EVALUATION OF RESTORED WETLANDS
USING THE OHIO RAPID ASSESSMENT METHOD

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ABSTRACT

THESIS: Evaluation of Restored Wetlands Using the Ohio Rapid Assessment Method

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The history of wetland regulation, identification, and delineation was researched to examine the current status of wetland assessment. One area of interest was the Natural Resources Conservation Service (NRCS) programs to construct and restore wetlands on previously farmed land. Indices of biotic integrity and other intensive assessment methods such as Floristic Quality Assessments are frequently used to document condition and quality for both natural and constructed wetlands. This research used the Ohio Rapid Assessment Method (ORAM) to evaluate five NRCS wetlands of different ages and an undisturbed natural wetland for comparison. In addition, an intensive vegetative survey was conducted at each wetland to determine the characteristics of the plant community and to create a Vegetation Index of Biotic Integrity (VIBI) based on the Ohio wetland assessment program. The goals of the research were to document the condition of the wetlands, to evaluate the use of the rapid assessment method compared to the more extensive vegetative assessments, and to examine the vegetative composition of the wetlands as a function of age since establishment under the NRCS programs. Scores determined by the ORAM and the VIBI demonstrated a close correlation. ORAM scores also correlated to Floristic Quality Assessment Index scores calculated as part of the VIBI. Scores calculated by the ORAM and VIBI were regressed against the age of the wetland. These assessment scores were not significantly related to age, however lack of significance might have been constrained by the small number of samples. This research demonstrated that the rapid assessment technique used provided results comparable to more intensive methods and could provide a relatively quick and accessible method to monitor wetland condition and development.

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EXPLANATION OF FORMAT

This thesis is divided into three chapters. Chapter one is a general introduction and extended literature review. Chapter two is an embedded technical paper intended for publication in a peer-reviewed journal. Chapter three includes additional information, a general summary and conclusions.

Chapter one contains an introduction to the subject of wetland identification and delineation and extensive review of literature. The review of literature is divided into sections by topic. It also contains information on the methods and sites chosen for the research.

Chapter two is an embedded technical paper. It was written with the intent of publication in *Proceedings of the Indiana Academy of Science* and is formatted accordingly. It contains the following: abstract, introduction, methods and analysis, results and discussion, and literature cited. Appropriate figures and tables are embedded within the text.

Chapter three consists of additional information from the project. Data and observations not included in the technical paper are presented in this section along with personal observations and recommendations for future research. This chapter is followed by several appendices containing raw data and other supporting information.

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CHAPTER 1. General Introduction

1.1 Wetlands

Wetlands consist of areas defined by their name, in other words, wet lands. Wetlands naturally form in areas where surface water periodically collects and/or where groundwater discharges, at least seasonally, enough to create waterlogged soils (Tiner 1999). This prolonged saturation allows the establishment of specific vegetation able to withstand periods of anaerobic and/or reducing conditions (hydrophytes) and the development of specific soils (hydric soils). Because of the variation in ecological settings, multiple plant communities and soil types have developed in wetland conditions. For instance, in the late 1970s, Cowardin et al. (1979) identified five systems of wetland and deepwater habitats incorporating ten subsystems and fifty-six classes. Wetlands are valued for their functions in the water cycle: storing, stabilizing, and purifying water; for their roles in providing habitat and supporting biodiversity; and for their ability to act as carbon sinks and climate stabilizers on a global scale (Mitsch and Gosselink 1993). It has become increasingly important to identify, classify, and delineate wetlands for both protection and jurisdiction. In addition, methods have been developed to measure the success of restoration of degraded wetlands and the creation of new wetlands.

1.2 History of Wetlands

At the time of European settlement, the contiguous United States contained 221 million acres of wetlands. By 1990, less than half remained (Dahl 2000). At the time of European settlement in Indiana, 24 percent of the state was covered by wetlands. Today 3.5 percent of the state is considered wetland; 85 out of every 100 acres of original wetland have been lost (IDEM 2004).

Native Americans valued wetlands as a source of wild rice, game, and fur-bearing animals (Meyer 2004). With the advent of European settlement, wetlands were regarded in a different light. Wetlands could not be used for traditional farming methods familiar to the colonists, they provided obstacles to travel, and coastal wetlands blocked commerce and expansion of cities. Low-lying coastal developments also suffered from flooding.

A major factor in the approach to wetlands was the fear of disease. Malaria, introduced by the colonists, and meaning “bad air”, was blamed on miasma, a gaseous product supposedly given off by stagnant waters and decaying vegetation. By draining these swampy areas, the threat of disease was removed, and land was made available for agriculture or development.

The Swamp Act of 1849 was the first federal legislation to deal with wetlands (Gaddie and Regens 2000). This act was passed to allow Louisiana to drain and fill wetlands for the purpose of disease control and reclamation. Additional legislation extended this authority to twelve other states in 1850. Individual states passed ditch laws in the following years (Meyer 2004), guaranteeing the right to dig channels across the private land of others. Because most wetlands covered significant areas, drainage districts were formed, allowing local governments to form bodies that could undertake large-scale reclamation projects and tax landowners who shared in the benefits. This approach lasted well into the 20th century. As late as 1968, Congress was appropriating funds to the Department of Agriculture to fill wetlands under the Soil Conservation and Domestic Allotment Act (Gaddie and Regens 2000).

After World War I, the United States entered a period of low agricultural prices and overproduction, lasting through the 1920s and 1930s. Farmers were left with high costs and declining incomes, and the drainage districts suffered, with many declaring bankruptcy during the Great Depression. In addition, the land produced from draining wetlands became less productive, and in some cases proved to be a fire hazard (Gaddie and Regens 2000).

Equally important to wetland preservation was the discovery that malaria was not caused by the miasma associated with wetlands, but by pathogens transmitted by mosquitoes. This meant that the disease could be controlled through measures aimed at the insects rather than wetlands in general. These control measures, particularly the use of DDT, had damaging effects on their own, but control was no longer tied to wetland drainage.

While the U. S. Government still supported the drainage of wetlands, attitudes were beginning to change. Declining numbers of migratory waterfowl and other species were linked to the loss of wetland habitat as a result of drainage. In the early 1900s, novelist and nature photographer Gene Stratton-Porter wrote about life in and around the Limberlost swamp in east central Indiana, introducing thousands of readers to the vegetation and wildlife of the wetland. In the 1920s and 1930s, the political cartoonist Jay

N. Darling alerted readers to the problems of wetland loss (Meyer 2004). Darling served in the Franklin D. Roosevelt administration at the start of the New Deal and helped create the federal Duck Stamp program in 1934 that tagged a portion of hunters' license fees to develop and maintain wetland refuges. "A Sand County Almanac," a collection of essays by Aldo Leopold, was published in 1948, including one essay on the contrasts between thriving wetlands and their drained aftermath. In 1962, Rachel Carson published "Silent Spring," making people aware of the harmful effects of DDT on songbirds and other wildlife. The first Earth Day was held on April 22, 1970, with rallies on college campuses and in large cities, and accompanied by extensive media coverage.

At the same time that popular environmentalism was increasing, more scientists were becoming aware of the benefits of wetlands. The ecosystems that support plant and wildlife also function as a water filtration system for streams and rivers, removing pollutants, toxins, and nutrients. Wetlands provide a more stable water system in times of drought, and act as a storage system during high water flows and flooding.

1.3 Wetland Regulation

In the early 1970s, major environmental legislation was passed, including the National Environmental Policy Act. This act was a basic charter for the protection of the environment, requiring among other things that federal agencies conduct assessments of the environmental impact of major programs. Several pieces of legislation were amended to become the Clean Air Act and the Federal Water Pollution Control Act of 1972 (NRDC 2000).

The 1972 Federal Water Pollution Control Act set the basic structure for regulating discharges of pollutants to waters of the United States (US EPA 2003a). Section 404 of this Act established a program to prohibit the discharge of dredged and fill material into “navigable waters” of the United States without obtaining a permit from the U. S. Army Corps of Engineers (US EPA 2003b). The Clean Water Act definition of “navigable waters” excluded most wetlands that are generally non-navigable and other isolated or shallow waters from Section 404’s jurisdiction (Pittman 2002). Activities that were regulated by this section included fills for development, water resource projects such as dams and levees, infrastructure development such as highways and airports, and conversion of wetlands to uplands for farming and forestry. The basic premise of the program was that no discharge of dredged or fill material would be permitted if (1) a practicable alternate existed that was less damaging to the aquatic environment or (2) the nation’s waters would be significantly degraded.

Section 404 of the Clean Water Act assigned different duties to different agencies. The U. S. Army Corps of Engineers administered the day-to-day program, conducted or verified jurisdictional determinations, developed policy and guidance, and enforced Section 404 provisions. The U. S. Environmental Protection Agency (EPA) developed and interpreted policy, guidance, and environmental criteria used in evaluating permit applications; determined the scope of geographical jurisdiction and applicability of exemptions; approved and oversaw state and tribal assumptions; reviewed and commented on individual permit applications; had the authority to prohibit, deny, or restrict the use of any defined area as a disposal site; could elevate specific cases; and enforced Section 404 provisions. The U. S. Fish and Wildlife Service and the National

Marine Fisheries Service were responsible for evaluating impacts on fish and wildlife of all new federal projects and federally permitted projects, conducting site visits to assess function and quality, and advising the Corps of Engineers and the EPA on specific cases or policy issues.

