Addendum to: INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 4: Vegetation Index of Biotic Integrity for Ohio Wetlands Part 7: Amphibian Index of Biotic Integrity for Ohio Wetlands

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INTRODUCTION

Vegetation

A Vegetation Index of Biotic Integrity (VIBI) for wetlands was previously developed using vascular plants as the indicator taxa group (Mack et al. 2000, Mack 2001b, Mack 2004a) using data from sites sampled in Ohio between 1996-2000 representing different wetland types and ecological regions. An important step in the development of an IBI is the subsequent testing and refinement with new data sets from the same or different regions and/or community types (Karr and Chu 1999). This addendum presents additional reference wetland data using the metrics and scoring ranges for the VIBI as outlined in Mack (2004a) (Table 1). These reference sites include wetlands that 1) can be classified as depression, riverine, slope, and coastal wetlands and as marsh, swamp forest, shrub swamp, and wet meadow plant communities, and 2) were located in multiple ecoregions including the Eastern Corn Belt Plains (ECBP), Erie-Ontario Drift and Lake Plains (EOLP), Western Allegheny Plateau (WAP), and the Huron-Erie Lake Plains including the Oak Openings subregion (Omernik 1987; Woods et al. 1998).

Amphibians

In 2003 the focus of site selection was monitoring for amphibians in the Huron/Erie Lake Plains (HELP) ecoregion. While the entire ecoregion was the focus we had the most success in locating suitable sites in the Oak Openings subregion. Within the Oak Openings we had identified a good number of forest and shrub depressional wetlands, that spanned the range of disturbance, for monitoring. Unfortunately, 2002 was an extremely dry year for northwest Ohio and the drought left the ground water table in the Oak Openings and much of the HELP ecoregion significantly below normal. As a result, when we arrived in the area to begin monitoring in late March 2003 most of the wetlands we had scouted and identified for study were completely dry. Resource managers in the area told us they had never seen those wetlands dry at that time of year before.

We were forced to look for alternative wetlands to sample within a very narrow time frame. Sites had to be selected and monitored within a couple of days of discovering that our originally selected sites were dry to avoid missing the start of the amphibian sampling window. We ended up monitoring 32 wetlands in the HELP ecoregion, 18 of which were in the Oak Openings (Table 1).

METHODS

Sampling Methods - Vegetation

Sampling methods are summarized in detail in Mack (2004c). Sites were selected using a targeted selection approach to ensure that wetlands representing a gradient of disturbance, different plant communities and hydrogeomorphic classes, and different ecoregions were adequately represented in the data set (Karr and Chu 1999; Parker 2002, Fennessy et al. 2001). "Reference standard" (Smith et al. 1995) sites were used to set biological expectations, and are defined as sites lacking obvious human cultural influence or the least-impacted systems available.

A plot-based vegetation sampling method was used to sample wetland plant communities (Peet et al. 1998; Mack 2002; Mack 2004c). At most sites, a "standard" plot was established consisting of a 2 x 5 array of 10m x10m modules, i.e. 20m wide by 50m long (1000m^2 or 0.1 ha), within the boundary of the wetland and within each vegetation community of interest. Location of the plot was qualitatively selected by the investigator based on site characteristics and rules for plot location (Mack 2004c). Presence and areal cover was recorded for herb and shrub stratums, stem density and basal area was recorded for all woody species >1m. All species encountered in a plot were identified to the lowest taxonomic level possible (usually species). The nomenclature and species concept generally followed Gleason and Cronquist (1991). Standing biomass (g/m^2 from 8 $0.1m^2$ clip plots) and various physical variables (% open water, % bare ground, % litter cover, depth of litter, depth of inundation, depth to saturated soils, number of tussocks, number of hummocks, amount of coarse woody debris, standing dead trees, and overall microtopographic complexity) were also recorded. Percent cover was estimated using cover classes of Peet et al. (1998) (solitary/few, 0-1%, 1-2.5%, 2.5-5%, 5-10%, 10-25%, 25-50%, 50-75%, 75-90%, 90-95%, 95-99%). The midpoints of the cover classes were used in all subsequent analyses. A soil pit was dug in the center of every plot and soil color, texture, and depth to saturation was recorded and a sample was collected from the top 12 cm and analyzed for standard nutrient parameters and metals at the Ohio EPA laboratory. If standing water was present in the wetland, a grab sample of water was collected and analyzed for various water quality parameters.

Sampling Methods - Amphibians

Monitoring techniques followed the protocols in Micacchion (2004). Ten aquatic funnel traps placed evenly around the perimeters were used to sample wetland amphibian communities. Traps were deployed three times during the breeding season, late March – late June, and remained in wetlands for a twenty-four hour period. Contents of the traps were shaken into a collecting pan. All individuals that could be identified in the field were recorded and released. Other individuals were deposited in bottles, preserved and later identified in the laboratory. A qualitative sample involving dip netting for a least a half an hour was also taken at each site each sampling pass.

Classification

Each wetland was classified using an *a priori* classification system. The classification was subsequently evaluated and refined (Mack 2004a). Wetland class is based on dominant landscape position dominant plant community. There are nine landscape positions identified: depression, impoundment, riverine, slope, fringing, Lake Erie coastal, bog and mitigation which correspond generally to the hydrogeomorphic classification system outlined by Brinson (1993) (see Table 1 in Mack 2004a). There are three main plant community divisions: forest, emergent, and shrub. Each of these types has several subtypes: forest (swamp forests, bog forests, forest seeps); emergent (marsh, fen, other sedge-grass communities, sphagnum bog); and shrub (buttonbush swamp, alder swamp, mixed shrub swamp, bog and fen shrub swamps). Refer to Mack 2004a for a detailed description of these classes.

Human disturbance gradient

The score from the Ohio Rapid Assessment Method for Wetlands v. 5.0 (ORAM) was used as human disturbance gradient (Mack et al. 2000, Mack 2001a, Mack 2001b, Mack 2004b). The ORAM was designed to perform regulatory categorizations and to be used as a wetland disturbance scale (Mack 2001a). Questions in ORAM are designed to assess the condition of the wetland. The score ranges from 0 (very poor condition) to 100 (excellent condition). Questions are mostly site specific and include buffer width, dominant land use outside of the buffer, and intactness of natural hydrologic regimes, intactness of natural substrates, and intactness of natural wetland habitats (disturbance questions) as well as size, water sources, hydroperiod, connectivity, microtopography, and spatial heterogeneity, amphibian habitat features. Because the "disturbance" questions in the ORAM correlate strongly with the total ORAM score (df=72, F=295.75, R^2=0.806, p<0.001), the total ORAM v. 5.0 score was used as a disturbance gradient.

Data analysis

Descriptive statistics, box and whisker plots, regression analysis, analysis of variance, multiple comparison tests, and t tests (Minitab v. 12.0) were used to explore and evaluate the biological attributes measured for VIBI development.

RESULTS AND DISCUSSION

Vegetation

The VIBI was calculated for sites sampled in 2003 and 2004 using the metrics and scoring ranges in Mack 2004b (Tables 3, 4 and 5). All three VIBIs continued to correlate significantly ($p < 0.001$) with the disturbance gradient (Figures 1, 3 and 4) with very strong correlations (R^2 = 82.1%, 71.9%, and 68.6%, respectively for VIBI-E, -F, and -SH). Wet meadow communities had a significant ($p < 0.001$) threshold to curvilinear relationship to the disturbance gradient (R^2 = 65.6%) (Figure 5).

