State of Ohio
Environmental Protection Agency

Wetland Ecology Unit
Division of Surface Water

ORAM v. 5.0 Quantitative Score Calibration
Last Revised: August 15, 2000

John J. Mack

122 South Front Street, P.O. Box 1049
Columbus, Ohio 43216-1049

Table of Contents

1.0 Introduction 3

2.0 VIBI general characteristics and calibration of the ORAM score and wetland categories. 6

3.0 Comparison of ORAM v. 4.1 to v. 5.0. 11

4.0 Revised Scoring breakpoints for ORAM v. 4.1. 13

5.0 Cautionary Statement. 14

6.0 References 15

List of Tables

Table 1. Factors associated with wetlands that can be negatively impacted by human activities causing wetland degradation. 3

Table 2. Interim scoring breakpoints for wetland regulatory categories for ORAM and VIBI scores. . . 7

Table 3. Comparison of wetland categorization results for N=45 wetlands using quantitative score and scoring breakpoints for ORAM v. 4.1 and 5.0 and the Vegetation IBI.. 12

Table 4. A comparison of the categorization results for ORAM v. 4.1, 5.0, and the Vegetation IBI using a data set the 45 wetlands used to derive the VIBI score.. 12

Table 5. Provisional Breakpoints between Wetland Categories in Ohio Rapid Assessment Method Version 3.0, 4.0, and 4.1 Scoring Scheme. 13

Table 6. Breakpoints for Forested and Scrub-Shrub vegetation communities for Ohio Rapid Assessment Method Version 3.0, 4.0, and 4.1 Scoring Scheme. 13

List of Figures

Figure 1. Ecoregions of Ohio, Indiana, and neighboring states. From Woods et al. 1998. 4

Figure 2. VIBI scores for emergent (E), forested (F) and scrub-shrub(SS) vegetation communities versus ORAM v. 5.0 score. Line is fitted line from linear regression of 45 wetland IBI scores. 8

Figure 3. Box an whisker plots of emergent (E), forested (F), and scrub-shrub (SS) vegetation community VIBI scores. A line is drawn across the box at the median. Number on line is mean VIBI score. Means with different letters were significantly different. 8

Figure 4. Box an whisker plots of all VIBI scores by wetland condition. Dot is the mean score. All means were significantly different from one another except "very poor" versus "poor", "poor" versus "fair," and "good" versus "reference" (df=44, F=35.27, p=<0.001). 9

Figure 5. Box an whisker plots of all VIBI scores by wetland type (reference or nonreference condition, i.e. lacking in obvious human cultural influences). Dot is the mean score. Means were significantly different from one another (df=44, F=45.3, p=<0.001). 9

Figure 6. Box an whisker plots of all VIBI scores by wetland category as determined by the wetland's VIBI score. Dot is the mean score. All means were significantly different from one another (df=44, F=93.78, p=<0.001). 10

Figure 7. Interim VIBI scores and interim wetland categorization breakpoints for emergent, forested, and scrub-shrub wetland vegetation community classes and ORAM score for 45 wetlands in the Eastern Corn Belt Plains Ecoregion of the State of Ohio. 10

1.0 Introduction

A principal goal of the Clean Water Act is to maintain and restore the physical, chemical and *biological integrity* of the waters of the United States. 33 U.S.C. §1251(a). Biological integrity has been defined as "...the capability of supporting and maintaining a balanced integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region (Karr and Dudley 1981).

The factors in natural wetlands which can be degraded by human activity fall into several broad classes: biogeochemistry, habitat, hydrology, and biotic interactions (Table 1). The quantitative measurement (assessment) of the degree of integrity of a particular natural system, and conversely the degree of impairment, degradation or impoverishment, can be attempted in many ways. The State of Ohio has successfully developed a sophisticated system using ambient biological monitoring of fish and macroinvertebrate assemblages to assess the quality of streams and lakes in Ohio (the Invertebrate Community Index (macroinvertebrates), the Index of Biological Integrity (fish), and the Modified Index of Well Being (fish) (Ohio EPA 1988a, 1988b, 1989a, 1989b; Yoder and Rankin 1995). The State of Ohio's system was based on methods and results first published by Karr et al. (1986). This type of system is often referred to as an "Index of Biotic Integrity" and has been used and adopted throughout North America and Europe (Karr 1993). *See also* Karr and Kerans (1992); Barbour et al. (1992); Bode and Novak (1995); Hornig et al. (1995); Simon and Emery (1995), Hughes et al. (1998). The statistical properties of Ohio's IBI was investigated and validated by Fore, Karr, and Loveday (1993). They concluded that the IBI could distinguish between five and six nonoverlapping categories of integrity and that the IBI is "...an effective monitoring tool that can be used to communicate qualitative assessments to the public and policy makers or to provide quantitative assessments for a legal or regulatory context based on confidence intervals or hypothesis testing procedures (Fore, Karr, and Loveday, p. 1077, 1993).

Table 1. Factors associated with wetlands that can be negatively impacted by human activities causing wetland degradation. Adapted from lists for flowing waters from Karr and Kerans (1992), Karr et al. (1986), Ohio EPA (1988a).

factor	description	examples of disturbances
biogeochemistry	natural patterns of that type of wetland for nutrient cycling, decomposition, photosynthesis, nutrient sequestration and release, aerobic/anaerobic regimes, etc.	nutrient enrichment, sedimentation, addition of organic or inorganic chemicals, heavy metals, toxic substances, etc.
habitat	natural patterns and structures of that type of wetland for floral and faunal communities.	mowing, grazing, farming, vehicle use, clearcutting, woody debris removal, shrub/sapling removal, herbaceous/aquatic bed removal, sedimentation,, etc.
hydrology	natural hydrologic regime of that type of wetland: frequency, duration, amount of inundation; sources of water, etc.	ditching, tiling, dikes and weirs, additions of stormwater, point source discharges, filling and grading, construction of roads and railroad beds, dredging, etc.
biotic interactions	natural patterns of competition, predation, disease, parasitism, etc.	introduction of nuisance or nonnative species (carp, reed canary grass, purple loosestrife, European buckthorn), etc.