Once the Clean Water Act was in place, litigation and additional legislation expanded the scope of the original program, originally written to protect "navigable waters." A landmark case in 1975, National Resources Defense Council, Inc. v. Callaway, extended jurisdiction to include the "waters of the United States to the maximum permissible" (Mandelker 1998). This included wetlands, justified by the possibility that pollutants discharged into a wetland might be carried out of the wetland and into an adjacent body of water by natural surface and groundwater flows, and from there be carried downstream and eventually across a state line. As a result of the Callaway decision, the Corps modified its interpretation of the Clean Water Act "to cover all freshwater wetlands that are defined as areas that are 'periodically inundated' and normally characterized by the prevalence of vegetation that requires saturated soil conditions for growth and reproduction as well as those that are adjacent to other covered waters" (Pittman 2002). In 1977, the Corps redefined its interpretation of a wetland by eliminating the "periodically inundated" requirement and terminated the requirement that wetlands be adjacent to navigable water. In 1985 the EPA issued a memorandum stating that a wetland that is used or potentially can be used by migratory waterfowl that may have crossed a state or national boundary meets the definition of "waters of the United States" and in 1986 the Corps of Engineers issued a memorandum supporting the EPA position (McEowen 2006).

In January of 2001, the Supreme Court determined that the Corps of Engineers' use of the "migratory bird rule" to establish jurisdiction over isolated waters was invalid. The effect of this decision for the Solid Waste Agency of Northern Cook County, referred to as the SWANCC decision, is still being argued, but it has affected a large number of permits and changed how isolated wetlands in particular are regulated (Meltz and Copeland 2004).

The federal government has taken additional approaches to regulating wetland preservation. The Food Security Act of 1985 contained provisions to discourage the conversion of wetlands into farmed areas. The "Swampbuster" provision denied federal farm program benefits to producers who converted wetlands after December 23, 1985. The Emergency Wetlands Resources Act of 1985 authorized the purchase of wetlands, and required a National Wetlands Inventory to be updated at ten-year intervals. The Food, Agriculture, Conservation, and Trade Act of 1990 strengthened the "Swampbuster" provisions of the Food Security Act (US EPA 2003b). The Wetland Reserve Program (WRP), established by Congress in the 1990 Farm Bill, is a voluntary easement or restoration cost-sharing agreement with landowners to restore, protect, and enhance wetlands (USDA 2002). The establishment of the National Conservation Reserve Program, administered by the U. S. Department of Agriculture, covers a variety of conservation practices on agricultural land including wetland restoration (CP23), farmable wetlands (CP27), and buffers (CP28) (USDA 2002; USDA 2004).

1.4 Identification and Delineation

The earliest wetland definitions were developed for scientific studies or management purposes. One early reference to wetlands was published in 1890 in a U. S. Geological Survey report by Nathaniel Shaler titled “Freshwater Morasses of the United States” and refers to inundated land unsuitable for farming until drained or diked (Tiner 1999). Early ecological studies characterized wetlands by vegetation, such as Warming in the 1909 “Oecology of Plants,” or by plant communities and soil types in “The Plant Life of Maryland” (Tiner 1999). Martin et al. (1953) developed a wetland classification system for a national survey to inventory important waterfowl wetlands for the U. S. Fish and Wildlife Service (FWS). This system was used by the FWS as well as the U. S. Department of Agriculture Soil Conservation Service and state agencies to map and inventory wetlands through the mid 1960s (Tiner 1999). Since the emphasis of the system was on waterfowl habitats, the Martin system combined different habitats and different ecological types of wetlands into the same category, making it difficult to apply the classifications across the United States (Cowardin et al. 1979).

The FWS began planning for a national wetland survey in 1974 and designed a new classification system. The system had three primary objectives: (1) to group ecologically similar habitats, (2) to furnish habitat units for inventory and mapping, and (3) to provide uniformity in concepts and terminology (Tiner 1999). In 1979, the U. S. Fish and Wildlife Service published the Classification of Wetlands and Deep Water Habitats of the United States (Cowardin et al. 1979) that set the standard for wetland classification. The Cowardin classification system moved from a broad definition of five basic wetland systems to ten subsystems to eleven classes based on dominant vegetative life or wetland substrate if vegetation is lacking. Classes were further subdivided based on water regimes, water chemistry, soil or specific modifiers. The Cowardin classification system has become widely used for identifying and classifying wetlands.

In 1993, wetland ecologist Mark Brinson developed a wetland classification system to take into account hydrogeomorphic features that are directly linked to wetland functions but not addressed in the Cowardin system (Brinson 1993). The hydrogeomorphic-based (HGM) system provided a framework for evaluation of wetland function based on such items as the dominant hydrological source supporting the wetland, size, and landscape position. The HGM model identified seven basic hydromorphic classes and further divided riverine wetlands based on water gradient. Interest in the HGM approach to wetlands encouraged the FWS to reexamine the Cowardin classification system. By 1997, the FWS had developed a pilot system that used the information in the HGM system as descriptors to the official wetland classification system to provide additional information for mapped wetlands. This additional information included landscape position, land form, and water flow path. Other descriptors and modifiers are being examined and may be added in the future.

As a classification system for wetland types was being developed, a consistent means of identifying or delineating a wetland was needed. Wetland and water resource laws established land use controls on private and public lands that required the identification of wetlands and the determination of their boundaries (Tiner 1999). Early efforts in the 1960s began with laws to protect tidal wetland based on indicator plants and plant communities. These laws were expanded to inland and non-tidal wetlands, again using lists of characteristic species. Since many wetland communities were a mixture of obligate wetland species and upland species, the 50% rule was used. If more than 50% of the plants in an area were wetland indicator species, that is facultative or wetter, then the community would be considered a wetland. Other factors such as soil type were used for identification, particularly after the completion of USDA Soil Conservation Service (SCS) soil maps. Eventually a combination of parameters was used for delineation. Regulatory agencies including the EPA and the Army Corps of Engineers who were charged with enhancing or preserving current areas and the jurisdictional requirements associated with construction and mitigation of new areas needed standardized techniques for wetland identification and delineation (Fennessy et al. 2004). Both the EPA and the Corps prepared wetland delineation manuals for identifying jurisdictional wetlands, with the Corps publishing a *Wetlands Delineation Manual* in 1987 (US Army Corps of Engineers 1987). These manuals considered plants, soils, and signs of wetland hydrology combined with the SCS's lists of hydric soils and the FWS's wetland plants, however there were still local and subjective guidelines for identification (Tiner 1999).

The Food Security Act passed by Congress in 1985 included the "Swampbuster" provisions designed to discourage drainage and conversion of wetlands for agricultural purposes (US EPA 2003b). The Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service, was charged with identifying wetlands on agricultural land to monitor compliance. The NRCS developed procedures to identify wetlands using a combination of soil survey information and aerial photographs provided by the Department of Agriculture.

With four governmental agencies using four different approaches to identifying and delineating wetlands, questions and confusion arose surrounding jurisdictional wetlands in particular. An interagency meeting in 1988 set the stage for the development of a technically based federal methodology, and in 1989 the “Federal Manual for Identifying and Delineating Jurisdictional Wetlands” was adopted (Federal Interagency Committee for Wetland Delineation 1989). The new manual extended jurisdiction to considerably more private land than previously regulated. In addition, provisions in the Swampbuster Act used hydric soils and hydrology to identify farmed wetlands. This meant that wetlands so identified, regardless of whether vegetation including agricultural crops was removed or not, required federal permits to convert to other uses. Political pressure forced the Corps to reconsider the 1989 manual, and in late 1991 the 1987 Corps manual was reinstated as the approved methodology. The EPA adopted the 1987 Corps manual for jurisdictional determinations in 1993. In addition to the federal agencies, individual states developed method manuals that use a variety of approaches to identification and delineation. Most methods rely on the use of the three main parameters; hydrophytic vegetation, hydric soils, and wetland hydrology.

Identification and delineation of a wetland are used for jurisdictional purposes to specify what areas are protected. Once the wetland has been identified, Section 401 and Section 404 of the Clean Water Act require assessments to determine whether to permit the destruction, alteration, or degradation of a wetland and to determine the mitigation required (Mack 2001). These can include the assessment of function, quality, and condition of wetlands. As individual states took over implementation of Sections 401 and 404, a number of methods were developed to meet assessment needs (Balcombe et al. 2005; Bartoldus 1999; Brooks and Hughes 1986; Spieles 2005).

1.5 Rapid Field Assessment Methods

In 2004, the U. S. Environmental Protection Agency issued a report reviewing rapid field assessment methods (Fennessy et al. 2004). According to this study, rapid field assessments (Level 2) are the middle level of a three-tier framework for wetland monitoring and assessment including broad, landscape-scale assessments (Level 1) and intensive biological and physico-chemical measures (Level 3). Rapid assessment methods were chosen for analysis in this research because they can provide "sound quantitative information on the status of a wetland resource with a relatively small investment of time and effort" (Fennessy et al. 2004). Fennessy et al. assessed the methods on the basis of four criteria: the method can be used to measure condition, the method should be rapid (requiring no more than two people a half-day in the field and a half-day of office preparation and data analysis), the method must be an on-site assessment, and the method can be verified. Of the sixteen methods, the authors concluded that seven met the criteria selected. One of these, the Ohio Rapid Assessment Method (ORAM) was particularly well suited to the type of analysis undertaken in this research.

1.5.1 *Ohio Rapid Assessment Method (ORAM)*

The Ohio EPA adopted regulations that categorize wetlands based on their quality and impose differing levels of protection based on the wetland category. These regulations specify three wetland categories: Category 1 (low quality), Category 2 (medium quality), and Category 3 (high quality). The ORAM was developed by the Ohio Environmental Protection Agency (Ohio EPA), Division of Surface Water, as a Level 2 tool to provide a relatively fast and easy method for determining the appropriate category of a particular wetland (Mack 2001). Indiana, on the other hand, regulates isolated wetlands that do not fall under Section 404 jurisdiction using a three class system based on amount of disturbance, species diversity, percentage of non-native or invasive species, hydrological function, and quality of wildlife and aquatic habitat.

The ORAM focuses on freshwater wetlands, and records observations on characteristics that particularly apply to wetlands such as sources of water, hydraulic alterations, presence of buffer zones around the wetland and human land use in the buffer zones (Mack 2001). The ORAM has been used in Ohio to assess over sixty different wetlands in the Eastern Cornbelt Plains Ecoregion, (Figure 1) an area that also includes east central Indiana (Omernik 1987).