Box and whisker plots of VIBI scores by ORAM score tertiles showed strong graphical separation with no overlap of 25th and 75 percentiles. Mean values of VIBI-E, -F, and -SH scores were all significantly different after ANOVA ($p < 0.001$) and individual tertile means were all significantly different following Tukey's Multiple Comparison test ($p < 0.05$). Overall, the Vegetation IBI as developed and proposed in Mack (2004b) continued to perforn very well with the addition of new IBI testing data

The only minor modification made to the metric scoring ranges was a "low-end" scoring procedure. The need for this has become apparent when extremely disturbed natural wetlands or very poor quality mitigation wetlands were sampled. When wetlands are so disturbed that they are unvegetated or virtually unvegetated metrics using relative abundance, relative density, and importance values can lead to high metric scores. For example, a highly disturbed site may have low abundance of invasive graminoids not because it is intact, but because it is so disturbed that even these extremely tolerant plants cannot grow. This was the case with the Wills Creek Impact sites which were so extremely disturbed by acid mine drainage that they were unvegetated moonscapes. A similar situation occurs with the standing biomass metric. An analysis of minimum standing biomass (g/m^2) of natural wetlands revealed that standing biomass less than 100g/m^2 was indicative of disturbance or poor quality wetland restorations where wetland vegetation has not been established.

The following modifications were made to the metric scoring ranges:

1. Metrics that use relative cover (%bryophyte, %hydrophyte, %sensitive, %tolerant, %invasive graminoid). Where the sum of cover values for all plant species observed in a sample plot is less than 10% (absolute not relative cover values), then these metrics are scored "0".

2. The standing biomass metric is score "0" when standing biomass is greater than or equal to 801 g/m^2 or less than 100 g/m^2. In addition, a supplemental metric (%unvegetated) should also be calculated for mitigation wetlands.

3. The woody stem metrics (relative density of small trees, subcanopy IV, and canopy IV) should be manually scored as 0 in highly disturbed wetlands where most or all woody species have been removed or when stem densities are very low, as may occur in natural emergent communities.

The Wetland Tiered Aquatic Life Use tables were updated but the scoring ranges were not modified (Tables 6, 7, and 8).

Amphibians

Three of the wetlands in the Oak Openings remained inundated only long enough to allow the first pass of monitoring. Twelve additional wetlands in the HELP were only inundated long enough to allow the first two passes and one was flooded during the second pass and could not be monitored then but was dry for the third pass. All three monitoring passes were completed at fifteen wetlands. Of this fifteen, seven were dominated by emergent plant communities and the remaining eight were forest and shrub sites, three of which were riverine. Site names, vegetation class, number of sampling passes, species collected and their total numbers are shown in Table 9. Amphibian Index of Biotic Integrity (AmphIBI) scores were calculated for the 15 sites where three sampling passes were completed using the protocols in (Micacchion 2002). (AmphIBI scores were also calculated for the 12 sites where only two sampling passes occurred -this was done to better illustrate the characteristics of the amphibian communities encountered) (Table 10).

Box and whisker plots of the AmphIBI scores by ORAM score categories for the 15 three pass sites when added to the 111 natural, 10 individual mitigations and 35 mitigation bank subareas continued to show strong graphical separation. (Figure 1) Mean values of AmphIBI sites, for forested and shrub sites by category were all significantly different after ANOVA ($p<0.001$). Mitigation and mitigation bank sites were also significantly different from Category 2 and Category 3 forest and shrub sites. The AmphIBI continues to perform well even given the addition of these sites that were less than optimal in their selection criteria. No changes to the AmphIBI protocols are proposed.

Salamander hybrids and state listed species

Salamander hybrids of the family, Ambystomatidae are common in the HELP. At many sites we collected individuals that were clearly hybrids. We were able to send some live adults to Jim Bogart, at the University of Guelph in Guelph, Ontario, Canada for DNA analysis. Results from that genetic analysis showed that the five of the six individuals we sent were all hybrids of the blue-spotted salamander, *Ambystoma laterale* and the smallmouth salamander, *A. texanum*. Four were diploid hybrids (LT) and one was a tetraploid hybrid (LLLT). The sixth individual was confirmed as *A. laterale*. The Lucas County wetland, within the Oak Openings, where this individual was collected is one of only four or five confirmed locations for the state endangered species in Ohio.

We also observed, during our monitoring spotted turtles, *Clemmys guttata,* a state endangered species, at two sites within the Oak Openings in Lucas County. A Blandings turtle, *Embydoidea* *blandingi*, another state endangered species, was observed at the Marie DeLarme property in Paulding County where two of our study sites were located. An adult four toed salamander, *Hemidactylium scutatum*, a species of special concern, was observed at Swan Creek Metro Park in Lucas County.

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LITERATURE CITED

Andreas, B. K. and J. J. Mack, J. S. McCormac. 2004. Floristic Quality Assessment Index for Vascular Plants and Mosses for the State of Ohio. Wetland Ecology Group, Division of Surface Water, Ohio Environmental Protection Agency, Columbus, Ohio. 217 p.

Brinson, M. M. 1993. A hydrogeomorphic classification for wetlands. U.S. Army Corps of Engineers Waterways Experiment Station. Wetlands Research Program Technical Report WRP-DE-4. Vicksburg, MS.

Fennessy, S., Gernes M., Mack J., Wardrop DH. 2001. Methods for evaluating wetland condition: using vegetation to assess environmental conditions in wetlands. EPA-822-R-02-020. U.S. Environmental Protection Agency; Office of Water; Washington, DC.

Gleason, H.A. and A. Cronquist. 1991. Manual of the Vascular Plants of Northeastern United States and Adjacent Canada, 2nd ed. The New York Botanical Garden, New York. 901 p.

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

Mack, J.J., M. Micacchion, L. D. Augusta, and G. 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. Wetland Ecology Group, Division of Surface Water, Ohio Environmental Protection Agency, Columbus, Ohio.

Mack, J.J. 2001a. Ohio Rapid Assessment Method for Wetlands v. 5.0, User's Manual and Scoring Forms. Ohio EPA Technical Report WET/2001-1. Ohio Environmental Protection Agency, Division of Surface Water, Columbus, Ohio.

Mack, J.J. 2001b. Vegetation Indices of Biotic Integrity (VIBI) for Wetlands: ecoregional, hydrogeomorphic, and plant community comparision with preliminary wetland aquatic life use designations. Final Report to U.S. EPA Grant No. CD985875, Volume 1. Wetland Ecology Group, Division of Surface Water, Ohio Environmental Protection Agency, Columbus,Ohio.

Mack, John J. 2004a. Integrated Wetland

Assessment Program. Part 2: an ordination and classification of wetlands in the Till and Lake Plains and Allegheny Plateau regions. Ohio EPA Technical Report WET/2004-2. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Mack, John J. 2004b. Integrated Wetland Assessment Program. Part 4: Vegetation Index of Biotic Integrity (VIBI) and Tiered Aquatic Life Uses for Ohio Wetlands. Ohio EPA Technical Report WET/2004-4. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Mack, J.J. 2004c. Integrated Wetland Assessment Program. Part 9: Field Manual for the Vegetation Index of Biotic Integrity for Wetlands v. 1.3. Ohio EPA Technical Report WET/2004-9. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.
Columbus, Ohio.