The State of Ohio's indices are codified in Ohio Administrative Code Chapter 3745-1 and constitute numeric "biological criteria" which are a part of the state's water quality standards required under the Clean Water Act. *See* 33 U.S.C. §1313. Biological criteria are numerical values or narrative expressions that describe the reference biological integrity of natural communities (U.S. EPA 1990). It is important to stress that the overall index score resulting from an IBI, as well as each individual metric represent testable hypotheses as to how a natural system responds to human disturbance (Karr 1993). Attributes of natural communities are selected and predictions are made as to how the attribute will respond, e.g. increase or decrease; not change until a particular threshold is reached and then increase quickly; increase linearly, or curvilinearly, etc. Moreover, the existing biological condition of a natural system is the integrated result of the chemical, physical, and biological processes that comprise and maintain the system, and the biological condition of the system can be conceived as the integration or result of these processes over time (Ohio EPA 1988a). The organisms, individually and as communities, are indicators of the actual conditions in that system since they inhabit the system and are subject to the variety of natural and human-caused variation (disturbance) to the system (Ohio EPA 1988a). In this regard, biological monitoring and biocriteria take advantage of this inherent integrative characteristic of the biota of a system, whereas chemical and toxicity monitoring only represents a single point in time unless costly, continuous sampling over time is performed. Table 3 lists some of the advantages inherent in biological monitoring.

"Wetlands" are a type of water of the United States and a water of the State of Ohio under federal and state law. *See e.g.* Ohio Revised Code (ORC) §6111.01(H), OAC Rule 3745-1-02(B)(90), 33 CFR 323.2(c). Until recently, wetlands in Ohio were only generically protected under state's water quality standards. On May 1, 1998, the State of Ohio adopted wetland water quality standards and a wetland antidegradation rule. OAC Rules 3745-1-50 through 3745-1-54. The water quality standards specify narrative criteria for wetlands and created the "wetland designated use." All jurisdictional wetlands are assigned to the "wetland designated use." However, numeric criteria were not proposed since they had not yet been developed.

Ohio began working on the development of biological criteria for wetlands in 1996. To date, Ohio has sampled over 60 different wetlands located primarily in the Eastern Cornbelt Plains Ecoregion (Figure 1). These wetlands have included isolated wetlands and wetlands located in riparian settings, wetlands dominated by predominately emergent, forested, and scrub vegetation, wetlands located on the margins of kettle lakes, and wetlands which can be classified as fens and bogs. The wetlands being studied span the range of condition from "impacted" (i.e., those that have sustained a relatively high level of human disturbance) to "least-impaired" (i.e., the best quality sites available). This work has been funded since 1996 by several different U.S. EPA Region 5 Wetland Program Development Grants

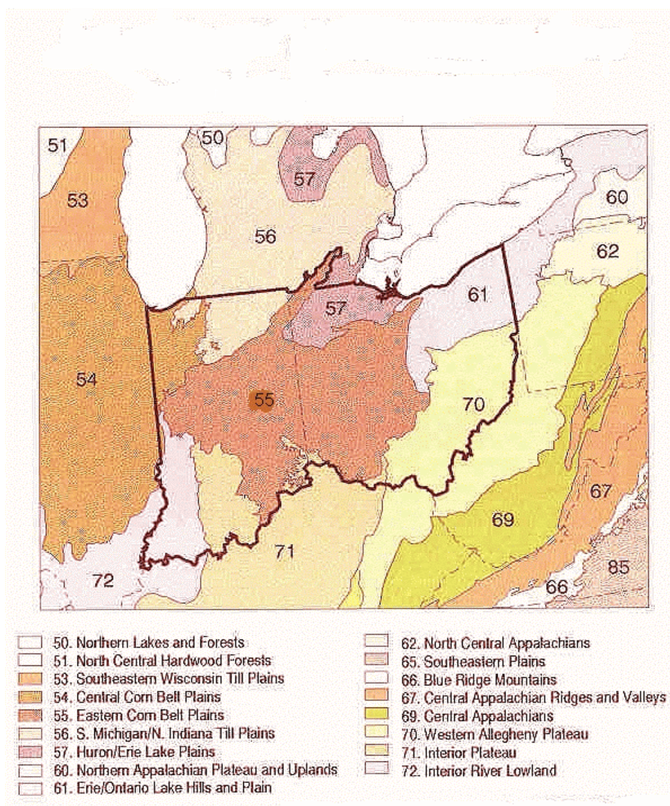

Figure 1. Ecoregions of Ohio, Indiana, and neighboring states. From Woods et al. 1998.

including CD995927, CD995761, CD985277, CD985276, and CD985875. Based on preliminary results (Fennessy et al.1998a, 1998b), Ohio EPA concluded that vascular plants, macroinvertebrates, and amphibians could be used as indicator organisms for the development of wetland-specific IBIs

The objectives of the wetland biocriteria development project are as follows:

1. To develop Indices of Biotic Integrity (both interim and final) to evaluate ecological integrity of a wetland using vascular plants, macroinvertebrates and amphibians indicator taxa.