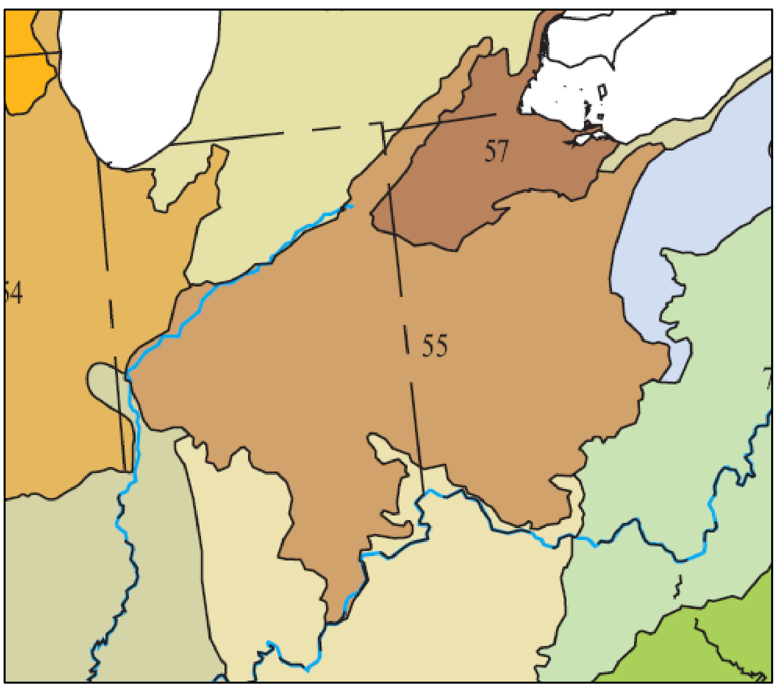

Figure 1.---Eastern Cornbelt Plains Ecoregion #55 (Omernik 1987). Jay County is located in the center of the ecoregion on the Indiana / Ohio state line.

The ORAM was developed from the Washington State Department of Ecology Wetlands Rating System (Washington Department of Ecology 1993) and was adapted for use in Ohio. The ORAM version 5.0 was updated to include assessment of a wetland's hydrology and human alterations to a wetland's natural habitat. The ORAM calculates the category of a wetland based on information reported on six metrics. These include wetland area or size; upland buffers and surrounding land use, including width of buffer around the wetland perimeter and intensity of surrounding land use; hydrology, including sources of water, water depth, modifications to the natural hydrology and hydrology disturbances; habitat alteration and development, including mowing, grazing, or farming; special wetland communities, if found; and plant communities, interspersion, and micro topography. Several indicators are scored for each metric, and the total number of points from the addition of all the metrics defines the category of the wetland in a range from 0 to 100. A Category 1 wetland would fall in the 0 – 34.9 range, a Category 2 wetland in the 35 – 64.9 range, and a Category 3 wetland in the 65 – 100 range. Under Ohio regulations, each category would require differing levels of regulatory protection.

The use of multiple metrics combined into a single index has been used by several states in developing wetland assessment procedures, including Montana (Jones 2004), Florida (Reiss 2006), Oklahoma (Hartzell et al. 2007), Pennsylvania (Miller et al. 2006; Wardrop et al. 2007) and the Great Lakes area (Ingram et al. 2001). The ORAM method itself has been used as a reference in developing other wetland assessments, such as the California Rapid Assessment Method (Collins et al. 2004), by Rhode Island in developing a wetland monitoring and assessment plan (Pelton and Murphy 2005), and by Montana to assess wetland conditions (Jones 2004; Fehringer 2005).

1.5.2 *Vegetative Index of Biotic Integrity (VIBI)*

As a supplement to the ORAM rating, the Ohio Environmental Protection Agency, Division of Surface Water, has developed a Level 3 Integrated Wetland Assessment Program that uses wetland biological assessments, such as macroinvertebrates and amphibians (Micacchion et al. 2000). One method in the program is a biological assessment of wetlands using vascular plants as an indicator species (Mack 2004). The vegetation sampling procedures were adapted from methods developed for the North Carolina Vegetation Survey (Peet 1998). The information obtained in the vegetation assessment is used to calculate a Vegetation Index of Biotic Integrity or VIBI. VIBIs have been developed for three different wetland types, included emergent vegetation covering marshes, wet meadows, and sphagnum bogs (VIBI-E); forest vegetation covering swamp forests, bog forests, and forest seeps (VIBI-F); and shrub vegetation covering shrub swamps, bog shrub swamps, and tall shrub fens (VIBI-SH); with each index having its own set of metrics. Like the ORAM field rating, the VIBI is a multiple metric assessment based on 10 different metrics with a maximum score of 100. The VIBI is calculated by summing the metric scores.

The typical application of the VIBI method uses a set of 10 modules in a 20 m x 50 m plot layout. The investigator determines the length, width, and orientation of the plot based on site characteristics. Plots are sited to be the most representative of the plant community of interest at the wetland. At least four of the 10 m x 10 m modules are intensively sampled with a series of nested quadrats. Within each of these "intensive" modules, species cover class values are estimated for the 100 m^2 area. Species located outside of the intensive modules ("residual" modules) are also recorded and percent cover is estimated over the area of the residual modules. Woody species are measured (diameter at breast height or dbh) and counted separately for each module of the plot (Mack 2004). Data from the survey are entered onto a spreadsheet or database used for data reduction, calculation, and coding. Database software has been developed for automated data handling, although hand calculations can be used. Once the specific metrics for the site have been calculated, they are recoded as scores of 0, 3, 7, or 10 using designated scoring ranges. These metrics are summed to obtain the VIBI score.

One metric in the VIBI is the Floristic Quality Assessment Index (FQAI). The FQAI was developed for the northern Ohio region as a tool to assess the nativeness of an area based on the presence of conservative species, but can be applied throughout an ecological region such as the Eastern Corn Belt Plains (Andreas 1995; Andreas et al. 2004). Native species are assigned a value from 0 to 10 indicating a degree of conservatism or fidelity to a specific natural community. Species with high conservatism values are sensitive to habitat degradation and species with low conservatism values have little or no fidelity to specific communities and can be resistant to disturbance. Swink and Wilhelm (1994) developed a Floristic Quality Index for the Chicago region, and more recently Rothrock (2004) published a Floristic Quality Assessment for Indiana using the same concept of coefficients of conservatism to evaluate the effects of restoration and management efforts.

1.6 Site Descriptions

Sites for assessment were chosen in Jay County, Indiana with the assistance of the NRCS District Conservationist. All sites were located on previously farmed land that met the requirements for inclusion in the Wetlands Reserve Program or the Conservation Reserve Program's Farmable Wetlands Program. Eligibility was based on factors such as farming history, soil type and available acreage. Sites were chosen for assessment to reflect a range of ages. The natural wetland chosen for comparison was located in the same general area of the NRCS wetlands and reflected similar underlying geology and hydrology.

Site 1 is a Wetland Reserve Program wetland. The wetland was installed in 1993 on the site of a former grass filter strip. The wetland was created by digging out a low area and constructing a berm to retain drainage from upland fields. The wetland is surrounded by open fields and a wooded area to the north. The landowners installed prairie and upland grasses surrounding the wetland. Farming is still practiced to the northwest, although there is a wide buffer area. The property was in a 15-year easement, with 2008 as the renewal year. In order to maintain the wetland easement, the landowners are required to install additional practices, including wetland and buffer plantings. As a result of the dry summer, the wetland open water area had shrunk to a small pond, approximately 15 cm deep. The VIBI plot was laid out on a northwest/southeast line, stretching from the mudflat area of the wetland up into an upland area.

Site 2 is also a Wetland Reserve Program wetland. It was installed in 1998, using earth-moving equipment to excavate a low area that was bermed to store surface water runoff from surrounding farm fields. The wetland is bordered along the southeast by a berm that separates it from a county ditch. The wetland is connected to the ditch by a flood control unit that allows spillover to run to the ditch at a selected height. Plantings have been limited to *Asclepias* (milkweed) species. The wetland is surrounded by about 30 ha of habitat plantings and a small 4 ha *Carya* (hickory) woods to the northwest. The VIBI plot was laid out on the north side of the wetland, from the mudflat area into the woods on a southeast to northwest axis.

Site 3 is a Farmable Wetland under the Conservation Reserve Program. It was installed over a grass waterway in an area that has a history of flooding. The wetland is designated as 3 ha, with 8 ha of buffer area planted in cool and warm season grasses. A small woods is located to the south. The depression collects surface water from surrounding agricultural land and can be hold up to 2 to 3 m of water after significant rainfall, although it drains rapidly to 0.2 to 0.3 m of water. The area was completely dry during the assessment period. The plot was laid out on a north/south line from the lowest elevation to an upland area.

Site 4 is a Farmable Wetland developed in 2004. The wetland of approximately 2 ha lies in a depression surrounded by 5 ha planted with warm and cool season grasses. Surface water collects in the depression to a depth of 1.2 – 1.8 m after a rainfall, but quickly drains through an existing tile to a county ditch. The landowner has installed some habitat plantings around the wetland area, and there is a small wooded wetland to the northwest. An adjoining depressional wetland owned by a different landowner has been cleared and filled in the last two years. The sampling plot was laid out on an east-west axis from the lowest elevation.

Site 5 is a Farmable Wetland and was installed in 2005. The wetland consists of 2 ha in a depression that abuts a low area along a county ditch to the northwest and the Salamonie River to the north and east. Approximately 6 ha of buffer are planted in cool and warm season grasses. Outside of the buffer area are active agricultural fields of corn and soybeans. The depression receives surface runoff from the adjoining fields and seasonal flooding from the Salamonie River. The VIBI plot was laid out on an east-west axis, from a low elevation into the edge of the wooded area.