Micacchion, M. 2002. Amphibian Index of Biotic Integrity (AmphIBI) for Wetlands. Final report to U.S. EPA Grant No. CD985875-01, Testing Biological Metrics and Development of Wetland Assessment Techniques Using Reference Sites, Volume 3.

Micacchion, M. 2004. Integrated Wetland Assessment Program. Part 7: Amphibian Index of Biotic Integrity (AmphIBI) for Ohio Wetlands, Including New Sites in the Erie/Ontario Lake and Drift Plains and Western Allegheny Plateau Ecoregions and Mitigation Sites. Ohio EPA Technical Report WET/2004-7.

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

Parker, A. K. 2002. Methods for evaluating wetland condition: Study design for monitoring wetlands. EPA-822-R-02-015. Office of Water, U.S. Environmental Protection Agency; Washington, DC.

Peet, R. K., T. R. Wentworth, and P. S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63(3): 262-274.

Smith R. D., A. Ammann, C. Bartoldus, and M. M. Brinson. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and funtional indices. Technical Report WRP-DE-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Woods, A.J., J.M. Omernik, C.S. Brockman, T.D. Gerber, W.D. Hosteter, and S.H. Azevedo. 1998. Ecoregions of Indiana and Ohio (Map) and Supplementary text.

Table 1. Summary of numbers of separately analyzable sample plots by major hydrogeomorphic and plant community classes and ecoregions 1996-2004. ECBP = Eastern Corn Belt Plains, EOLP = Erie-Ontario Drift and Lake Plains, HELP = Huron-Erie Lake Plains, MIDP = Michigan-Indiana Drift and Lake Plains, WAP = Western Allegheny Plateau.

Hydrogeomorphic Classes	N	Plant Community Classes	N	Ecoregion	N
Depressions	74	Swamp forests (all types)	47	ECBP	64
Impoundments	10	Marshes (all types)	59	EOLP	74
Riverine headwater depressions	10	Wet meadows - Fens	16	HELP	27
Riverine mainstem depressions and Riverine channel	34	Wet meadows - Other (prairie sedge meadows, lake plains sand prairies, reed canary grass meadows)	14	MIDP	4
Slope (excluding lacustrine fens)	34	Shrub swamps (all types)	33	WAP	22
Bog	9	Bogs	9		
Coastal (Lake Erie fringing)	20	Fen Shrub Swamps	3		
Mitigation Bank	103	Forest seeps	10		
Mitigation Individual	13				
TOTAL (excluding mitigations)	191		191		191

Table 2. Reference sites monitored in 2003-2004.

site code	site name	year	County	region	HGM class	plant community
BDPOLAND	BDarby Poland Property	2004	Union	ECBP	mainstem	marsh
BRKNRFEN	Brukner Fen	2004	Miami	ECBP	slope	fen meadow
CDRPT-NE	Cedar Pt. NE	2004	Ottawa	HELP	coastal	marsh
CDRPT-SW	Cedar Pt. Swale	2004	Ottawa	HELP	coastal	marsh
CDRPT-W	Cedar Pt. West	2004	Ottawa	HELP	coastal	marsh
COWLESCR	Cowles Cr Swale	2004	Ashtabula	EOLP	coastal	marsh
DERBYVILL	Derby Village	2003	Lucas	HELP	depression	swamp forest
GOTTFEN	Gott Fen	2003	Portage	EOLP	slope	fen meadow
GRAYFARM	Gray Farm	2004	Darke	ECBP	slope	forest seep
IRWINPIN	Irwin Pin Oak	2003	Lucas	HELP	depression	swamp forest
KINGDORR	King-Dorr Rd	2004	Lucas	HELP	depression	swamp forest
LD-LK-MD	LDarby Lake Cr Meadow	2004	Madison	ECBP	mainstem	wet meadow
LD-TERR	LDarby Terrace Seep	2004	Madison	ECBP	depression	swamp forest
LD-TIMMS	LDarby Timmons Fen	2004	Madison	ECBP	slope	tall shrub fen
MILLCAME	Mills Campus E	2003	Franklin	ECBP	depression	swamp forest
MILLCAMG	Mills Campus G	2003	Franklin	ECBP	depression	swamp forest
MSFCR1D1	MSF-CR1D#1	2004	Henry	HELP	depression	swamp forest
MSFCR1D5	MSF-CR1D#5	2004	Henry	HELP	slope	forest seep
MSFMARON	MSF-Marone Rd.	2004	Lucas	HELP	depression	wet meadow
MSFMUCK	MSF-Muck Farm	2003	Henry	HELP	depression	wet meadow
OLDSTATE	Old State Line Rd.	2003	Lucas	HELP	depression	swamp forest
OWENSFEN	Owens Fen	2003	Logan	ECBP	slope	fen meadow
PUMPKNOX	Pumpkintown Rd. Oxbow	2003	Gallia	WAP	mainstem	swamp forest
PUMPKNSW	Pumpkintown Rd. Swamp	2003	Gallia	WAP	slope	forest seep
RAMSRFEN	Ramsar Fen	2004	Knox	EOLP	slope	wet meadow
SLTRUN04	Slate Run 2004	2004	Pickaway	ECBP	depression	shrub swamp
STLFRKSW	Stillfork Swamp	2003	Carroll	WAP	headwater	marsh
SWANBLUE	Swan Creek Blue Oxbow	2003	Lucas	HELP	mainstem	swamp forest
SWANCRMD	Swan Cr. Meadow	2004	Lucas	HELP	slope	wet meadow
SWANGRN	Swan Creek Green Oxbow	2003	Lucas	HELP	mainstem	swamp forest
UPPCUYSW	Upper Cuyahoga Swamp	2003	Geauga	EOLP	mainstem	marsh
WHEELMD	Wheeler Cr Meadow	2004	Ashtabula	EOLP	coastal	wet meadow
WHEELMSH	Wheeler Cr Marsh	2004	Ashtabula	EOLP	coastal	marsh
WILKSEEP	Wilkins Rd. Seep	2004	Lucas	HELP	slope	forest seep
WLLSIMLO	Wills Cr Impact Lower	2003	Guernsey	WAP	mainstem	marsh
WLLSIMUP	Wills Cr Impact Upper	2003	Guernsey	WAP	slope	forest seep
WLLSREFL	Wills Cr Reference Lower	2003	Guernsey	WAP	mainstem	marsh
WLLSREFU	Wills Cr Reference Upper	2003	Guernsey	WAP	slope	forest seep
WSTVLLMA	Westerville Marsh	2003	Franklin	ECBP	mainstem	marsh
WSTVLLSW	Westerville Swamp	2003	Franklin	ECBP	depression	swamp forest

Table 3. Scoring ranges for assigning metric scores for Vegetation IBIs. Descriptions of metrics are found in Table 3. E = Emergent, SH = Shrub, F = Forest, $E_{COASTAL}$ = Lake Erie Coastal Marshes, MITIGATION = emergent mitigation wetlands.

