	0.550	0.571	0.571	0.032	0.682
DYTISCID TX	0.095	0.044	0.024	0.027	0.002	0.021	0.026	0.001	0.277	0.193
ALLBEETLE TX	0.174	0.035	0.508	0.275	0.031	0.416	0.197	0.021	0.482	0.723
CHIRONOM TX	0.005	0.008	0.229	0.469	0.687	0.160	0.135	0.456	0.026	0.250
DIPTERAN TX	0.000	0.002	0.152	0.669	0.896	0.200	0.301	0.626	0.026	0.232
EPT TX	0.042	0.026	0.055	0.368	0.238	0.034	0.346	0.196	0.348	0.341
ODONATE TX	0.670	0.385	0.001	0.048	0.217	0.001	0.044	0.235	0.003	0.052
ABUNDANCE	0.544	0.108	0.521	0.280	0.332	0.391	0.214	0.197	0.403	0.608
OLIGO	0.013	0.000	0.252	0.635	0.548	0.000	0.064	0.034	0.669	0.395
MICROCRUST	0.000	0.000	0.000	0.271	0.790	0.000	0.231	0.475	0.054	0.584
CLADOCERAN	0.002	0.000	0.003	0.336	0.897	0.000	0.238	0.355	0.049	0.390
OSTRACOD	0.014	0.000	0.108	0.213	0.308	0.000	0.878	0.919	0.185	0.567
COPOD	0.030	0.000	0.053	0.107	0.090	0.000	0.473	0.575	0.163	0.174
MICRO-COPOD	0.000	0.000	0.000	0.110	0.400	0.000	0.157	0.309	0.016	0.297
TOTAL MAY	0.401	0.015	0.592	0.335		0.002	0.133	0.107	0.458	0.404
EPT	0.146	0.015	0.689	0.581	0.215	0.220	0.516	0.087	0.480	0.714
CALLIBAETIS	0.032	0.019	0.647	0.689	0.991	0.002	0.364	0.440	0.830	0.743
CAENIS	0.928	0.164	0.334	0.181	0.145	0.074	0.335	0.204	0.328	0.388
TOT CAD	0.147	0.272	0.730	0.888	0.726	0.888	0.813	0.453	0.107	0.451
LIMNEPHILUS			0.541	0.655	0.264	0.084	0.399	0.324	0.099	0.096
LEPTOC	0.127	0.226	0.385	0.484	0.036	0.170	0.230	0.078	0.658	0.067
IRON	0.676	0.910	0.774	0.887	0.271	0.936	0.864	0.685	0.197	0.404
ODONATE	0.511	0.242	0.079	0.105	0.251	0.005	0.025	0.179	0.051	0.040
TOT HEMIPTER	0.001	0.001	0.000	0.969	0.356	0.000	0.623	0.102	0.306	0.763
TOT CORIXID	0.027	0.030	0.002	0.470	0.958	0.000	0.364	0.490	0.126	0.809
CORIXNOHES	0.034	0.043	0.000	0.046	0.238	0.000	0.003	0.160	0.020	0.375
TOL BEETLE	0.003	0.003	0.000	0.053	0.079	0.000	0.096	0.371	0.010	0.038
DYTISCID	0.553	0.501	0.003	0.002	0.013	0.057	0.018	0.029	0.004	0.086
TOT HYDHAP						0.000	0.834	0.983		
TOT DIPTERAN	0.007	0.010	0.023	0.855	0.782	0.020	0.511	0.862	0.897	0.702
TOT CHIRONOM	0.027	0.019	0.102	0.615	0.468	0.121	0.653	0.795	0.345	0.462
TANYPOD	0.261	0.355	0.025	0.026	0.017	0.070	0.026	0.025	0.090	0.119
ORTHCLAD	0.231	0.019	0.332	0.132	0.173	0.036	0.041	0.207	0.012	0.037
CHIRMINI	0.009	0.001	0.052	0.440	0.569	0.010	0.907	0.611	0.730	0.632
TANYTARSINI	0.232	0.927	0.816	0.542	0.517	0.185	0.125	0.197	0.070	0.133
TOL SNAIL	0.007	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SNAIL-TOL.SN	0.759	0.520	0.172	0.070	0.071	0.600	0.309	0.119	0.041	0.016

Appendix Table 2. Wetland Invertebrate Community Index (WICI) metric scores for the Ohio EPA database 1996-2002.