Site 6 is a natural, undisturbed wetland along the Loblolly ditch. The wetland is a *Cephalanthus occidentalis* (buttonbush) shrub swamp, surrounded by a mature forest. It is bounded by county roads on the north and east, mature forest to the west and the Loblolly creek to the south. The depression receives stormwater runoff from surrounding agricultural fields, and seasonal flooding from the Loblolly. The VIBI was laid out on a northeast to southwest axis along the edge of the wetland. Due to the dense vegetation of the buttonbush area, the VIBI consisted of 5 modules of 10 x 10 m in the wooded area and 5 modules of 10 x 5 m in the buttonbush area. The VIBI was calculated accordingly.

1.7 Project Overview

For this research project the Ohio Rapid Assessment Method (ORAM) was used to evaluate five NRCS wetlands of different ages and an undisturbed natural used wetland for comparison. In addition, an intensive vegetative survey was conducted at each wetland to determine the characteristics of the plant community and to create a vegetation index of biotic integrity based on the Ohio VIBI. Scores determined by the ORAM and the VIBI were regressed against the age of the wetland and other metrics to evaluate the effectiveness of the ORAM as an indicator of NRCS wetland development. In addition, metrics developed as part of the VIBI were examined to evaluate the vegetation of the wetlands studied. Although the hydrology of a wetland site is of prime importance (Mitsch and Gosselink 1993), a complete study of the hydrology of a site was much more complicated and was beyond the scope of this research. However, 30% of the total points possible in the ORAM rating system are awarded to hydrological features noted during the site assessment.

The U. S. Army Corps of Engineers' Wetland Delineation Manual bases wetland delineation on three characteristics: hydrophytic vegetation, hydric soils, and wetland hydrology (US ACE 1987). Most assessments use vegetative information as a performance standard for delineation (Fennessy et al. 2004; Wentworth et al. 1988; U. S. EPA 2002b), and in some cases it is the only standard (Spieles 2005). Hydric soils are also used in wetland delineation, but are considered less frequently in assessing the functional success of wetlands (Fennessy et al. 2004), since the development of hydric soil indicators can take many years. As with hydrology of the site, soil indicators were recorded as part of one of the ORAM metrics, but an on-site soil survey of the site was not attempted. Information from the NRCS Soil Survey (Soil Survey Staff 2007) was listed in the background section of the ORAM and soil survey map units were identified.

The goals of the research were to document the condition of the wetlands, to evaluate the use of the rapid assessment method compared to the more extensive vegetative assessments, and to examine the vegetative composition of the wetlands over a period of time since development under the NRCS programs.

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CHAPTER 2. TECHNICAL PAPER

EVALUATION OF RESTORED WETLANDS USING THE OHIO RAPID ASSESSMENT METHOD

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ABSTRACT. The Natural Resources Conservation Service has developed programs to construct and restore wetlands on previously farmed land. This research used the Ohio Rapid Assessment Method (ORAM) to evaluate five NRCS wetlands of different ages and an undisturbed natural wetland. In addition, an intensive vegetative survey was conducted at each wetland to determine the characteristics of the plant community and to create a Vegetation Index of Biotic Integrity (VIBI) based on the Ohio wetland assessment program (Mack 2004). The goals of the research were to document the condition of the wetlands, evaluate the use of the rapid assessment method compared to the more intensive vegetative assessment, and examine the vegetative composition of the wetlands as a function of age since establishment under the NRCS programs. Scores determined by the ORAM and the VIBI demonstrated a close correlation. ORAM scores and Floristic Quality Assessment Index (FQAI) scores calculated as part of the VIBI

were also correlated. Scores calculated by the ORAM were not statistically related to the age of the wetland, however significance may have been constrained by the small number of samples.

Keywords: wetlands, rapid assessment, Ohio Rapid Assessment Method, Vegetative Index of Biotic Integrity, Floristic Quality Assessment Index

INTRODUCTION

In 1990, the U. S. Department of Agriculture introduced the Wetlands Reserve Program (WRP), administered by the Natural Resources Conservation Service (NRCS). The WRP is a voluntary program that offers landowners the means and opportunity to protect, restore, and enhance wetlands. In exchange for easements, landowners are offered payments and technical and financial assistance to restore vegetation through practices such as tree and warm-season grass plantings and shallow water restoration through macrotopography development, ditch plugs, tile breaks, dikes, and water control structures. Options for the program include permanent easements, 30-year easements, and restoration cost-share agreements of a minimum 10-year duration (USDA 2002).

A second program, the Farmable Wetlands Program (FWP) was developed as an addition to the USDA Conservation Reserve Program (USDA 2004). These wetlands are limited to a maximum of 4.05 hectares, with a 12.15 hectares maximum buffer area surrounding. NRCS requirements for meeting WRP and FWP eligibility include specifications for soil types, cropping history, and previous wetland or flood listing. FWP contracts provide annual rental payments for 10 to 15 years, incentive payments, and cost-share for installing necessary practices. In Jay County, Indiana, several landowners have taken advantage of these programs to create or enhance wetlands in the past 15 years.

There were three goals of this research. The first was to document the condition of the wetlands developed under the NRCS programs using both a rapid assessment method and a more intensive vegetative index of biotic integrity. The second was to evaluate the results of the rapid assessment compared to the index of biotic integrity. The third was to examine the vegetative composition of the wetlands over a period of time since development.

METHODS

Assessment Methods.---The Ohio Rapid Assessment Method (ORAM) and the Ohio Vegetation Index of Biotic Integrity (VIBI) were the methods chosen for assessment of the wetlands. ORAM scores are used by the Ohio EPA to identify wetlands as one of three groups indicating low (Category 1), medium (Category 2), or high (Category 3) "quality" to designate the level of protection and determine the level of mitigation if required. The ORAM is quick, requiring approximately one-half day of offsite preparation and one-half day of site work; uses on on-site verification; and has been verified against other assessment techniques. The VIBI requires more intensive sampling and evaluates analysis a wetland using vascular plants as an indicator species. The VIBI can be used to monitor mitigation wetlands, serve as a general plant community characterization, or to clarify other assessments such as the ORAM. Both methods result in a numerical value that can be used to compare different wetlands.

The ORAM can be conducted most of the year, but the VIBI sampling period is specified as June to October to maximize the identification of vegetation with fruiting bodies such as grasses and sedges. Sites were visited throughout the growing season for initial survey work, but final ORAM and VIBI determinations were conducted in September and October.

Table 1.---Assessment site information using criteria from Ohio EPA methods, NRCS, and landowners.

Name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Wetland Program	WRP	WRP	FWP	FWP	FWP	Natural
Year Installed	1993	1998	2004	2004	2005	NA
Age (years)	14	9	3.7	3.4	2.5	NA
Wetland (ha)	0.4	2.8	1.9	1.6	1.6	1.8
Buffer (ha)	8.2	7.8	5.5	4.9	5.5	7.8
ORAM HGM Class	Human Impoundment	Human Impoundment	Isolated Depression	Isolated Depression	Riverine Depression	Riverine Depression
Dominant Soil Map Unit Name	Glynwood clay loam*	Glynwood clay loam*	Wallkill variant silty clay	Pewamo silty clay	Glynwood clay loam*	Bono silty clay
ORAM Plant Community	Aquatic Bed/ Emergent/ Shrub/ Mudflats/ Open Water	Aquatic Bed/ Emergent/ Shrub/Forested/ Mudflats/ Open Water	Emergent	Emergent	Emergent/ Shrub	Shrub/ Forested
VIBI Plant Community	Marsh/ Wet Meadow	Marsh/ Wet Meadow	Wet Meadow	Wet Meadow	Wet Meadow/ Shrub Swamp	Shrub Swamp/ Swamp Forest

* Note: The Glynwood soil sites are probably constructed (vs. restored) wetland.

Site Information.---Two wetlands developed under the NRCS Wetland Reserve Program and three wetlands developed under the Farmable Wetlands and Buffer Program were assessed using both the ORAM and VIBI methods. In addition, a natural wetland was assessed with both methods for comparison. The VIBI can be used to monitor mitigation wetlands, serve as a general plant community characterization, or to clarify other assessments such as the ORAM. Both methods result in a numerical value that can be used to compare different wetlands.

Initial information on each site was collected in discussions with the NRCS District Conservationist, Scott Mynesberg (Personal Communications 2006-2008). Additional information was obtained from the Web Soil Survey provided on the NRCS web site (Soil Survey Staff 2007) and from interviews with the landowners (Table 1). Each site was visited multiple times, including initial visits, visits to lay out sampling plots, and actual sampling visits. The ORAM field sheet was filled out for each site at the same time the VIBI sampling was done.

Categories used in the assessments followed guidelines listed in the Ohio Rapid Assessment Method for Wetlands v. 5.0 User's Manual (Mack 2001) and the Field Manual for the Vegetation Index of Biotic Integrity (Mack 2004). Hydrogeomorphic (HGM) classes were based on Brinson (1993) with others. The Ohio HGM system identified seven classes including Riverine with class modifiers as Headwater depression, Mainstem depression, and Channel; and Impoundment with class modifiers of Beaver and Human. Wetland plant communities were based on Cowardin et al. (1979) and identified six communities for use with the ORAM form including aquatic bed, emergent, shrub, forested, mudflats, and open water.

Taxonomy and nomenclature followed the guidelines of the USDA PLANTS website (USDA, NRCS 2008), including the listing of the asters under the *Symphotrichum* genus of the *Asteraceae* family.

Field Methods.--- The ORAM was completed at the start of the VIBI assessment. The Background Information Scoring Form, the Narrative Rating Scoring Form, the Quantitative Rating Scoring Form, and the ORAM v. 5.0 Field Scoring Form were completed for each site. Copies of the forms are available on the Ohio EPA website (http://www.epa.state.oh.us/dsw/401/). The scores for each of the six metrics in the ORAM were summed for the final ORAM score with a possible 100 point maximum. The VIBI is also a multimetric index with 19 possible metrics divided into categories for emergent, shrub, or forest vegetation. Each VIBI category uses 10 metrics with a maximum score of 100. Sites 1 through 5 were assessed using the Emergent metrics. Site 6 was assessed as a single unit for the ORAM, but was divided into Shrub and Forest wetlands for the VIBI. The Floristic Quality Assessment Index (FQAI) is one metric of the VIBI and can be used on its own as an assessment method. The VIBI and FQAI scores for Site 6 in Table 2 are an average of two scores as recommended in the VIBI field manual (Mack 2004).