metric	community	score 0	score 3	score 7	score 10
Carex	E, SH	0 - 1	2 - 3	4	≥5
Cyperaceae	$E_{COASTAL}$	0 - 1	2 - 3	4 - 6	≥7
dicot	E	0 - 10	11 - 17	18 - 25	≥25
	SH	0 - 9	10 - 14	15 - 23	≥24
shade	F	0 - 7	8 - 13	14 - 20	≥21
shrub	E, SH	0 -1	2	3 - 4	≥5
hydrophyte	E	0 -10	11 - 20	21 - 30	≥31
	SH	0 -9	10 - 14	15 - 20	≥21
A/P ratio*	E	>0.48	0.32 - 0.48	0.20 - 0.32	0.0 - 0.20
SVP	F, SH	0	1	2	≥3
FQAI	E, SH	0 - 9.9	10.0 - 14.3	14.4 - 21.4	≥21.5
	F	0 - 14.0	14.1 - 19.0	19.1 - 24.0	≥24.1
%bryophyte*	F, SH	0 - 0.01	0.01 - 0.03	0.031 - 0.06	≥0.06
%hydrophyte*	F	0 - 0.1	0.1 - 0.15	0.151 - 0.28	≥0.281
%sensitive*	E	0 - 0.025	0.025 - 0.10	0.10 - 0.15	0.15 - 1.0
	F	0 - 0.035	0.035 - 0.12	0.12 - 0.3	0.31 - 1.0
	SH	0 - 0.02	0.021 - 0.06	0.061 - 0.13	0.131 - 1.0
%tolerant*	E	0.60 - 1.0	0.40 - 0.60	0.20 - 0.40	0 - 0.20
	F	0.45 - 1.0	0.30 - 0.45	0.15 - 0.30	0 - 0.15
	SH	0.15 - 1.0	0.10 - 0.15	0.05 - 0.10	0 - 0.05
%invasive* graminoids	E	0.31 - 1.0	0.15 - 0.3	0.03 - 0.15	0 - 0.03
small tree**	F	0.32 - 1.0	0.22 - 0.32	0.11 - 0.22	0 - 0.11
subcanopy IV**	F	0 - 0.02	0.02 - 0.072	0.072 - 0.13	≥0.131
	SH	0 - 0.02	0.02 - 0.05	0.05 - 0.1	≥ 0.11
canopy IV***	F	0.21 - 1.0	0.17 - 0.21	0.14 - 0.17	0 - 0.14
%unvegetated****	MITIGATION	≥0.46	0.31 - 0.46	0.15 - 0.31	0 - 0.15
biomass	E	≥801 or <100	451 - 800	201 - 450	100 - 200

* If total cover (sum of cover values for all species observed in sample plot) is <10%, abundance metrics are scored as 0.
** If no woody stems >1m tall in sample plot or if stems per ha <10, score metric as 0.
*** If no canopy trees or only a few individuals of canopy species present in sample plot, score metric as 0.
**** This metric should be calculated for wetland mitigation sites where perennial hydrophyte vegetation is not well established or where g/m^2 of biomass is less than 100.

Table 4. Description of metrics used in 2004 version of VIBI-E, VIBI-F, VIBI-SH. "E" = emergent, "$E_{coastal}$" = Lake Erie Coastal Marsh, "$E_{MITIGATION}$" = Mitigaiton Marshes, "F" = forested", "SH" = shrub.

metric	E, F, SH	code	type	metric increase or decrease w/ disturbance	description
Carex spp.	E, SH	carex	richness	decrease	Number of species in the genus *Carex*
cyperaceae spp.	$E_{coastal}$	cyperaceae	richness	decrease	Number of species in the Cyperaceae family
native dicot spp.	E, SH	dicot	richness	decrease	Number of native dicot (dicotyledon) species
native shade spp.	F	shade	richness	decrease	Number of native shade[1] tolerant or shade facultative species
native, wetland shrub spp.	E, SH	shrub	richness	decrease	Number of shrub species that are native and wetland (FACW, OBL) species
hydrophyte spp.	E, SH	hydrophyte	richness	decrease	Number of vascular plant species with a Facultative Wet (FACW) or Obligate (OBL) wetland indicator status (Reed 1988; 1997; Andreas et al. 2004).
ratio of annual to perennial spp.	E	A/P	richness ratio	decrease	Ratio of number of nonwoody species with annual life cycles to number of nonwoody species with perennial life cycles. Bienniel species excluded from calculation
seedless vascular plant (SVP) spp.	F, SH	SVP	richness	decrease	Number of seedless vascular plant (ferns, fern allies) species
FQAI score	E, F, SH	FQAI	weighted richness index	decrease	The Floristic Quality Assessment Index score calculated using Eqn. 7 and the coefficients in Andreas et al. (2004)
relative cover of bryophytes	F, SH	%bryophyte	dominance ratio	decrease	Sum of the relative cover of all bryophyte species. Bryophytes include all mosses (Musci) and aquatic lichens *Riccia* and *Ricciocarpos*
relative cover of shade tolerant hydrophyte spp.	F	%hydrophyte	dominance ratio	decrease	Sum of the relative cover of shade or partial shade tolerant FACW and OBL plants in the herb and shrub stratums
relative cover of sensitive plant spp.	E, F, SH	%sensitive	dominance ratio	decrease	Sum of the relative cover of plants in herb and shrub stratums with a Coefficient of Conservatism (C of C) of 6,7,8,9 and 10 (Andreas et al. 2004)
relative cover tolerant plant spp.	E, F, SH	%tolerant	dominance ratio	increase	Sum of the relative cover of plants in herb and shrub stratums with a C of C of 0, 1, and 2 (Andreas et al. 2004)

1 Shade tolerance and other codes to calculate VIBI metrics are available in Mack (2004c).

Table 4. Description of metrics used in 2004 version of VIBI-E, VIBI-F, VIBI-SH. "E" = emergent, "$E_{coastal}$" = Lake Erie Coastal Marsh, "$E_{MITIGATION}$" = Mitigaiton Marshes, "F" = forested", "SH" = shrub.

metric	E, F, SH	code	type	metric increase or decrease w/ disturbance	description
relative cover of invasive graminoid spp.	E	%invgram	dominance ratio	increase	Sum of the relative cover of *Typha* spp., *Phalaris arundinacea,* and *Phragmites australis*
relative density of small trees (pole timber)	F	pole timber	density ratio	increase	The density (stems/ha) of a tree species in size classes between 10 and 25 cm dbh divided by the density of all trees
importance of native shade subcanopy spp.	F, SH	subcanopy IV	importance value	decrease	Sum of the mean importance value of shade tolerant subcanopy (shrub, subcanopy tree) species plus the mean importance value of facultative shade subcanopy (shrub, small tree) species. Importance value is the average of relative size class frequency[2], relative density, and relative basal area. Subcanopy trees are tree species which only grow in the subcanopy, e.g. *Carpinus caroliniana*
importance canopy spp.	F	canopy IV	importance value	decrease	The mean of the importance values of trees in the canopy of the forest where importance value is calculated by averaging relative size class frequency, relative density, and relative basal area. Canopy tree species are species which at maturity will inhabit the upper canopy of the forest even if at the time of sampling they are growing in the subcanopy
unvegetated and annual cover	$E_{MITIGATION}$	%unvegetated	dominance ratio	increase	The sum of the relative cover of annual plant species (percent annual spp. cover divided by total spp. cover) and the percent cover of unvegetated areas
standing biomass	E	biomass	primary production	increase	The average grams per square meter of clip plot samples collected at each emergent wetland

2 Size class frequency is the number of size classes in which there is at least one stem for that woody species. There are 11 size classes 0-1, 1-2.5, 2.5-5, 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, 35-40, and >40 cm.

Table 5. Summary of metrics for final Vegetation IBIs. See Table 3 for definitions.