Wetland Name	Date	Oligo.	Microcrst	Dytisc	Corixid	TolBeetl	Odonate	Snail	TolSnail	Metric
2 Meadows Sw	6/2/99	3	0	7	3	0	3	10	0	26
Ackerman	6/12/97	0	0	0	0	3	0	7	0	10
Ackerman	7/25/97	7	7	3	3	3	3	7	0	33
American Leg	7/30/98	3	0	0	0	0	7	3	0	13
American Leg	5/15/98	10	0	3	3	0	7	7	0	30
Area K Wetla	5/27/99	3	7	10	0	3	3	3	0	29
Baker	5/15/01	10	3	0	10	3	7	3	0	36
Baker	6/19/01	10	3	3	10	3	3	10	0	42
Ballfield	5/18/01	10	3	3	0	0	0	7	0	23
Ballfield	6/20/01	10	7	0	10	3	7	7	0	44
Beaver Creek	7/30/98	7	3	0	0	7	0	0	7	24
Beaver Creek	5/15/98	0	0	0	0	7	10	7	7	31
Berger Road	5/27/99	7	0	7	3	3	0	7	0	27
Big Bailey	7/2/02	0	3	0	10	3	0	0	0	16
Big Bailey	5/24/02	0	10	0	3	0	7	0	3	23
Big Woods	5/7/99	0	10	0	10	10	7	3	7	47
Big Woods	6/4/99	3	10	0	10	10	7	7	3	50
BigIsland	5/20/01	0	0	3	0	0	0	7	0	10
BigIsland	6/30/01	3	0	7	0	0	0	0	3	13
Birkner Pond	5/5/00	3	0	0	0	0	3	7	0	13
Birkner Pond	6/23/00	7	0	0	0	0	0	10	0	17
Blackjack Rd	6/20/00	3	3	10	0	3	0	10	0	29
Blackjack Rd	5/17/00	0	7	7	3	0	0	3	10	30
Blackjack Rd	5/17/00	0	7	10	10	7	0	7	0	41
Blackjack Rd	6/20/00	3	7	10	0	3	3	7	10	43
Blanchard Ox	7/9/96	0	10	7	0	7	10	0	3	37
Blanchard Ox	5/23/96	0	10	7	10	10	0	0	3	40
Bluebird	6/16/01	0	0	7	0	0	0	0	0	7
Bluebird	5/8/01	0	0	3	0	0	7	0	0	10
Buckeye Furn	6/27/02	10	0	0	3	3	3	7	10	36
Calamus	6/19/01	10	3	7	0	3	7	10	3	43
Calamus 1997	6/17/97	0	0	10	10	0	0	3	0	23
Calamus 1997	5/15/01	0	0	0	3	7	10	3	7	30
Calamus 1997	5/21/96	3	3	10	3	3	0	10	3	35
Calamus 1997	7/11/96	7	7	7	10	0	0	10	3	44
Calamus 1997	8/21/96	10	7	3	10	3	0	7	7	47
Callahan	6/12/97	0	0	0	10	10	3	0	10	33
Callahan	7/25/97	10	7	7	0	10	10	10	0	54
Cessna	5/23/96	0	0	10	10	7	0	3	7	37
Cessna	7/9/96	10	3	7	10	10	7	10	3	60
Collier Wood	6/11/99	7	10	10	10	7	7	3	3	57
Collier Wood	5/4/99	7	10	3	10	10	10	0	10	60
County Rd 20	5/28/97	0	3	7	10	0	3	0	0	23
County Rd 20	8/20/96	0	10	0	0	3	10	0	0	23
County Rd 20	7/9/96	3	10	3	0	3	3	0	3	25

Appendix Table 2. (continued)