The VIBI for each site was conducted over a one or two day period, using the Background Information Form for VIBI Submissions and Field Data Sheets (Mack 2004). The VIBI was conducted using a set of 10 modules in a 20 x 50 m plot layout (Fig. 2). Orientation of the plot as each site was based on site characteristics. Plots were sited to be the most representative of the plant community of interest at the wetland.

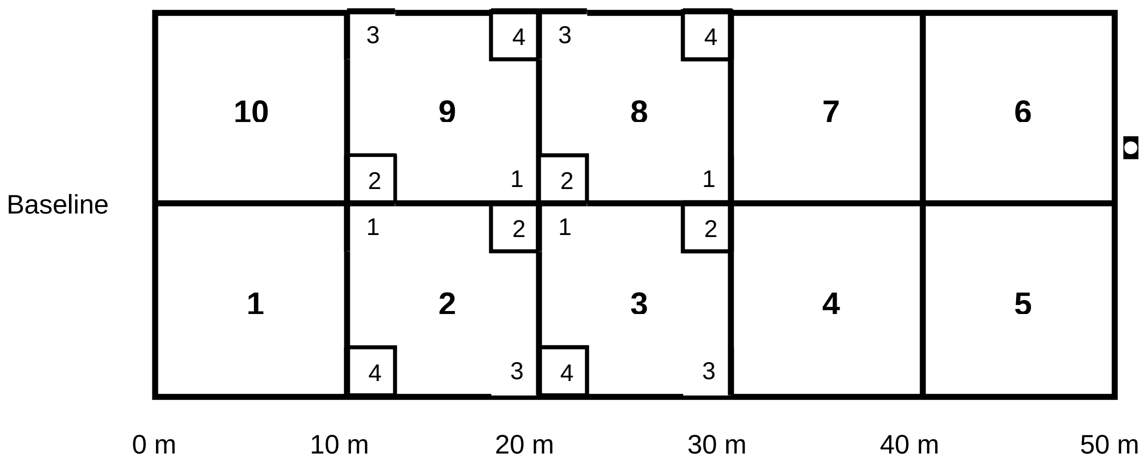

Figure 2.--- Standard 20 x 50 m plot layout for the VIBI sample plot. Modules are numbered in the direction of movement (down 1-5, back 6-10) along the center baseline; module corners are numbered clockwise in direction of movement down the center baseline (1 – 4). Standard corners for nested subquadrats (2 and 4) are indicated by small squares.

For the NRCS wetlands, siting followed recommendations (Mack 2001) for a typical emergent community with a sampling plot laid out such that the intensive modules were within the emergent zone but the tail ends of the plot included portions of the shrub and aquatic bed zones if present. The sampling plot at the undisturbed wetland was laid out along the length of the buttonbush swamp to include five 10 x 10 m plots of forest wetlands and five 5 x 10 m plots of buttonbush swamp. Once each plot area was identified, the starting point was mapped using a Garmin GPSMAP 76 unit to identify a UTM location and approximate elevation. A 50-m baseline was laid out from the starting point and staked. Modules were laid out from the baseline at 10-meter intervals and staked. Angles of the modules were confirmed with a Brunton compass.

Four of the 10 x10 m modules were intensively sampled with a series of nested subquadrats in opposing corners (corner numbers 2 and 4 on Fig. 2). A subquadrat of

0.316 x 0.316 m (0.1 m^2) was laid out with a hinged quadrat frame and all rooted species were identified. A second subquadrat of 1.0 x 1.0 m (1.0 m^2) was laid out on top of the first and all rooted species not previously observed were recorded. A third subquadrat of 3.16 x 3.16 m (10 m^2) was laid out on top of the previous two and new species recorded. This presence survey was repeated in the opposing corner of the module. Finally new species within the remainder of the module were identified. Within each of these "intensive" modules, species cover class values were estimated for the 100 m^2 plot using ten cover classes. Species located outside of the intensive modules ("residual" modules) were recorded and percent cover estimated over the area of the residual modules. Diameter at breast height (dbh) of woody species was measured and assigned to size classes for each module of the plot with eleven classes identified (Mack 2004).

Data Assessment.---Data from the VIBI survey were entered onto a spreadsheet used for data reduction, calculation, and coding. Cover and diameter at breast height (dbh) classes were recoded using the midpoints of the classes for the calculation of relative cover for all species, basal area (dominance), and relative dominance for woody species. Frequency for woody species was calculated using the number of dbh size classes in which a species has stems. A Floristic Quality Assessment Index (FQAI) was calculated for each site using Coefficient of Conservatism (C of C) values (Andreas et al. 2004). C of C values and other information used in the calculation of the metrics were obtained from a chart included in the VIBI Field Manual (Mack 2004). Once the specific metrics in each category for the site had been calculated, they were recoded to scores of 0, 3, 7, or 10 using scoring ranges designated in the VIBI field manual (Mack 2004). These metrics were summed to obtain the VIBI score.

VIBI scores were completed for each of the assessment sites. VIBI-Emergent assessments were conducted on each of the first five sites. The emergent assessment used cover and relative percent cover along with other vegetative data collected to calculate six metrics. One metric, Standing Biomass, was not calculated on any of the wetlands due to lack of equipment.

The final site, the natural wetland, was assessed using the VIBI-Shrub metrics for the portion of the buttonbush swamp sampled, and the VIBI-Forest metrics for the surrounding wooded area sampled. The VIBI-Shrub uses similar metrics to the VIBI-Emergent and includes mean importance values for the shrub class. The VIBI-Forest metrics include calculation of relative frequency, relative density, and relative dominance to determine mean importance values for the tree class. A count of herbaceous species was not a metric in the VIBI calculations for shrub or forest indices.

Data were analyzed using the linear regression function of SPSS version 15.0.1 for Windows (SPSS 2006), with an alpha value of 0.05.

RESULTS AND DISCUSSION

The ORAM and VIBI assessment methods provided a consistent numerical measure of the condition or quality of the wetlands studied. Both ORAM and VIBI scores were highest for the natural wetland; the Wetland Reserve Program sites scored in the middle and the Farmable Wetland Program sites scored the lowest in all assessment methods.

There are some differences between the Ohio categories assigned based on the ORAM and VIBI scores: Site 2 is at the low end of the Category 3 based on ORAM scores (65 to 100) compared to a Category 2 rating by the VIBI, and Site 5 is at the low end of Category 2 based on ORAM scores of 35 to 64.9 compared to a Category 1 rating by the VIBI. The natural wetland scored as a Category 2 by the VIBI and Category 3 by the ORAM. According to the ORAM manual, narrative criteria or detailed functional or biological assessments can be used to clarify or change a categorization based on the ORAM alone (Mack 2001).

Table 2.---Assessment scores for each site with resulting Ohio EPA categories based on the ORAM and VIBI.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
ORAM Rating	55	67	40	30	36	78
Ohio Category	2	3	2	1	2	3
VIBI Rating	36	37	33	13	10	50.5
Ohio Category	2	2	2	1	1	2
FQAI Rating	10.6	15.0	6.6	4.0	5.3	16.4

Ohio Category 1 wetlands are of “low quality”; Category 2 wetlands are a middle designation of “moderate to good quality”; and Category 3 wetlands are “high quality” (Mack 2001).

Floristic Quality Assessment Index scores showed an increasing trend in general with the age of the restored wetlands, with the natural wetland (Site 6) scoring the highest. Mushet et al. (2002) used a Floristic Quality Assessment to compare restored wetlands to natural wetlands. They reported the same trend with index scores increasing as the wetlands aged and peaking at 21.0 for the oldest restored wetland. A comparison of 14 mitigation and 7 reference wetlands in Ohio (Fennessy and Roehrs 1997) resulted in

FQAI scores for the mitigation wetlands ranging from 12.6 to 26.3 and for the reference sites of 17.0 to 25.5. The difference between these scores was not significant, possibly because of the wide range of conditions at the reference sites and the diverse species found at the mitigation sites.

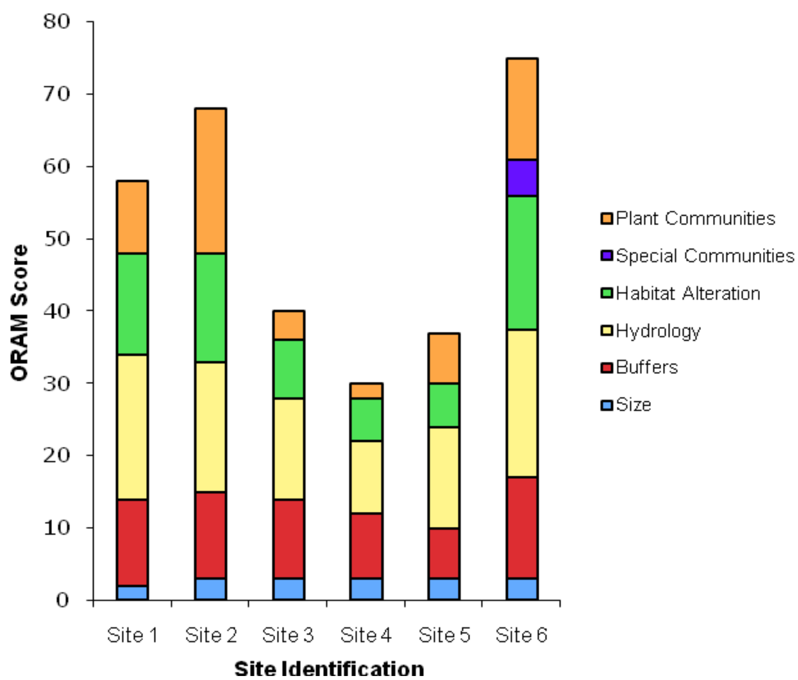

Figure 3.---Total ORAM scores showing the individual metric components.