2. To identify and describe reference wetlands in the Ohio's four main ecoregions Eastern Cornbelt Plains, Erie/Ontario Drift and Lake Plain, Huron-Erie Lake Plain, and Western Allegheny Plateau.

3. To continue to assess and calibrate the Ohio Rapid Assessment Method, and to test and refine breakpoints between the wetland categories required under the Wetland Antidegradation Rule (see below).

A key feature of Ohio's current regulatory program for wetlands is found in the wetland antidegradation rule. *See* OAC Rule 3745-1-54. The wetland antidegradation rule categorizes wetlands based on their functions, sensitivity to disturbance, rarity and irreplaceability and scales the strictness of avoidance, minimization, and mitigation to a wetland's category. Three categories were established: Category 1 wetlands with minimal wetland function and/or integrity; Category 2 wetlands with moderate wetland function and/or integrity; and Category 3 wetlands with superior wetland function and/or integrity. A wetland is assigned to one of these three categories "...as determined by an appropriate wetland evaluation methodology acceptable to the director." OAC Rule 3745-1-54(C)(1)(a), (C)(2)(a), and (C)(3)(a). During the rule development process, Ohio EPA began developing its own wetland evaluation methodology known now as the Ohio Rapid Assessment Method (ORAM) for wetlands. The ORAM is a rapid, semiquantitative, wetland ranking tool. *See* discussion below and ORAM Manual (Mack 2000).

The ORAM is designed to categorize a wetland based on whether it is particular type of wetland (e.g. fen, bog, old growth forest, etc.) or contains threatened or endangered species, or based on its "score." Fennessy et al. (1998) found significant correlations between a wetland's score on the ORAM and the wetlands biological quality and/or degree of disturbance. The initial scoring ranges proposed in Fennessy et al. (1998) were descriptively derived from a sample of wetlands scored using the ORAM and the professional judgment of The Ohio Rapid Assessment Workgroup (Fennessy et al. 1998). Recalibration of the scoring ranges using actual measures of a wetland's biology and functions has been a continuing need since the adoption of the Wetland Water Quality Standards and Wetland Antidegradation rules and the use of "draft" versions of the ORAM (versions 3.0, 4.0, and 4.1) in regulatory decision making.

This report describes scoring ranges for ORAM version 5.0 for determining Category 1, 2, and 3 wetlands when using the ORAM. *See* Mack et al. (2000) for a detailed discussion of the development of the interim Vegetation Index of Biotic Integrity (VIBI) for forested, emergent, and scrub-shrub wetlands.

The interim VIBI and ORAM scoring ranges are based on vegetation data collected by Ohio EPA from wetlands located in the Eastern Corn Belt Plains Ecoregion of Ohio in 1996, 1997, 1998, and 1999 (Figure 1). Ohio EPA is sampling wetlands in the Erie-Ontario Lake Plains Ecoregion (Lake Plains and glaciated Allegheny Plateau) during the 2000 and 2001 field seasons, and the Western Allegheny Plateau (unglaciated Allegheny Plateau) and the Huron-Erie Lake Plains ecoregions in the following years.

2.0 VIBI general characteristics and calibration of the ORAM score and wetland categories.

Vegetation Indices of Biotic Integrity (VIBIs) were developed for emergent, forested, and scrub-shrub wetland vegetation classes (Mack et al. 2000). The VIBI scores for wetland classes and condition were compared and evaluated. Very strong linear trends were observed when VIBI scores for all wetlands were compared to ORAM v. 5.0 score (Figure 2) (R^2=84.5%, df=44, F=235.23, p<0.001).

In a comparison of mean VIBI scores among emergent, forested, and scrub-shrub wetlands using analysis of variance followed by Tukey's multiple comparison test, the emergent and forested classes were not significantly different from each other, although the scrub-shrub class was significantly different from both emergent and forested classes (df=44, F=6.3, p=0.004) (Figure 3). However, this difference was caused by the lack of low and medium quality scrub-shrub communities in the data set. Thus, VIBI score appears to have a standardizing effect on natural variation caused by differences in dominant vegetation.

Significant differences were also observed between qualitatively assigned wetland “condition” categories (very poor, poor, fair, good, reference) as well as between reference and nonreference condition wetlands (Figures 4 and 5). Finally, very significant differences were observed between the VIBI score of Category 1, 2, and 3 wetlands (Figure 6) (df=44, F=67.7, p<0.001). Therefore, the VIBI appears to be able to discriminate between at least three to four different categories of wetland quality/disturbance. This finding comports with the results of Fore, Karr, and Loveday (1993) who concluded that the state of Ohio's stream IBI could distinguish between five and six nonoverlapping categories of integrity.

The final step in development of the VIBI was using the biologically-derived index to calibrate the score for the Ohio Rapid Assessment Method for Wetlands, which is a qualitative habitat/functional assessment method. Recalibration of the scoring ranges using actual measures of a wetland's biology and functions has been a continuing need since the adoption of the State of Ohio's Wetland Water Quality Standards and Wetland Antidegradation rules and the use of "draft" versions of the ORAM (versions 3.0, 4.0, and 4.1) in regulatory decision making.

Figure 7 summarizes the results from calibrating the ORAM using the VIBI scores for forested, emergent, and scrub-shrub wetland vegetation community classes. Four wetland integrity categories are distinguished: Category 1, modified Category 2, Category 2, and Category 3. Because of the very strong linear, dose-response relationship observed in the VIBI scores, the 95th percentile of the overall distribution of scores (89.6) was quadrisected resulting in the four IBI categories on the right side of the figure (Karr and Chu 1999). Quadrisection of the 95th percentile of the ORAM score (78.8) was evaluated but resulted in category breakpoints in which only one or two wetland s would have been categorized as Category 1. Because of this breakpoints for the ORAM score were visually assigned based on the VIBI score distribution and category breakpoints assigned by quadrisection. A 5% “gray zone” was placed below the cutoff for each main regulatory category. Scoring ranges are summarized in Table 23.