Wetland Name	Date	Oligo-chaet	Micro-crusts	Dytiscid Beetles	Corixids	Tolerant Beetles	Odonate	Sensitive Snail	Tolerant Snail	Metric score
County Rd 20	5/23/96	3	10	7	0	3	0	3	0	26
Dever 1997	7/25/97	3	7	3	3	0	0	0	0	16
Dever 1997	6/17/97	3	7	7	0	0	0	3	0	20
Drew Woods	6/4/99	7	7	7	0	7	10	0	7	45
Drew Woods	5/7/99	0	10	7	10	7	7	0	7	48
E.Br.Sunday	5/24/02	7	10	0	3	0	7	7	0	34
Eagle Beaver	6/23/00	3	7	0	3	0	3	10	7	33
Eagle Beaver	5/5/00	3	10	0	0	3	7	7	7	37
Eagle Cr Ver	6/23/00	0	0	10	10	10	10	0	10	50
Eagle Cr Ver	5/5/00	0	7	3	10	10	10	0	10	50
Eagle Marsh	7/10/01	10	7	7	10	3	0	7	0	44
Eagle Marsh	5/31/01	10	7	7	0	0	10	10	0	44
Falling Tree	6/18/02	10	7	3	10	7	7	0	10	54
Flowing Well	6/12/97	3	0	0	10	10	7	3	7	40
Fowler Woods	5/9/00	0	3	0	10	10	10	3	10	46
Fowler Woods	6/27/00	7	3	7	3	10	10	10	0	50
Gahanna 4th	7/11/96	0	10	3	10	7	7	3	3	43
Gahanna 4th	5/21/96	3	10	10	0	10	0	3	10	46
Graham Rd	6/2/99	7	0	3	0	3	3	7	0	23
Grand R Terr	5/12/00	3	10	3	3	7	7	0	10	43
Grand R Terr	7/7/00	7	3	10	10	7	0	3	7	47
Greendale Be	6/20/02	3	3	0	10	3	3	0	0	22
Greendale Bu	6/20/02	3	0	7	3	0	3	0	0	16
Guilford Lak	6/30/00	10	0	7	0	3	7	0	0	27
Guilford Lak	5/2/00	7	7	3	10	3	0	3	0	33
Hebron	6/10/97	3	0	7	0	0	3	10	0	23
Hebron	8/15/97	10	3	7	3	0	3	7	7	40
Hempelman	6/10/97	0	0	3	3	7	0	0	10	23
Hewitt Fork	6/25/02	10	7	3	10	7	0	7	0	44
JMB	6/14/01	0	0	3	0	0	0	7	0	10
JMB	5/22/01	0	0	3	0	0	3	10	0	16
Johnson Rd	5/27/99	0	0	0	3	7	7	0	7	24
Keller High	6/10/97	0	7	10	3	0	3	10	0	33
Keller High	8/15/97	7	3	10	10	0	3	0	7	40
Keller Low	6/10/97	0	7	10	0	0	0	3	3	23
Killdeer Pla	5/27/99	0	10	3	10	10	7	3	10	53
King Hollow	7/30/98	10	7	0	3	7	3	0	7	37
King Hollow	5/21/98	10	3	0	10	3	10	7	10	53
Lake Abrams	7/31/01	10	10	0	3	7	0	0	3	33
Lake Abrams	5/26/01	10	10	0	0	10	10	0	3	43
Lawrence Hig	5/28/97	7	0	10	10	0	3	10	7	47
Lawrence Hig	7/23/97	7	10	3	10	7	10	7	3	57
Lawrence Low	5/27/99	0	0	3	3	7	7	3	0	23
Lawrence Low	5/28/97	0	0	7	0	0	7	10	0	24
Leafy Oak 19	5/28/97	0	3	7	10	10	0	0	10	40
Leafy Oak 19	7/9/96	3	0	10	10	10	10	7	7	57

Appendix Table 2. (continued)