VIBI-E	VIBI-E$_{COASTAL}$	VIBI-E$_{MITIGATION}$	VIBI-SH	VIBI-F
---	Cyperaceae	---	---	---
Carex	---	*Carex*	*Carex*	---
Dicot, native	Dicot, native	Dicot, native	Dicot, native	---
Shrub, native, wetland	Shrub, native, wetland	Shrub, native, wetland	Shrub, native, wetland	---
Hydrophyte, native	Hydrophyte, native	Hydrophyte, native	Hydrophyte, native	---
A/P ratio	A/P ratio	A/P ratio	---	---
FQAI score	FQAI score	FQAI score	FQAI score	FQAI score
%tolerant	%tolerant	%tolerant	%tolerant	%tolerant
%sensitive	%sensitive	%sensitive	%sensitive	%sensitive
%invasive graminoids	%invasive graminoids	%invasive graminoids	---	---
biomass	biomass	---	---	---
---	---	%unvegetated	---	---
---	---	---	---	Shade
			SVP	SVP
---	---	---	---	%hydrophyte
---	---	---	%bryophyte	%bryophyte
---	---	---	---	pole timber density
---	---	---	subcanopy IV	subcanopy IV
---	---	---	---	canopy IV

Table 6. General Wetland Aquatic Life Use Designations.

code	designation	definition
SWLH	Superior Wetland Habitat	Wetlands that are capable of supporting and maintaining a high quality community with species composition, diversity, and functional organization comparable to the vegetation IBI score of at least 83% (five-sixths) of the 95th percentile for the appropriate wetland type and region as specified in Table 11.
WLH	Wetland Habitat	Wetlands that are capable of supporting and maintaining a balanced, integrated, adaptive community having a species composition, diversity, and functional organization comparable to the vegetation IBI score of at least 66% (two-thirds) of the 95th percentile for the appropriate wetland type and region as specified in Table 11.
RWLH	Restorable Wetland Habitat	Wetlands which are degraded but have a reasonable potential for regaining the capability of supporting and maintaining a balanced, integrated, adaptive community of vascular plants having a species composition, diversity, and functional organization comparable to the vegetation IBI score of at least 33% (one-third) of the 95th percentile distribution for the appropriate wetland type and region as specified in Table 11.
LQWLH	Limited Quality Wetland Habitat	Wetlands which are seriously degraded and which do not have a reasonable potential for regaining the capability of supporting and maintaining a balanced, integrated, adaptive community having a species composition, diversity, and functional organization comparable to the vegetation IBI score of less 33% (one-third) of the 95th percentile for the appropriate wetland type and region as specified in Table 11.

Table 7. Special wetland use designations.

subscript	special uses	description
A	recreation	wetlands with known recreational uses including hunting, fishing, birdwatching, etc. that are publicly available
B	education	wetlands with known educational uses, e.g. nature centers, schools, etc.
C	fish reproduction habitat	wetlands that provide important reproductive habitat for fish
D	bird habitat	wetlands that provide important breeding and nonbreeding habitat for birds
E	T or E habitat	wetlands that provide habitat for federal or state endangered or threatened species
F	flood storage	wetlands located in landscape positions such that they have flood retention functions
G	water quality improvement	wetlands located in landscape positions such that they can perform water quality improvement functions for streams, lakes, or other wetlands

Table 8. Wetland Tiered Aquatic Life Uses (WTALUs) for specific plant communities and landscape positions. tbd = to be developed. LQWLH = limited quality wetland habitat, RWLH = restorable wetland habitat, WLH = wetland habitat, SWLH = superior wetland habitat. Equivalent antidegradation categories as specified in Ohio Administrative Code Rule 3745-1-54 are indicated in parentheses below the TALU category.

HGM class	HGM subclass	plant community	ecoregions	LQWLH (Category 1)	RWLH (modified Category 2)	WLH (Category 2)	SWLH (Category 3)
Depression	all	Swamp forest, Marsh, Shrub swamp	EOLP	0 - 30	31 - 60	61 - 75	76 - 100
			all other regions	0 - 24	25 - 50	51 - 62	63 - 100
	all	Wet Meadow (incl. prairies and sedge/grass dominated communities that are not slopes)	all regions	0 - 29	30 - 59	60 - 75	76 - 100
Impoundment	all	Swamp forest, Marsh, Shrub Swamp	EOLP	0 - 26	27 - 52	53 - 66	67 - 100
			all other regions	0 - 24	25 - 47	48 - 63	64 - 100
		Wet Meadow (incl. prairies and sedge/grass dominated communities that are not slopes)	all regions	0 - 29	30 - 59	60 - 75	76 - 100
Riverine	Headwater	Swamp forest, Marsh, Shrub swamp	EOLP	0 - 27	28 - 56	57 - 69	70 - 100
			all other regions	0 - 23	24 - 47	47 - 59	60 - 100
	Mainstem	Swamp forest, Marsh, Shrub swamp	EOLP	0 - 29	30 - 56	57 - 73	74 - 100
			all other regions	0 - 20	21 - 41	42 - 52	53 - 100
	Headwater or Mainstem	Wet Meadow (incl. prairies and sedge/grass dominated communities that are not slopes)	all regions	0 - 29	30 - 59	60 - 75	76 - 100
Slope	all	Wet meadow (fen), tall shrub fen, forest seep	all regions	0 - 29	30 - 59	60 - 75	76 - 100
Fringing[1]	Natural Lakes (excluding lacustrine fens) and reservoirs	tbd	tbd	tbd	tbd	tbd	tbd
Coastal[2]	closed embayment, barrier-protected, river mouth	Swamp forest, Marsh, Shrub swamp	all regions	0 - 24	25 - 49	50 - 61	62 - 100
	open embayment, diked (managed unmanaged failed)	tbd	tbd	tbd	tbd	tbd	tbd
Bog	weakly ombrotrophic	Tamarack-hardwood bog, Tall shrub bog	all regions	0 - 32	33 - 65	66 - 82	83 - 100
	moderately to strongly ombrotrophic	Tamarack forest, Leatherleaf bog Sphagnum bog	all regions	0 - 23	24 - 47	48 - 59	60 - 100

1. Depending on the circumstances, scoring breaks for depression, impoundment, or riverine may be used.
2. Scoring breaks for coastal embayment, barrier-protected, and river mouth may be usable.