Comparing the IBI determined category to the ORAM determined category, 1 site was "overscored "by the ORAM (2.5%), 5 sites were "underscored" by the ORAM (11.1%, two in the category 1-2 (4.9%) and 3 in the category 2 to 3 (6.7%)). However, 3 of the underscored sites were scrub-shrub wetlands and this may be an artifact of the procedure for calculating scrub-shrub IBIs. Five sites (11.1%) were located in the gray zone.

It should be noted that scoring breakpoints have been developed based on the scoring and study of wetlands located primarily in the Eastern Corn Belt Plains (ECBP) Ecoregion (Figure 1; Omernik 1987; US EPA 1997). Ohio EPA will be studying wetlands in other ecoregions of Ohio in the coming years, but persons using these scoring ranges and breakpoints should keep in mind that they have been calibrated based on biological data obtained from predominately depressional wetlands located in the Eastern Corn Belt Plains Ecoregion. Thus, they should be applied with caution to wetlands located in other ecoregions of the state and to wetlands of other vegetation types and other landscape settings. Ohio EPA has found significant ecoregional differences in streams, and this may also be the case for wetlands (Ohio EPA 1988a, 1988b, 1989). Ohio EPA will be studying wetlands in the Erie-Ontario Lake Plains (including the glaciated Allegheny Plateau) in 2001 and 2002, and in the Huron-Erie Lake Plains and Western Allegheny Plateau Ecoregions in subsequent years.

Table 2. Interim scoring breakpoints for wetland regulatory categories for ORAM and VIBI scores.

category	ORAM v. 5.0 score	VIBI score
1	0 - 29.9	0 - 21
1 or 2 gray zone	30 - 34.9	----
modified 2	35 - 44.9	22 - 44
2	45 - 59.9	45 - 66
2 or 3	60 - 64.9	----
3	65 - 100	67 - 100

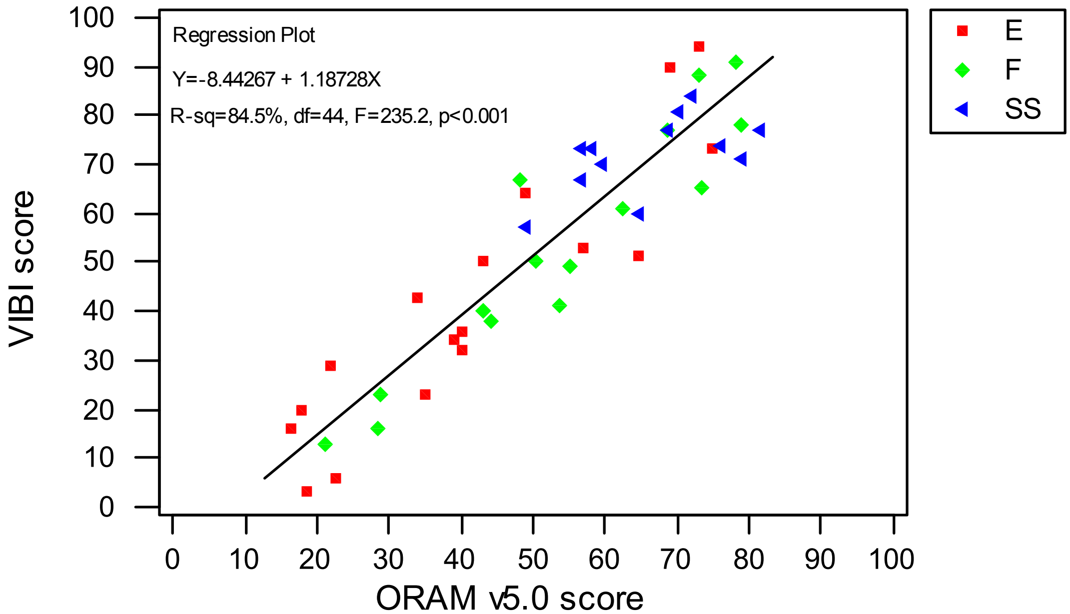

Figure 2. VIBI scores for emergent (E), forested (F) and scrub-shrub(SS) vegetation communities versus ORAM v. 5.0 score. Line is fitted line from linear regression of 45 wetland IBI scores.

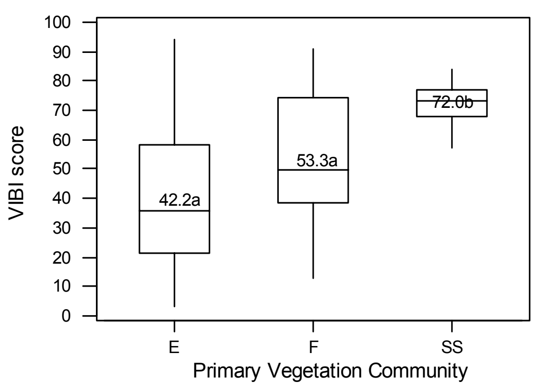

Figure 3. Box an whisker plots of emergent (E), forested (F), and scrub-shrub (SS) vegetation community VIBI scores. A line is drawn across the box at the median. Number on line is mean VIBI score. Means with different letters were significantly different. The bottom of the box is at the first quartile (Q1), and the top is at the third quartile (Q3) value. The whiskers are the lines that extend from the top and bottom of the box to the adjacent values. The adjacent values are the lowest and highest observations that are still inside the region defined by the following limits: Lower Limit = Q1 - 1.5 (Q3 - Q1); Upper Limit = Q3 + 1.5 (Q3 - Q1). Outliers are points outside of the lower and upper limits and are plotted with asterisks (*).