Wetland Name	Date	Oligo.	Microcrst	Dytisc	Corixid	TolBeetl	Odonate	Snail	TolSnail	Metric Score
Lodi North	5/18/01	0	3	3	0	0	0	7	0	13
Lodi North	7/3/01	0	0	7	3	3	7	7	0	27
Mantua	7/10/01	10	3	0	3	3	3	3	3	28
Mantua	5/31/01	0	10	3	3	0	3	7	7	33
McKinley	7/11/96	0	7	3	0	0	3	0	0	13
McKinley	8/21/96	7	10	0	0	7	0	0	0	24
McKinley	5/21/96	3	7	0	10	10	7	0	7	44
Medallion	6/14/01	0	0	3	0	0	0	10	0	13
Medallion	5/8/01	0	0	3	10	0	0	10	0	23
Mishne 1997	5/21/96	0	3	7	10	0	0	10	0	30
MorganMarsh	7/13/01	10	10	3	0	3	7	0	10	43
New Albany	5/1/01	0	7	3	3	0	0	3	0	16
New Albany	6/9/01	10	0	0	3	3	7	10	0	33
Oyer Wood Fr	6/18/99	3	0	10	0	7	10	10	3	43
Oyer Wood Fr	5/11/99	7	7	10	3	7	7	10	3	54
Paine Beaver	6/20/02	0	0	7	3	0	0	0	10	20
Pallister	5/12/00	0	10	0	7	10	10	0	10	47
Pallister	7/7/00	3	3	10	0	10	10	3	10	49
Palmer Rd	5/25/99	3	0	7	0	0	10	10	0	30
Pawnee Rd	5/9/00	0	3	0	10	10	10	10	10	53
Pizzutti	5/13/98	0	0	10	0	0	3	0	0	13
Pizzutti	6/14/01	0	0	10	3	0	0	7	0	20
Pizzutti	7/28/98	0	0	0	0	7	10	0	10	27
Prairie Lane	7/3/01	0	0	7	0	0	3	10	0	20
Prairie Lane	5/17/01	0	0	3	10	0	7	10	0	30
Rickenbacker	7/11/96	3	0	7	3	0	0	7	3	23
Rickenbacker	5/15/01	7	7	3	0	0	0	0	7	24
Rickenbacker	6/19/01	7	10	3	0	0	3	3	7	33
Rickenbacker	5/21/96	10	10	0	3	7	0	3	3	36
Rickenbacker	8/21/96	7	0	7	10	3	3	3	3	36
Route 29	6/12/97	3	0	10	10	0	0	7	0	30
Route 29	7/25/97	3	0	10	10	10	7	10	3	53
Rutherford	6/25/02	7	7	0	10	7	3	3	0	37
Sacks	6/21/01	0	7	0	0	0	3	0	0	10
Sacks	5/18/01	0	0	7	3	0	0	0	0	10
Sawmill	6/17/97	3	7	3	0	7	3	10	0	33
Sawmill	5/21/96	10	10	7	0	7	0	7	3	44
Scofield	5/27/99	0	0	3	0	3	0	10	0	16
Slate Run	5/25/99	3	7	7	0	0	0	10	0	27
Slate Run 3	5/3/01	0	0	7	0	0	0	0	0	7
Slate Run 3	6/12/01	0	0	3	3	0	3	10	0	19
Steels Corne	7/17/01	0	0	0	10	7	0	0	0	17
Steidt Marsh	7/1/03	10	7	0	10	7	3	0	0	37
The Rookery	6/2/99	7	10	7	3	7	0	10	0	44
Tinkers Cree	5/5/00	3	3	0	0	0	3	7	0	16
Tinkers Cree	6/23/00	3	0	0	3	0	7	7	7	27

Appendix Table 2. (continued)

Wetland Name	Date	Oligo.	Microcrst	Dytisc	Corixid	TolBeetl	Odonate	Snail	TolSnail	Metric Score
Towners Wood	6/23/00	7	7	3	0	7	7	0	10	41
Towners Wood	5/5/00	7	10	7	10	7	3	0	10	54
Townline Rd	6/27/00	7	3	3	0	3	0	10	0	26
Townline Rd	5/9/00	0	10	7	3	7	0	10	7	44
Trotwood	6/21/01	7	0	7	0	0	0	0	0	14
Trotwood	5/26/01	3	0	0	0	3	7	7	0	20
US 42	5/17/00	0	7	0	0	3	10	0	0	20
US 42	6/20/00	3	0	0	0	7	10	0	0	20
Watercress M	6/30/00	7	0	3	0	0	3	10	0	23
Watercress M	5/2/00	0	3	3	10	0	3	10	0	29
Wilson Swamp	5/7/99	0	10	3	3	10	7	0	3	36
Wilson Swamp	6/4/99	10	0	7	0	3	10	7	0	37

Appendix Table 3. Sensitivity/tolerance values were computed for the organism groups from the metric values in Table 2. Taxa withsensitivity values near 40 and above are considered sensitive and taxa with values around 20 or less considered tolerant.