The breakdown of metrics listed in Fig. 3 indicates that two of the ORAM metrics, Size and Buffers, were relatively consistent for all assessments, as shown in Table 1. The Farmable Wetland Program (FWP) mandates a maximum size of 4.1 ha and the other sites were selected to be comparable. The ORAM assigns a score of 2 points for wetland areas of 0.12 to < 1.2 ha and 3 points for wetland areas of 1.2 to < 4.0 ha so the scoring for all sites was consistent. Metric 2 (Buffers) reflected both the average buffer width and surrounding land use. FWP buffers are based on the size of the created wetland and since the constructed wetlands were all NRCS sites, surrounding land use was primarily agricultural. The hydrology metric (Metric 3) was based on sources of water, connectivity to other water sources, maximum water depth, length of inundation or saturation, and modifications to the natural hydrologic regime. In this metric, the majority of points scored and the major difference among the sites were based on the duration of saturation and the modifications to the natural regime. Sites 1 and 2 featured manmade impoundments that trapped and stored water, providing permanent to semi-permanent saturation. Both of the WRP sites and the natural wetland scored higher points for the length of time since modifications to the hydrological regime were made. The Habitat Alteration metric (Metric 4) evaluated the amount of disturbance to the natural habitat. Scores for this metric increased with age. Site 6, the natural wetland, received the highest score but was affected by agricultural runoff and the effects of a county road and ditch bordering the wetland. The three FWP sites scored lower due to the presence of mowing, woody debris removal, and other disturbances related to farmed areas surrounding the sites. The natural wetland, Site 6, was the only wetland identified to have Special Communities (Metric 5) as designated in the ORAM scoring manual with the presence of a mature forested area. The Plant Communities metric (Metric 6), which indicates the number of specific wetland vegetation communities, was greater for the natural wetland and the two older wetland reserve program sites and lower for the FWP sites that contained primarily emergent communities.

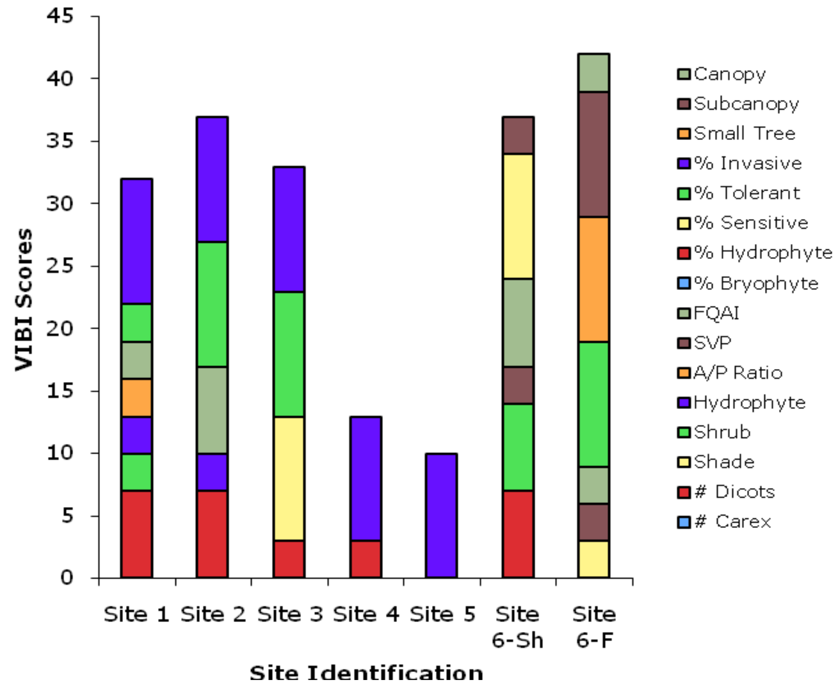

Figure 4.---Total VIBI scores showing the individual metric components.

The VIBI metric scores (Fig. 4) followed a similar pattern with an overall decrease in scores due to the age and type of wetland, with the natural wetland scoring the highest. The older WRP sites and the natural wetland shrub site scored higher in the native dicotyledon species (# Dicots) and in the number of vascular plant species with Facultative or Obligate wetland indicator status (Hydrophyte). Both metrics decrease with disturbance (Mack 2004). FQAI scores for all sites showed an increase with age with the natural wetland scoring the highest. This metric is expected to show a decrease with disturbance (Mack 2004) as the younger sites were more recently disturbed. Balcombe et al. (2005) found that wetland mitigation sites generally had more pioneer species, more non-native dominants, and more species with lower conservation qualities, all of which would result in lower FQAI scores. The metric for relative cover of tolerant plant species (%Tolerant) is calculated using the percent coverage of plants in herb and shrub stratums with a Coefficient of Conservatism of 0, 1, or 2 (Andreas et al. 2004). Plants with low Coefficients of Conservatism tolerate a wide range of ecological habitats and are frequently the first to colonize disturbed land. This metric is expected to increase with disturbance (Mack 2004) and the youngest wetlands scored the highest values. The metric for relative cover of invasive graminoid species (*Typha* spp, *Phalaris arundinacea*, and *Phragmites australis*) for the emergent sites (% Invasive) also would be expected to increase with disturbance, however, all sites recorded very few of the invasive species.

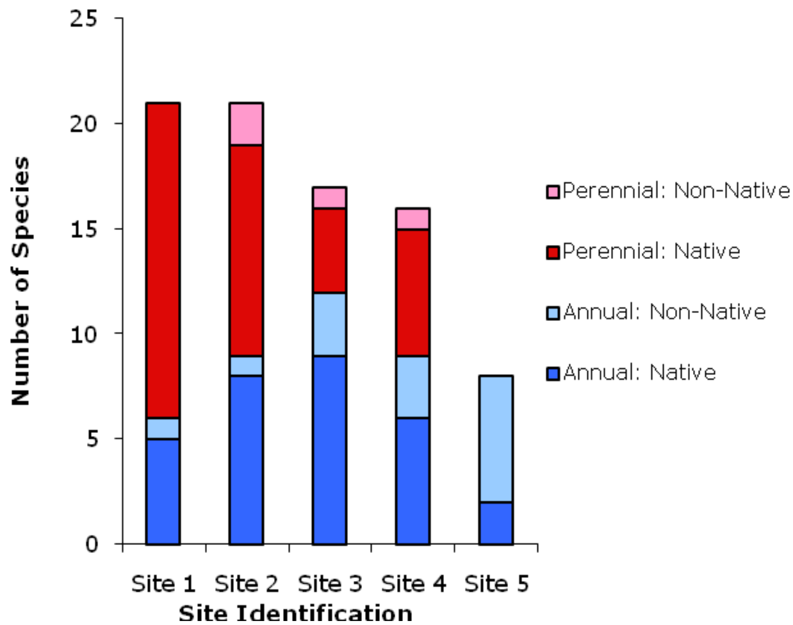

Figure 5.---Herbaceous annual and perennial species identified in the VIBI.

Herbaceous annual and perennial species were identified in the emergent VIBI assessment. While Sites 3 and 4 in Figure 5 show a wide range of vegetation, the species have low C of C numbers, typical for sites more recently disturbed. Numbers of non-woody species increased with age (Fig. 5), and the ratio of annual to perennial species decreased, demonstrating that the more recent wetlands have a proportionately higher number of annual species. Site 5, the most recently constructed site, had no perennial species recorded. Site 6, as a forest / shrub community, contains far fewer herbaceous species and is not included in Figure 5. The metric ratio of annual to perennial species would be expected to decrease in relationship to disturbance (Mack 2004) and the assessments follow this pattern.

Annual non-native species decreased with age while native perennials increased, however a regression of native species and age was not significant ($P = 0.106$, $R^2 = 0.635$). Fennessy and Roehrs (1997) found that the proportion of native species was significantly higher in reference wetlands, indicating a significant loss of native plant diversity with the replacement of native species by non-native species in mitigation wetlands. Confer and Niering (1992) compared created and natural emergent wetlands in Connecticut. The incidence of wetland taxa was recorded significantly more frequently in natural sites, with cattails (*Typha* spp.) as the characteristic emergent vegetation in created wetlands. Campbell et al. (2002) also found vegetation species richness and total cover to be greater in natural wetlands, with a greater number of upland species found in created wetlands. The age of the wetlands in this research regressed against the number of perennial species was significant ($P = 0.027$, $R^2 = 0.792$), confirming the increase of perennial species over time. Seabloom and van der Valk (2003) determined that restored wetland flora were represented as a subset of species found in natural wetlands and that species found only in natural wetlands tended to be native perennials. Spieles (2005) found a greater incidence of non-native plant species in created or restored mitigation wetlands, particularly in depressional systems with a single vegetation class similar to the FWP wetlands. Rothrock and Homoya (2005) evaluated the Indiana Floristic Quality Assessment method and found that restored sites converted from agricultural use had the lowest scores and retained a legacy of non-native weeds.