Table 9. Sites and Amphibian Species Present

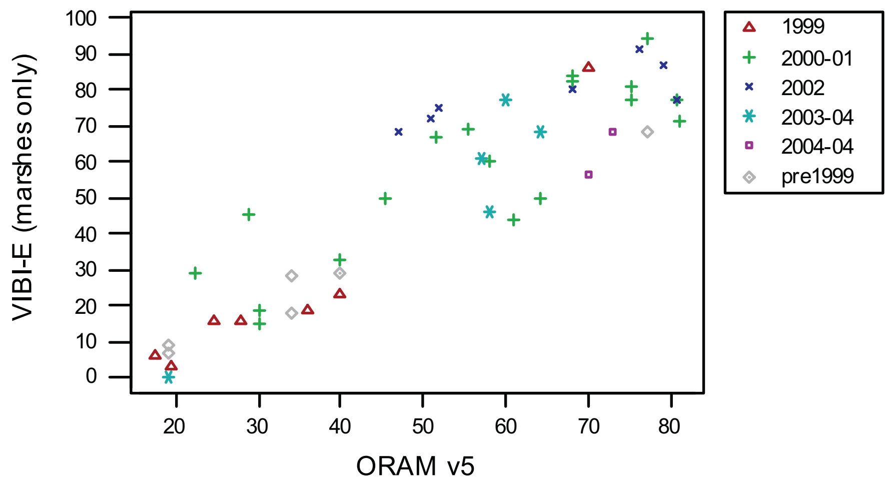
Site	Vegetation Class	Passes	Species	Total
Bike Path	F	3	Ambystoma jeffersonianum	5
Bike Path	F	3	Ambystoma texanum	6
Bike Path	F	3	Pseudacris crucifer	5
Bike Path	F	3	Pseudacris triseriata	220
Bike Path	F	3	Rana catesbeiana	1
Bike Path	F	3	Rana clamitans	4
Bike Path	F	3	Rana sylvatica	3608
Blue Heron Marsh	E	3	Rana clamitans	65
Blue Heron Marsh	E	3	Rana pipiens	6
Blue Heron Woods	F	2	Ambystoma texanum	11
Blue Heron Woods	F	2	Pseudacris triseriata	34
Blue Oxbow	F	3	Ambystoma hybrid	4
Blue Oxbow	F	3	Ambystoma texanum	1
Garden Rd. South	F	2	Ambystoma hybrid	2
Garden Rd. South	F	2	Pseudacris triseriata	9
Green Oxbow	F	3	Ambystoma hybrid	1
Hiltner	F	2	Rana pipiens	1
Irwin Pin Oak	E	3	Ambystoma hybrid	1
Irwin Pin Oak	E	3	Hyla versicolor	12
Irwin Pin Oak	E	3	Pseudacris crucifer	4
Irwin Pin Oak	E	3	Pseudacris triseriata	4
Irwin Pin Oak	E	3	Rana clamitans	29
Irwin Pin Oak	E	3	Rana pipiens	65
Irwin Prairie	E	2	Pseudacris crucifer	1
Irwin Prairie	E	2	Pseudacris triseriata	65
Irwin Prairie	E	2	Rana pipiens	2
Irwin Vernal	E	3	Pseudacris crucifer	1
Irwin Vernal	E	3	Pseudacris triseriata	7
Irwin Vernal	E	3	Rana clamitans	17
Irwin Vernal	E	3	Rana pipiens	49
Kinglet	F	2	Ambystoma texanum	11
Kinglet	F	2	Pseudacris triseriata	1
Kinglet	F	2	Rana clamitans	1
Lodge	F	2	Ambystoma jeffersonianum	7
Lodge	F	2	Ambystoma texanum	126
Lodge	F	2	Rana catesbeiana	1
Lodge	F	2	Rana clamitans	1
Lodge	F	2	Rana sylvatica	21
Lou Campbell	E	3	Pseudacris crucifer	24
Lou Campbell	E	3	Pseudacris triseriata	32
Lou Campbell	E	3	Rana catesbeiana	1
Lou Campbell	E	3	Rana clamitans	12
Lou Campbell	E	3	Rana palustris	9
Lou Campbell	E	3	Rana pipiens	1
Lucas	F	3	Pseudacris crucifer	2

Site	Vegetation Class	Passes	Species	Total
Lucas	F	3	Pseudacris triseriata	3
Lucas	F	3	Rana clamitans	1
Lucas	F	3	Rana sylvatica	10
Marie DeLarme N	F	2	Ambystoma hybrid	6
Marie DeLarme N	F	2	Rana sylvatica	3
Muck Farm	E	2	Hyla versicolor	1
Muck Farm	E	2	Pseudacris crucifer	17
Muck Farm	E	2	Pseudacris triseriata	17
Muck Farm	E	2	Rana pipiens	2
NASA 100	F	2	Rana clamitans	1
NASA 3	E	3	Ambystoma texanum	80
NASA 3	E	3	Pseudacris crucifer	8
NASA 3	E	3	Pseudacris triseriata	31
NASA 3	E	3	Rana catesbeiana	1
NASA 3	E	3	Rana pipiens	3
NASA 8	E	3	Ambystoma texanum	1
NASA 8	E	3	Bufo sp.	1
NASA 8	E	3	Pseudacris crucifer	82
NASA 8	E	3	Pseudacris triseriata	16
NASA 8	E	3	Rana clamitans	8
NASA 8	E	3	Rana pipiens	1
Old State Line Rd.	F	2	Ambystoma hybrid	11
Old State Line Rd.	F	2	Ambystoma texanum	1
Old State Line Rd.	F	2	Pseudacris crucifer	8
Old State Line Rd.	F	2	Pseudacris triseriata	24
Old State Line Rd.	F	2	Rana clamitans	17
Patton North	E	2	Ambystoma hybrid	14
Patton North	E	2	Ambystoma laterale	7
Patton North	E	2	Ambystoma texanum	12
Patton North	E	2	Hyla versicolor	1
Patton North	E	2	Pseudacris crucifer	12
Patton North	E	2	Pseudacris triseriata	115
Patton North	E	2	Rana clamitans	3
Patton Southwest	E	2	Pseudacris triseriata	8
Patton Southwest	E	2	Rana clamitans	2
Ranger	S	3	Hyla versicolor	3
Ranger	S	3	Pseudacris crucifer	41
Ranger	S	3	Pseudacris triseriata	108
Ranger	S	3	Rana catesbeiana	1
Ranger	S	3	Rana clamitans	4
Ranger	S	3	Rana sylvatica	20
Rudolph Savannah	F	3	Ambystoma hybrid	4
Rudolph Savannah	F	3	Ambystoma tigrinum	2
Rudolph Savannah	F	3	Pseudacris triseriata	19
Steidtmann BB	S	3	Ambystoma hybrid	2
Steidtmann BB	S	3	Ambystoma maculatum	4
Steidtmann BB	S	3	Ambystoma texanum	3
Steidtmann BB	S	3	Ambystoma tigrinum	3
Steidtmann BB	S	3	Pseudacris crucifer	6
Steidtmann BB	S	3	Pseudacris triseriata	12
Steidtmann BB	S	3	Rana clamitans	1
Steidtmann BB	S	3	Rana pipiens	12

Site	Vegetation Class	Passes	Species	Total
Steidtmann Marsh	E	3	Ambystoma hybrid	12
Steidtmann Marsh	E	3	Ambystoma tigrinum	1
Steidtmann Marsh	E	3	Pseudacris crucifer	1
Steidtmann Marsh	E	3	Pseudacris triseriata	2
Steidtmann Marsh	E	3	Rana clamitans	19
Steidtmann Marsh	E	3	Rana palustris	1
Steidtmann Marsh	E	3	Rana pipiens	4