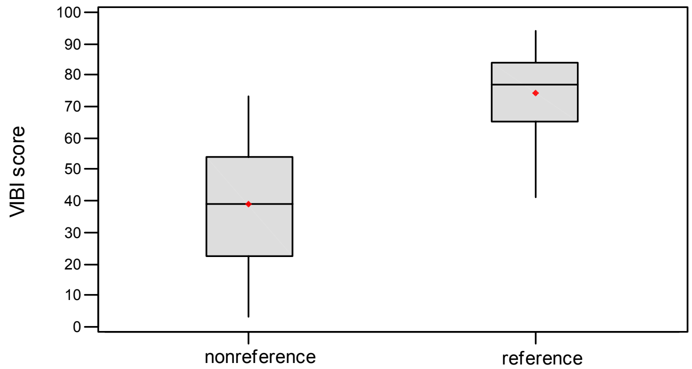

Figure 4. Box an whisker plots of all VIBI scores by wetland type (reference or nonreference condition, i.e. lacking in obvious human cultural influences). Dot is the mean score. Means were significantly different from one another (df=44, F=45.3, p=<0.001). A line is drawn across the box at the median. The bottom of the box is at the first quartile (Q1), and the top is at the third quartile (Q3) value. The whiskers are the lines that extend from the top and bottom of the box to the adjacent values. The adjacent values are the lowest and highest observations that are still inside the region defined by the following limits: Lower Limit = Q1 - 1.5 (Q3 - Q1); Upper Limit = Q3 + 1.5 (Q3 - Q1).

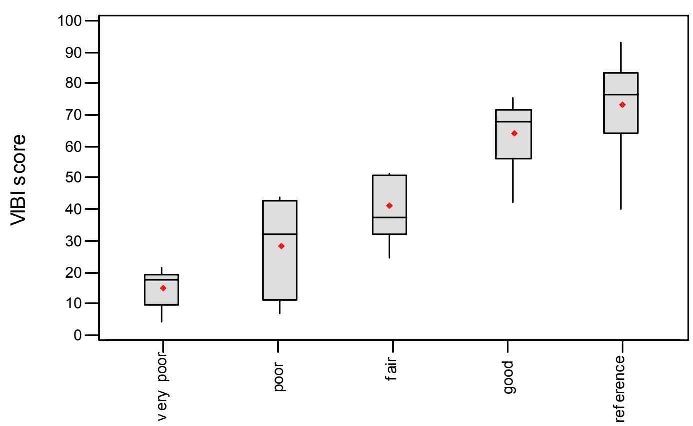

Figure 5. Box an whisker plots of all VIBI scores by wetland condtion. Dot is the mean score. All means were significantly different from one another except "very poor" versus "poor", "poor" versus "fair," and "good" versus "reference" (df=44, F=35.27, p=<0.001). A line is drawn across the box at the median. The bottom of the box is at the first quartile (Q1), and the top is at the third quartile (Q3) value. The whiskers are the lines that extend from the top and bottom of the box to the adjacent values. The adjacent values are the lowest and highest observations that are still inside the region defined by the following limits: Lower Limit = Q1 - 1.5 (Q3 - Q1); Upper Limit = Q3 + 1.5 (Q3 - Q1).

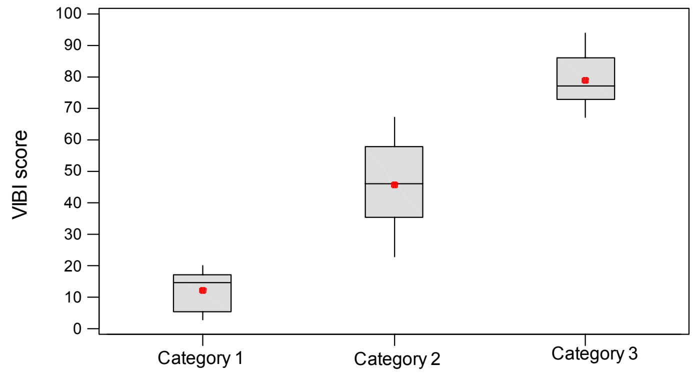

Figure 6. Box an whisker plots of all VIBI scores by wetland category as determined by the wetland's VIBI score. Dot is the mean score. All means were significantly different from one another (df=44, F=93.78, p=<0.001). Line across the box is the median. The bottom of the box is at the first quartile (Q1), and the top is at the third quartile (Q3) value. The whiskers are the lines that extend from the top and bottom of the box to the adjacent values. The adjacent values are the lowest and highest observations that are still inside the region defined by the following limits: Lower Limit = Q1 - 1.5 (Q3 - Q1); Upper Limit = Q3 + 1.5 (Q3 - Q1).