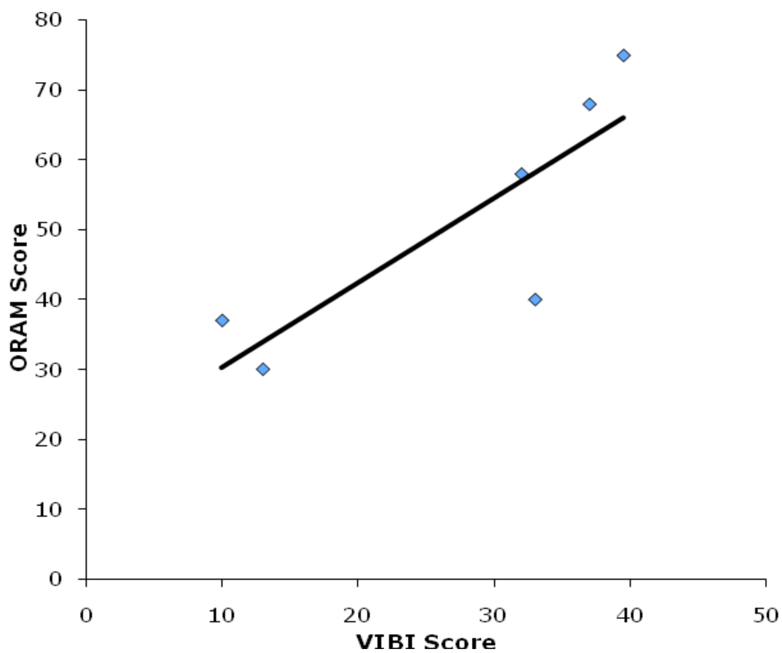

Figure 6.---Relationship of VIBI scores to ORAM scores (P = 0.034, R^2 = 0.645).

Fennessy et al. (2004) recommend that verification of rapid methods used for assessment of wetland conditions can be achieved by comparing information gathered through the more intensive Level 3 monitoring. Level 3 methods such as the indices of biologic integrity have been used in previous research to assess the condition of streams and wetlands. Simon (2006) reported on the development, calibration, and validation of an index of biotic integrity (IBI) for the Wabash River. The research used independent data from 36 other river assessments to calibrate the index, and determined that the IBI accurately measured the condition of the river based on anthropogenic disturbances.

In verifying the ORAM assessment method using the VIBI, the ORAM scores calculated were significantly related to the VIBI scores (Fig. 6). Mack et al. (2000) published an ORAM v. 5.0 Quantitative Score Calibration including a linear regression plot of ORAM and VIBI scores from 45 emergent, forested, and scrub-shrub communities with a calculated R^2 of 0.845 and a P value of <0.001. Fehringer (2005) developed a wetland rapid condition assessment method for the Montana Department of Environmental Quality (DEQ) using the ORAM and other rapid assessment methods as guides. The author compared the DEQ method to a VIBI and obtained a correlation coefficient of 0.627.

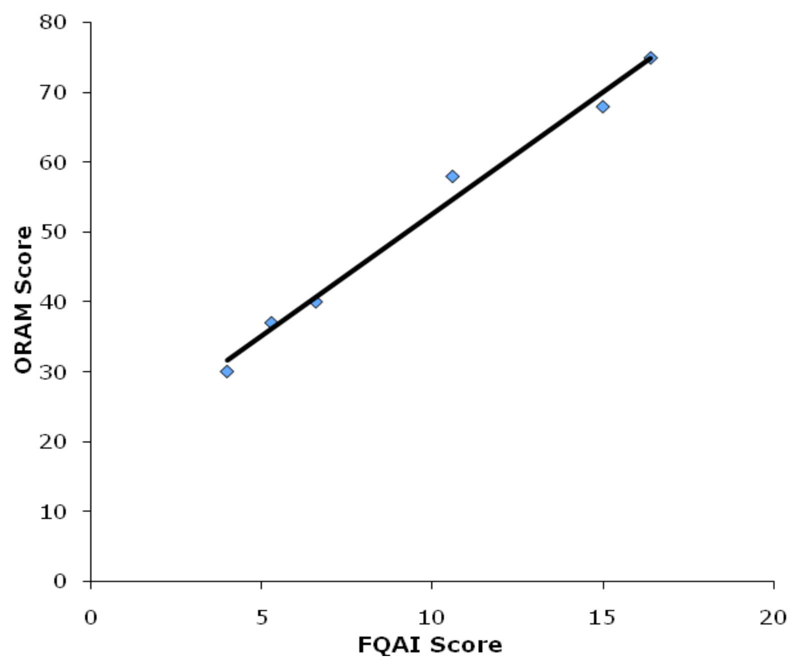

Figure 7.---Relationship of ORAM Scores and FQAI Scores for six wetlands ($P < 0.001$, $R^2 = 0.986$).

The FQAI calculated as a metric in the VIBI is also used as an assessment tool (Mushet et al. 2002; Rothrock and Homoya 2005). Andreas (1995) concluded that the FQAI provided a repeatable method for evaluating wetlands and assessing the success of restoration efforts. Regression of the results of this research showed a highly significant relationship between ORAM scores and FQAI scores (Fig. 7).

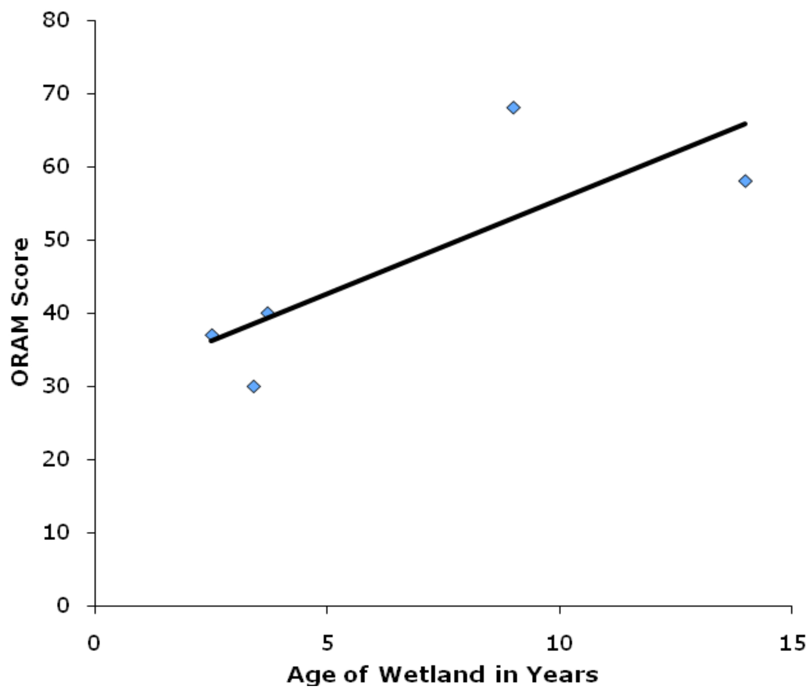

Figure 8.---Relationship between the age of wetland sites and ORAM scores ($P = 0.105$, $R^2 = 0.517$).

Rothrock and Homoya (2005) validated Floristic Quality Index metrics by applying assessments to checklist inventories of reference sites. They reported that restored sites of greater than 10 ha had an average floristic quality index of 25.1 compared to the undisturbed sites with indices of 59 to 77. For the smaller sites in this research, average FQAI scores for the restored sites in this research were 8.3 compared to

16.4 for the natural site. The index scores reflect a smaller number of species at the smaller sites; however, the assessment index of the natural site was twice the index of the restored sites, comparable to the results of Rothrock and Homoya.

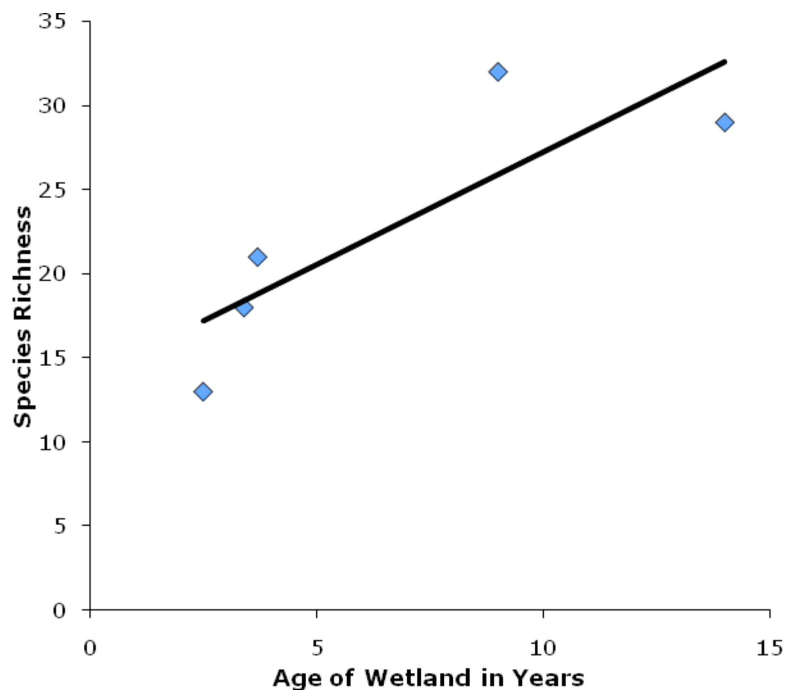

Figure 9.---Relationship of the total number of species identified compared to the age of the wetland (P = 0.059, R^2 = 0.662).

Linear regression of the assessment scores indicated that age is not significantly related to the scores obtained from the ORAM (Fig. 8); however, this may be due to the small sample size. Although the general opinion is that a restored wetland can be expected to become similar to a comparable natural wetland (Kentula et al. 1992; Spieles 2005; Reinartz and Wane 1993; Brown 1999, Balcombe et al. 2005; Galatowitsch and van der Valk 1996), not all studies were able to establish such a relationship (Fennessy and Roehrs 1997; Campbell et al. 2002). Wetland age was also regressed against scores from the VIBI and FQAI assessments. Both regressions indicated a positive relationship, but neither was statistically significant (VIBI: $P = 0.243$, FQAI: $P = 0.162$). Since the ORAM correlated with the two assessments, this result was expected.