Organism Group	Metric Score Sensitivity	Disturbance Scale Sensitivity	Metric Score Rank	Disturbance Scale Rank
HYDRA	30.70972	35.69565	73	57
TURB	41.08915	33.82951	120	46
OLIG	40.7673	39.70777	119	86
HIRUDINEA	34.75461	39.79371	94	88
HSTAG	23.97195	31.62557	44	29
PPAPI	33.36018	40.44988	86	97
ERPOB	18.17957	22.00615	16	1
EBUND	55	54.618	144	144
EVERN	42.1949	47.07682	124	125
LYNC	26.67867	39.59122	55	85
CLADOC	39.98912	41.8345	114	109
OSTRA	40.39752	41.65396	117	106
COPOD	39.49009	34.04073	112	50
MICRO	40.10046	40.96532	115	99
CLADOSTR	40.1666	41.76431	116	108
CAECI	39.72622	38.74211	113	81
HAZTEC	23.76072	29.91874	43	16
CRANGX	34.41852	42.6367	93	110
DECAPODSP	32.11714	46.93944	81	124
FALLI	49.42136	41.72235	141	107
ACUTIS	38.72511	52.66679	108	140
HCARIN	28.40763	37.72535	63	75
MAYSP	35	38.7	96	80
CALLI	22.60062	39.38308	36	83
CAEN	28.1311	33.93546	60	48
TOTMAY	26.24546	35.61211	52	56
LESTIDA	21.92997	31.28048	32	21
COENG	22.19151	30.75354	33	20
AESHS	17.97425	37.53435	15	72
LIBELS	8.430447	31.57106	2	28
PACHY	22.74287	25.0943	38	4
SYMPT	31.55889	40.32451	77	91
TOTODON	20.58899	33.09122	27	41
BELAS	19.82218	41.42165	23	104
RANAT	13.03006	36.33398	4	62
NEOPL	32.41394	40.02904	83	89
NEOMET	35.19484	41.23281	98	103
PLECR	25.13647	40.36207	49	92
BUENO	20.25484	44.11748	26	118
NOTO	19.76795	42.78194	22	111
CORIXS	15.75808	24.26027	7	3
HESP	27.9444	41.01693	59	100
HESPME	36.59805	43.96629	104	117
SIGAR	10.66574	30.20296	3	18

Appendix Table 3. (continued)

Organism Group	Metric Score Sensitivity	Disturbance Scale Sensitivity	Metric Score Rank	Disturbance Scale Rank
TRICHX	22.49269	28.3723	34	10
CORNOHES	14.43421	27.80563	6	7
TOTCORI	17.65619	32.94004	14	39
TOTHEMI	19.10019	36.19938	20	61
CHAULS	46.47973	43.66513	137	116
CADSP	41.51713	31.99221	123	34
IRONS	41.33018	50.03022	121	136
LIMNS	45.40129	47.15307	135	126
LEPTOC	29.06436	36.79691	68	66
TOTCAD	40.57032	45.24882	118	121
EPT	33.23557	40.44215	85	96
HALIP(1)	17.56214	31.5216	13	26
PELTO(1)	17.02272	31.84276	10	30
DYTIS	26.76305	37.1346	56	70
ACILI	47.58742	49.29216	138	134
AGBET	46.01671	54.61395	136	143
AGBUS	28.82544	39.33194	65	82
COPTO	19.47829	32.2571	21	37
DYTCUS	44.51699	48.78307	129	131
GRAPH	33.76019	42.8834	89	112
HYPOR	29.06135	41.58559	67	105
HYGRO	33.09601	37.44593	84	71
LACPH	18.97589	36.67018	19	64
LACOR	35.03466	39.78463	97	87
MATUS	34.22915	44.69741	92	120
THERM	33.87045	38.15543	90	77
TOTDYT	35.47096	43.63672	99	115
HYCAN	22.64601	36.8209	37	67
HYPHILS	23.02067	34.82632	39	53
BEROS(1)	13.30725	32.29215	5	38
ENOCH	37.72511	47.7095	107	128
HYBUS	49.51269	49.14718	142	133
HYCHAR	45.27564	52.51064	134	139
TROP	18.4321	35.58624	17	55
TROPMET	25.1322	37.58043	48	74
HALIPHYDO	20.69632	36.7863	28	65
TOLBEET	17.30583	33.50895	11	44
TOLNOTRP	16.49493	31.87851	9	31
CIRCU	23.70027	48.95722	41	132
DIPT1(1)	28.28962	41.07743	61	102
CHAOB(1)	36.08933	40.11024	101	90
MACHL(1)	48.86158	52.37028	140	138
CULIS(1)	33.40852	45.72893	87	122
AEDES(1)	44.70378	47.58599	131	127
CERAT(1)	25.45278	34.77008	51	52