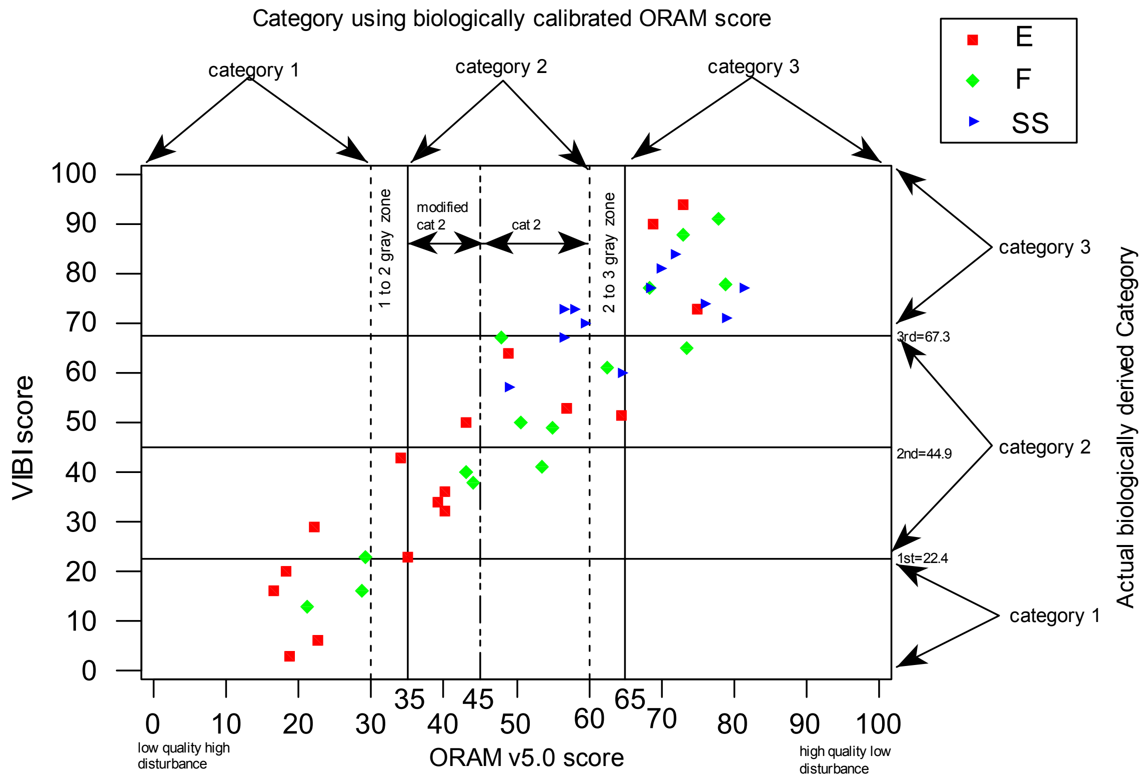

Figure 7. Interim VIBI scores and interim wetland categorization breakpoints for emergent, forested, and scrub-shrub wetland vegetation community classes and ORAM score for 45 wetlands in the Eastern Corn Belt Plains Ecoregion of the State of Ohio.

3.0 Comparison of ORAM v. 4.1 to v. 5.0.

Users familiar with earlier versions of the ORAM should find the approach discussed here to be familiar to that used in the prior versions. **It is not intended or expected that wetlands evaluated under earlier versions of the ORAM, and any certification and permitting decisions based on those evaluations, should be rescored or reconsidered using v. 5.0**. Version 5.0 should be used for applications pending as of the effective date of ORAM v. 5.0 and for applications received after that date. A detailed comparison of versions 4.1 and 5.0 can be found in the Section 1.4 ORAM users manual as well as in the discussion of many of the individual questions, however, several points will be reemphasized here.

First, the score from the Quantitative Rating now ranges from 0 to 100, whereas, under earlier versions of the ORAM the score ranged from 0 to some indeterminable limit (high 50s to low 60s). Ohio EPA believes that a 100 point provides several advantage: 1) it has a definite maximum, 2) it is a much more intuitive base 10 scale, and 3) it provides a greater range of scores, allowing for more visual "spread" when graphing the score versus quantitative biological data.

Second, one of the main shortcomings of earlier versions of the ORAM was a failure to expressly address the hydrology (and human modifications thereto) of a wetland and also human alterations to the wetlands natural habitat. These two factors account for much, if not most, of the possible disturbances to a wetland, and to the wetlands perceived overall "quality." Earlier versions of the ORAM addressed "human disturbance" in an indirect fashion, if at all, and did not expressly address all aspects of a wetland's hydrology, except qualitatively as in Question 1 of the Qualitative Rating in ORAM v. 4.0.

Finally, one of the other major shortcomings to prior versions of the ORAM was a clear preference for wetlands located near streams and discrimination against groundwater-driven or precipitation-driven depressional systems. In addition, earlier versions of the ORAM assigned 40-60% of the total points a wetland might obtain to an enumeration of the number of vegetation communities >0.25 acres in size and the number of species in those communities with an areal cover >10%. However, earlier versions of the ORAM did not include an express evaluation of the importance or quality of those vegetation communities for that wetland, or whether the species present were merely invasive weeds and disturbance-tolerant native plants. These problems led to both overscoring of low quality, highly disturbed wetlands that happened to have multiple vegetation classes and/or proximity to surface waters, as well as underscoring of high quality, undisturbed, depressional wetlands with a single vegetation class. The categorization results of ORAM v. 4.1 and 5.0 scores were compared to each other and to the category determined by the VIBI score (Tables 3 and 4). Basing categorization solely on the quantitative score, version 4.1 and version 5.0 reached the same result 55% of the time; 29% of the time version 4.1 assigned a lower category and 7% of the time a higher category (Table 3). When version 4.1 was compared to the VIBI score, similar percentages were found (Table 3).

Version 5.0 increased the number of wetlands in both the lowest and highest categories (1 and 3) and reduced the number of wetlands in the "gray zones" between categories when compared with version 4.1 (Table 4). Version 4.1 seriously over- and under-categorized forested and scrub-shrub wetlands. Using the version 4.1 score, no forested wetlands were found to be Category 1 or 3, versus 3 Category 1's and 5 Category 3's using version 5.0, and 2 Category 1's and 4 Category 3's using the VIBI score. This was due to version 4.1's emphasis on horizontal vegetation community classes and bias towards wetlands located in riparian settings. Forested wetlands usually have only a single vegetation class and are often in isolated landscape positions.