Table 10. Sites, Sampling Runs, AmphIBI Metric scores, AmphIBI scores and ORAM scores.													
Site Name	Runs	AQAI	Pts	RA Tol	Pts	RA Sens	Pts	Sal Sp	Pts	WF/SS	Pts	Amph IBI	ORAM v5
Bike Path	3	6.75	10	0.06	10	0.937	10	2	3	yes	10	43	60
Blue Heron Marsh	3	2.92	0	1	0	0	0	0	0	no	0	0	43
Blue Heron Woods	2	3.24	3	0.756	0	0	0	1	0	no	0	*3	41
Blue Oxbow	3	4.8	7	0	10	0	0	2	3	no	0	20	58
Derby	3	0	0	0	0	0	0	0	0	no	0	0	37
Garden Rd. South	2	3.36	3	0.818	0	0	0	1	0	no	0	*3	59
Green Oxbow	3	5	7	0	10	0	0	1	0	no	0	17	68
Hiltner	2	2	0	1	0	0	0	0	0	no	0	*0	51
Irwin Pin Oak	3	2.62	0	0.887	0	0	0	1	0	no	0	0	67
Irwin Prairie	2	2.96	0	1	0	0	0	0	0	no	0	*0	71
Irwin Vernal	3	2.32	0	1	0	0	0	0	0	no	0	0	64
Kinglet	2	3.85	3	0.154	7	0	0	1	0	no	0	*10	73
Lodge	2	4.48	3	0.013	10	0.135	7	2	3	yes	10	*33	50.5
Lou Campbell	3	3.34	3	0.886	0	0.114	7	0	0	no	0	10	47
Lucas	3	5.38	7	0.375	7	0.625	10	0	0	no	0	24	47
Mancy Tract N Meadow	1											na/	56
Marie DeLarme North	2	5.67	10	0	10	0.333	7	1	0	yes	10	*37	88
Marie DeLarme South	1											n/a	61
Muck Farm	2	2.54	0	0.973	0	0	0	0	0	no	0	*0	65
NASA 3	3	3.55	3	0.345	7	0	0	1	0	no	0	10	34
NASA 8	3	2.2	0	1	0	0	0	1	0	no	0	0	43
NASA 100	2	3	3	1	0	0	0	0	0	no	0	*3	31
Old State Line Rd.	2	2.97	0	0.803	0	0	0	2	3	no	0	*3	61.5
Patton North	2	3.48	3	0.793	3	0.043	3	3	7	no	0	*16	80
Patton Southwest	2	3	3	1	0	0	0	0	0	no	0	*3	75
Ranger	3	3.25	3	0.87	0	0.113	7	0	0	no	0	10	48
Reed Road	1											n/a	54
Rudolph Savannah	3	3.56	3	0.76	3	0.08	3	2	3	no	0	12	65
Skull 1	1											n/a	59
Skull 2	1											n/a	59
Steidtmann BB	3	2.86	0	0.721	3	0.163	7	4	10	yes	10	30	69
Steidtmann Marsh	3	3.7	3	0.65	3	0.05	3	2	3	no	0	12	59

* - indicates sites where results from only two passes of trapping were used to compile AmphIBI metrics and total scores.



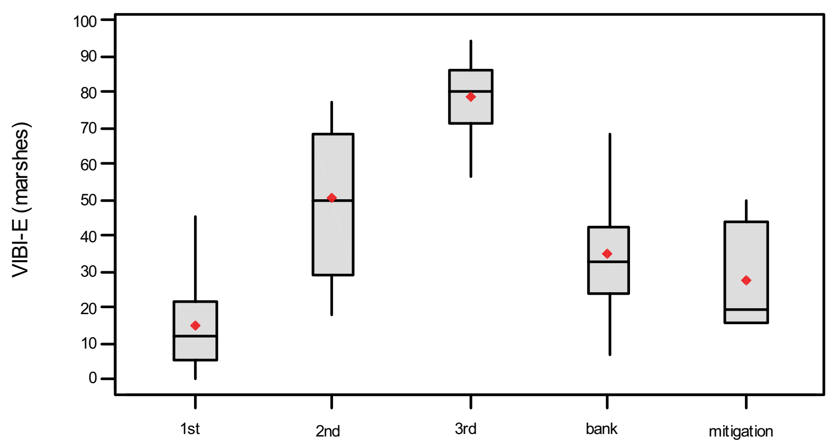


Figure 1. Scatterplot and box and whisker plot of VIBI scores for marsh communities 1996-2004, excluding Lake Erie coastal marshes.

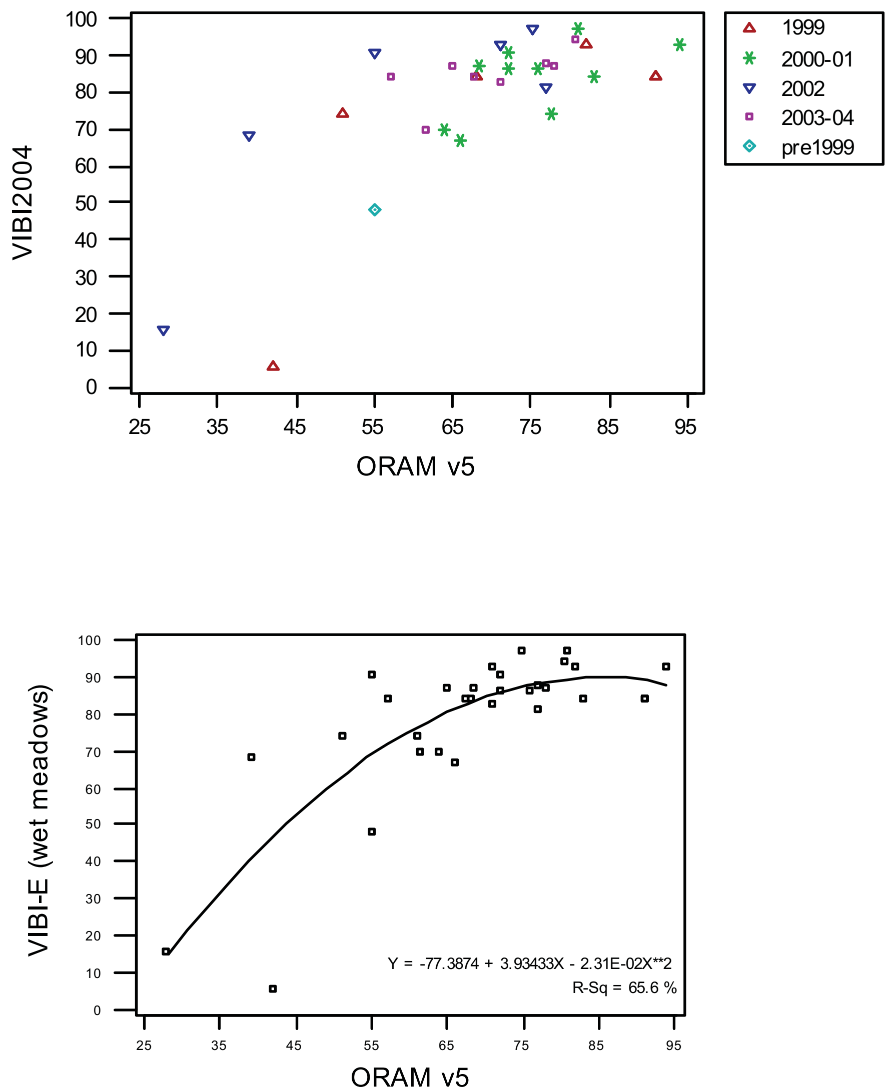


Figure 2. Scatterplot and quadratic regression line of VIBI scores for wet meadow communities 1996-2004. Wet meadows includes fens, Oak Openings sand prairies, wet prairies, reed canary grass meadows and other sedge-grass dominated wetlands.