Appendix Table 3. (continued)

Organism Group	Metric Score Sensitivity	Disturbance Scale Sensitivity	Metric Score Rank	Disturbance Scale Rank
TPOD1	29.31803	46.15764	69	123
TPOD2	36.88176	28.04474	105	9
ABPEL	30.3748	35.79304	72	58
LARS	23.25707	35.81879	40	59
PROCL	26.30045	31.3484	53	23
PSECT	34.00194	37.99972	91	76
TANPUS	21.28931	26.09084	30	5
ORCLAD	27.49234	31.3614	57	24
ACRIC	29.97748	32.05938	71	35
CSYLV	20.94678	31.89684	29	32
LYMNOP	39.35341	34.71292	111	51
PSCLAD	25.37673	33.96619	50	49
CHIRS	39.27251	47.80896	110	129
CDEC	42.54777	40.53342	125	98
CHINI	30.96966	38.30093	75	78
DICRS	21.46313	33.00804	31	40
DINEO	50.60841	23.3267	143	2
ENDO	30.7819	27.89405	74	8
GLYP	42.87456	35.34417	126	54
KIEF	44.54791	50.20593	130	137
PARAC	24.21021	28.40029	45	11
POLYS	27.69951	36.55753	58	63
TRITV1	45.02571	40.41513	133	95
PTRIG	31.47852	41.03471	76	101
ZELLA	28.64844	33.8715	64	47
TARSI	6.792849	27.1399	1	6
PARAT	23.70421	28.96406	42	13
TANYS	34.9802	37.55615	95	73
DIPT2	19.92447	31.55173	24	27
ODNTO	28.8671	29.42747	66	14
TOTTANPOD	28.39239	33.38966	62	43
TOTORTHO	25.07901	31.96802	47	33
TOTCMINI	36.30721	39.38343	102	84
TOTTARS	24.74239	32.08529	46	36
TOTCHIR	32.30972	36.87522	82	68
TOTDIPT	33.50119	38.40916	88	79
GAST	22.56881	31.31051	35	22
HYBII	45	31.368	132	25
FOSS	31.58691	44.20287	78	119
STAG	43.16586	48.17503	127	130
APLX	47.74432	53.70962	139	142
PHYS	20.22399	30.6463	25	19
PHYSMET	26.52754	33.27187	54	42
GYRL	15.79777	28.43906	8	12

Appendix Table 3. (continued)

Organism Group	Metric Score Sensitivity	Disturbance Scale Sensitivity	Metric Score Rank	Disturbance Scale Rank
HELI	39.12591	49.88974	109	135
MENES	43.90004	37.09812	128	69
PPILS	29.50841	40.40568	70	94
PARMI	35.52607	53.5051	100	141
PROME	41.34678	43.31962	122	113
FERR	32.06193	36.04806	80	60
SPHIDA	17.35586	29.83027	12	15
PISID	31.91597	33.66132	79	45
SPHIUM	37.58236	40.40118	106	93
TOLSNAIL	18.60914	30.02935	18	17
GASNOTOL	36.3581	43.46552	103	114