In contrast, emergent wetlands were similarly categorized by all three methods. Overall, ORAM v. 5.0

and its biologically defined scoring ranges, better defined the breaks between the regulatory classes and was more sensitive to differences in wetland quality.

Table 3. Comparison of wetland categorization results for N=45 wetlands using quantitative score and scoring breakpoints for ORAM v. 4.1 and 5.0 and the Vegetation IBI. "Same category" means the methods being compared reached the same categorization results. "1st lower than 2nd" means the first method listed assigned the wetland to a lower category than the 2nd method. "1st higher than 2nd" means the first method assigned the method to a higher category than the second method.

	4.1 versus 5.0	4.1 versus VIBI	5.0 versus VIBI
same category	25 (55%)	22 (49%)	34 (75%)
1st lower category than 2nd	13 (29%)	16 (36%)	8 (18%)
1st higher category than 2nd	7 (15%)	7 (15%)	3 (7%)

Table 4. A comparison of the categorization results for ORAM v. 4.1, 5.0, and the Vegetation IBI using a data set the 45 wetlands used to derive the VIBI score. Note that percentages should not be considered reflective of percentages of wetlands in Ohio that would be assigned to these categories but only of this data set.

Category	1	1 or 2	2	2 or 3	3
by All					
v. 4.1	4 (9%)	5 (11%)	25 (58%)	5 (11%)	5 (11%)
v. 5.0	8 (18%)	1 (2%)	20 (44%)	2 (4%)	14 (31%)
VIBI	6 (13%)	na	22 (49%)	na	17 (37%)
by Forested					
v. 4.1	0 (0%)	2 (4%)	13 (29%)	1 (2%)	0 (0%)
v. 5.0	3 (7%)	0 (0%)	7 (16%)	1 (2%)	5 (11%)
VIBI	2 (4%)	na	10 (22%)	na	4 (9%)
by Emergent					
v. 4.1	4 (9%)	3 (7%)	8 (18%)	0 (0%)	2 (4%)
v. 5.0	5 (11%)	1 (2%)	8 (18%)	0 (0%)	3 (7%)
VIBI	4 (9%)	na	10 (22%)	na	3 (7%)
by Scrub-Shrub					
v. 4.1	0 (0%)	0 (0%)	5 (11%)	4 (9%)	3 (7%)
v. 5.0	0 (0%)	0 (0%)	5 (11%)	1 (2%)	6 (13%)
VIBI	0 (0%)	na	2 (4%)	na	10 (22%)

4.0 Revised Scoring breakpoints for ORAM v. 4.1.

Based on the results discussed above and Mack et al. (2000), the scoring ranges for ORAM v. 4.1 should be recalibrated for forested and scrub-shrub wetlands. Fennessy et al. (1998) originally proposed the scoring breakpoints used for ORAM v. 3.0, 4.0, and 4.1 (Table 5).

Table 5. Provisional Breakpoints between Wetland Categories in Ohio Rapid Assessment Method Version 3.0, 4.0, and 4.1 Scoring Scheme. Now limited for use for Emergent wetland vegetation communities. From Fennessy et al. (1998, p. 35)

score	category
0-11	Category 1
12-16	Category 1 or 2
17-29	Category 2
30-34	Category 2 or 3
35+	Category 3

These scoring breakpoints appear to be adequate for characterization of emergent wetland vegetation communities but separate breakpoints are now proposed for forested and scrub-shrub wetland vegetation communities (Table 6), with the Category 1-2 threshold shifted upwards and the Category 2-3 threshold shifted down.

Table 6. Breakpoints for Forested and Scrub-Shrub vegetation communities for Ohio Rapid Assessment Method Version 3.0, 4.0, and 4.1 Scoring Scheme.

score	category
0-16.9	Category 1
17.0-19.9	Category 1 or 2
20.0-25.9	Category 2
26.0-28.9	Category 2 or 3
29.0+	Category 3

5.0 Cautionary Statement.

The Ohio Rapid Assessment Method is designed to aid in the determination of wetland categories as defined in Ohio's Wetland Antidegradation Rule (OAC Rule 3745-1-54). As such, the method is designed to identify the appropriate level of regulatory protection a particular wetland should receive. It is not designed or intended to be used to determine a particular wetland's ecologic or human value. The use of the Ohio Rapid Assessment Method should not be considered as a substitute, and is not intended to be a substitute, for detailed studies of the functions and biology of a wetland. In addition, while the score and conclusions of the ORAM are designed such that they correlate well with more detailed measures of the biology of wetland, they are not, and should not, be considered absolutely definitive.

While every effort has been made to reduce the failure rate, and to increase the usability of the method, the Rate should be aware that as a "rapid", "qualitative" procedure, the method, and especially, the quantitative score may incorrectly categorize a wetland. ***In all instances, the definitions and requirements found in OAC Rule 3745-1-54 are ultimately controlling, and in the event of a conflict between the ORAM and the rule, the definitions and requirements of the rule control.***

6.0 References

Barbour, Michael T., James B. Stribling, and James R. Karr. 1995. Multimetric approach for establishing and measuring biological condition. *In* Biological Assessment and Criteria, Tools for Water Resource Planning and Decision Making, Eds. Wayne S. Davis and Thomas P. Simon, CRC Press, Inc.

Barbour, Michael T., James L. Plafkin, Brian P. Bradley, Carol G. Graves, and Robert W. Wisseman. 1992. Evaluation of EPA's rapid bioassessment benthic metrics: metric redundancy and variability among reference sites. Environmental Toxicology and Chemistry, 11:437-449.