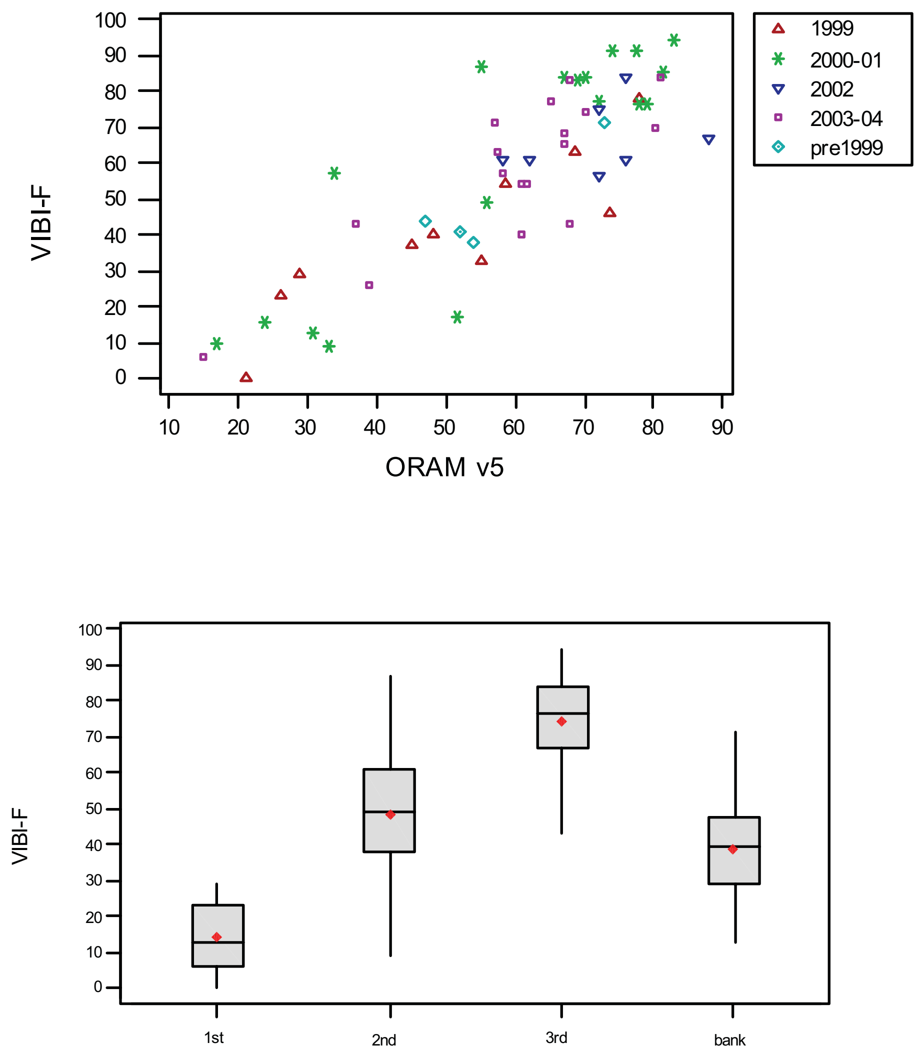
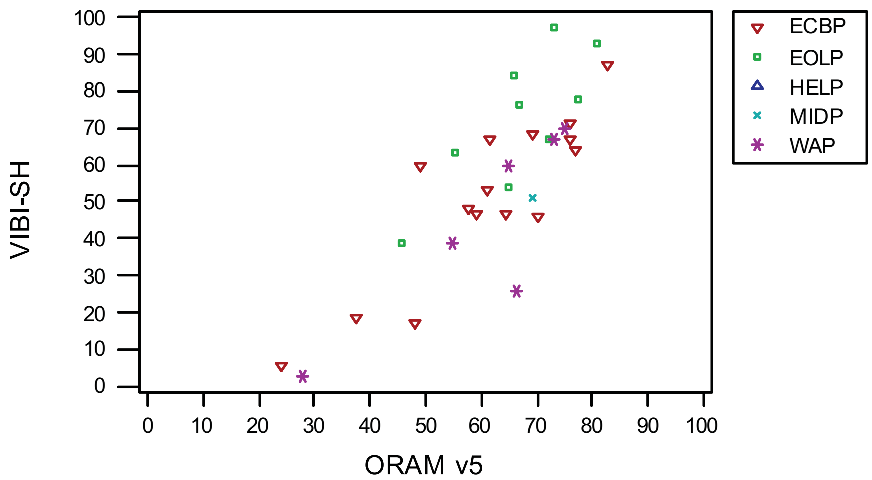


Figure 3. Scatterplot and box and whisker plot of VIBI scores for forest communities 1996-2004, excluding forest seeps and bog forests.



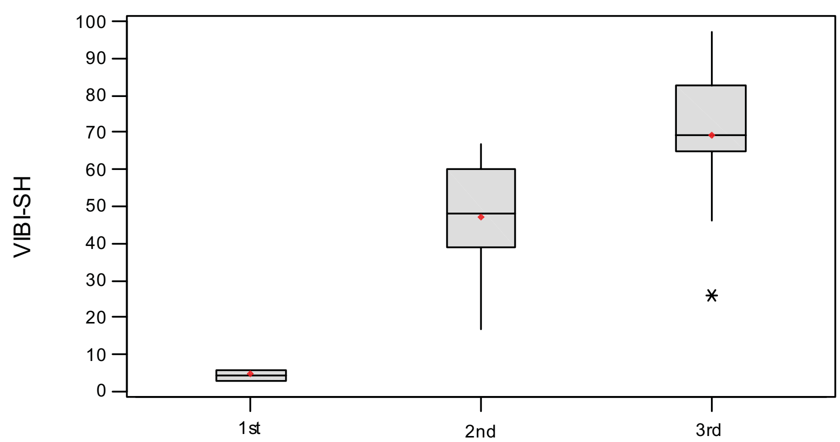


Figure 4. Scatterplot and box and whisker plot of VIBI scores for shrub communities 1996-2004, excluding tall shrub bogs and fens.

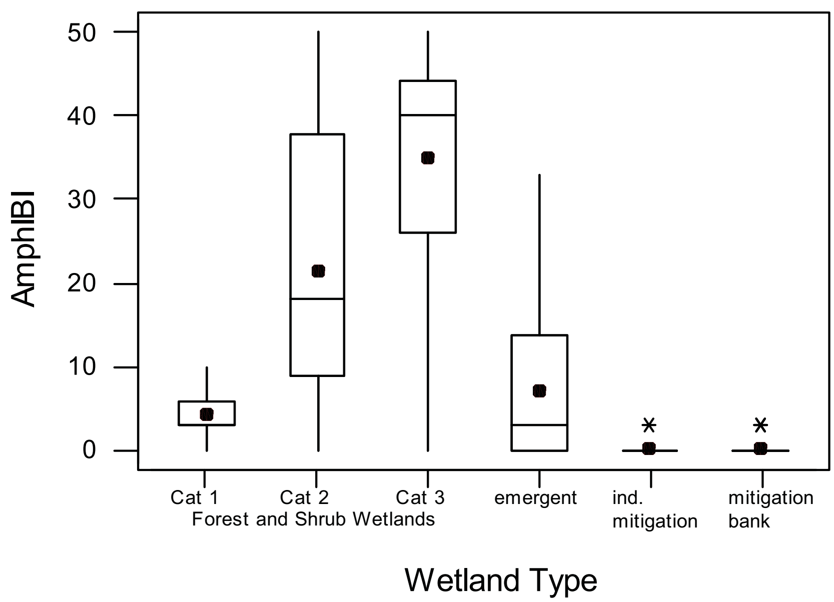


Figure 5. Box and whisker plot of AmphIBI scores for wetland communities 1996-2004.