Bode, Robert W. and Margaret A. Novak. 1995. Development and application of biological impairment criteria for rivers and streams in New York state. *in* Biological Assessment and Criteria, Tools for Water Resource Planning and Decision Making, Eds. Wayne S. Davis and Thomas P. Simon, CRC Press, Inc.

Fennessy, M. Siobhan, Michael A. Gray, and Ricardo D. Lopez (1998). An ecological assessment of wetlands using reference sites Volume 1: Final Report, Volume 2: Appendices. Final Report to U.S. Environmental Protection Agency. Wetlands Unit, Division of Surface Water. Grant CD995761-01.

Fore, Leska K., James R. Karr, and Loveday L. Conquest. 1994. Statistical properties of an index of biological integrity used to evaluate water resources. Canadian Journal of Fisheries and Aquatic Science, 51:1077-1087.

Hughes, Robert M., Philip R. Kaufman, Alan T. Herlihy, Thomas M. Kincaid, Lou Reynolds, and David P. Larsen. 1998. A process for developing and evaluating indices of fish assemblage integrity. Canadian Journal of Fisheries and Aquatic Sciences, 55:1618-1631.

Hornig, C. Evan, Charles W. Bayer, Steve R. Twidwell, Jack R. Davis, Roy J. Kleinsasser, Gordon W. Linam, and Kevin B. Mayes. 1995. Development of regionally based biological criteria in Texas. *in* Biological Assessment and Criteria, Tools for Water Resource Planning and Decision Making, Eds. Wayne S. Davis and Thomas P. Simon, CRC Press, Inc.

Karr, James R. 1993. Defining and assessing ecological integrity: beyond water quality. Environmental Toxicology and Chemistry, 12:1521-1531.

Karr, James R., and Ellen W. Chu. 1997. Biological monitoring and assessment: Using multimetric indexes effectively. U.S. Environmental Protection Agency, EPA 235-R97-001. University of Washington, Seattle.

Karr, James R., and Ellen W. Chu. 1999. Restoring life in running waters: better biological monitoring. Island Press, Washington, D.C.

Karr, James R., and Daniel R. Dudley. 1981. Ecological perspective on water quality goals. Environmental Management 5(1):55-68.

Karr, James R., and Billie L. Kerans. 1992. Components of biological integrity: their definition and use in development of an invertebrate IBI. *In* Proceedings of the 1991 Midwest Pollution Control Biologists Meeting: Environmental Indicators Measurement Endpoints. T.P. Simon and W. S. Davis, Eds. U.S. Environmental Protection Agency, Region V, Environmental Sciences Division, Chicago, Ill. EPA 905/R-92/003.

Mack, John J., Mick Micacchion, Lauren D. Augusta, and Gregg R. Sablak. 2000. Vegetation Indices of Biotic Integrity (VIBI) for Wetlands and Calibration of the Ohio Rapid Assessment Method for Wetlands v. 5.0. Final Report to U.S. EPA Grant No. CD985276, Interim Report to U.S. EPA Grant No. CD985875, Volume 1. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Unit, Columbus, Ohio.

Micacchion, Mick, Michael A. Gray, and John J. Mack. 2000. Amphibian and Macroinvertebrate Attributes for Wetlands. Final Report to U.S. EPA Grant No. CD985276, Interim Report to U.S. EPA Grant No. CD985875, Volume 2. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology and Ecological Assessment Units, Columbus, Ohio.

Ohio EPA. 1988a. Biological Criteria for the Protection of Aquatic Life: Volume I. The role of biological data in water quality assessment. Ohio Environmental Protection Agency, Ecological Assessment Section, Division of Water Quality Planning and Assessment, Columbus, Ohio.

Ohio EPA. 1988b. Biological Criteria for the Protection of Aquatic Life: Volume II. Users Manual for biological field assessment of Ohio surface waters. Ohio Environmental Protection Agency, Ecological Assessment Section, Division of Water Quality Planning and Assessment, Columbus, Ohio.

Ohio EPA. 1989a. September 30, 1989 Addendum to Biological Criteria for the Protection of Aquatic Life: Volume II, 1988. Ohio Environmental Protection Agency, Ecological Assessment Section, Division of Water Quality Planning and Assessment, Columbus, Ohio.

Ohio EPA. 1989b. Biological Criteria for the Protection of Aquatic Life: Volume III. Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities. Ohio Environmental Protection Agency, Ecological Assessment Section, Division of Water Quality Planning and Assessment, Columbus, Ohio.

Omernik, J. M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers 77:118-125.

Rankin, Edward T. 1989. The Qualitative Habitat Evaluation Index [QHEI]: Rationale, Methods, and Application. Ecological Assessment Section, Division of Water Quality Planning and Assessment, Ohio Environmental Protection Agency, Columbus, Ohio.

Rankin, Edward T. 1995. Habitat indices in water resource quality assessments. *In* Biological Assessment and Criteria, Tools for Water Resource Planning and Decision Making, Eds. Wayne S. Davis and Thomas P. Simon, CRC Press, Inc.

Simon, Thomas P. and Erich B. Emery. 1995. Modification and assessment of an index of biotic integrity to quantify water resource quality in great rivers. Regulated Rivers: Research & Management 11:283-298.

Yoder , Chris O, and Edward T. Rankin. 1995. Biological Criteria Program Development and Implementation In Ohio. *In* Biological Assessment and Criteria, Tools for Water Resource Planning and Decision Making, Eds. Wayne S. Davis and Thomas P. Simon, CRC Press, Inc.