The total number of species identified in this study increased with the age of the wetland and was nearly significant as shown in Fig. 9, however, the two oldest wetlands featured impoundments which provided standing water or saturated conditions for aquatic or emergent vegetation as opposed to the farmable wetlands which experience cycles of dry-down. Galatowitsch and van der Valk (1996) found a difference in the number of species recolonizing restored wetlands based on the presence of standing water, with more submersed aquatic species identified than emergent and wet meadow species. Farmable wetlands, which make up the three youngest wetlands and contained the three lowest species numbers, may also be affected by activities related to more recent agricultural disturbance including plowing, mowing, and residual herbicide effects. Since assessment took place during a specific period of the year, some seasonal and ephemeral species were not counted. In addition, identification of vegetation to the species level was difficult and while some samples were identified to the family level, they were not included in the count for metrics for the VIBI. Small sample size could also be a factor.

Overall, both the rapid assessment and the vegetative assessment provided comparable snapshots of the condition of the wetlands examined. Evaluation of the ORAM method does show that it can provide a simple and quick measurement of the condition of a wetland that compares favorably with other more intensive assessment methods. Finally, the vegetative composition of the wetlands is comparable to results obtained from other research, indicating the lowest species diversity and quality in wetlands restored on agricultural land, but with a trend of increasing diversity and quality as the wetlands develop.

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Chapter 3: ADDITIONAL INFORMATION

3.1 Additional Results and Discussion

3.1.1 *Correlations with the age of the wetlands*

The trend line of VIBI scores regressed against the age of the wetlands showed a positive relationship, but lacked a significant correlation (Fig. 10), similar to the results obtained by regressing ORAM scores with the age of the wetlands.

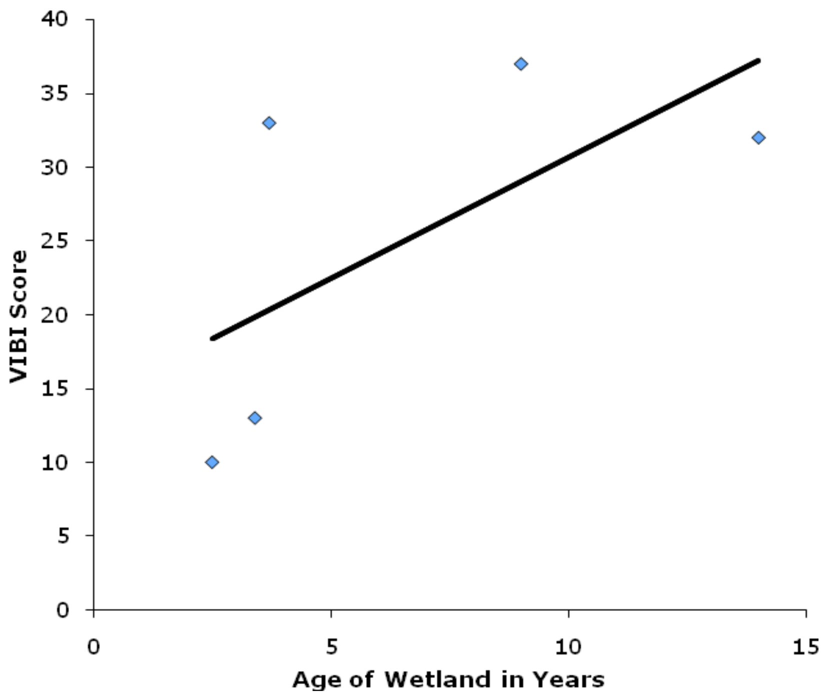

Figure 10.---Relationship between the age of the wetlands and VIBI scores ($P = 0.243$, $R^2 = 0.216$).

The age of the wetland was not statistically correlated with any of the other individual metrics such as species richness or the floristic quality index. However, sample size for the calculations was small, using the five wetlands in the NRCS program, which may have contributed to the variability and in turn the lack of statistical significance for these regressions.

3.1.2 *Hydrology Metric*

Individual metrics as a component of ORAM scores (Fig. 3) seemed to indicate that some of the metrics might show a better correlation to the ORAM score than the age of the wetland. To avoid confounding of the data, the hydrology metric was subtracted from the total ORAM score for the calculation. A regression analysis conducted on the two variables showed a statistically significant P value of 0.038, indicating that the hydrology metric was a better indicator of higher wetland assessment scores than the age of the wetland (Fig. 11).

Hydrological considerations, such as the ones identified in the ORAM hydrology Metric 3, appeared to be better predictors of wetland quality as defined by the ORAM guidelines. The hydrology metric includes sources of water; connectivity to floodplains, streams and lakes, or other wetlands; maximum water depth; and duration of inundation or saturation. With thirty of the potential 100 total points allotted to hydrology, the ORAM method recognizes the importance of identifying the hydrology or hydrologic indicators of a site. Ashworth (1997) in comparing the hydrological and soil parameters of restored and reference sedge meadows found the strongest correlations between the average and the minimum water level and the abundance of twelve wetland plant taxa.

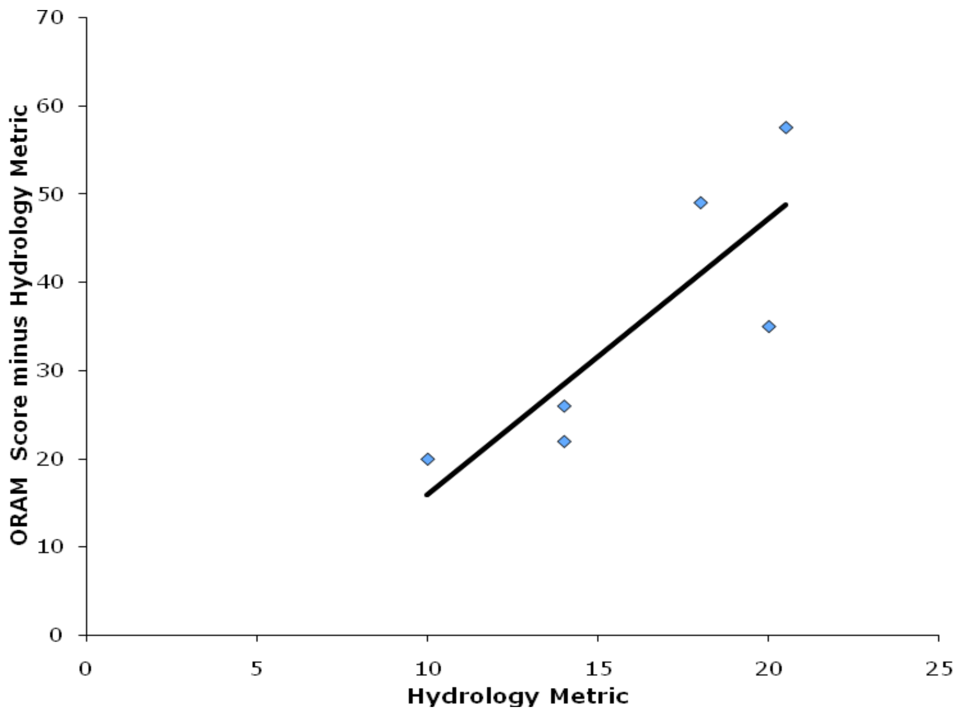

Figure 11.---Relationship of the hydrology metric (Metric 3) for six wetland sites compared to total ORAM score minus hydrology metric (P = 0.038, $R^2 = 0.699$).

3.1.3 *FQAI Scores and ORAM Metric 4*

FQAI scores are indicators of the natural quality of an area by calculating the weighted average of species richness in conjunction with species abundance (Andreas 2005; Rothrock 2004). A lower FQAI score indicates human disturbance by taking into account the presence of alien or non-native species in a wetland site (Appendix F). The ORAM Metric 4 assesses the effect of human-caused factors and activities such as substrate disturbance or vegetation removal on the natural habitat. This metric was an expansion of an earlier version of an ORAM question that qualitatively rated human-caused disturbances. The relationship between FQAI scores and Metric 4 scores (Fig. 12) was highly significant.

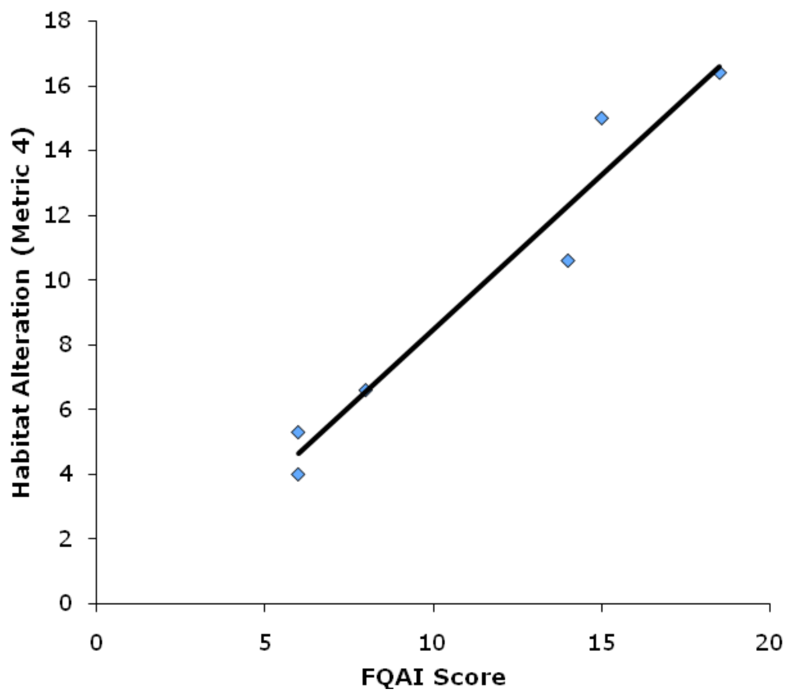

Figure 12.---Relationship of FQAI scores and Metric 4 ($P = 0.001$, $R^2 = 0.937$).

3.1.4 *Soils and Plant Colonization*

Research has indicated that soils in restored wetlands have less organic material and a higher bulk density than in natural wetlands. Reference wetlands in both Iowa and Pennsylvania were found to have clay loam textures with high silt content, while created wetlands had sandy clay loams (Galatowitsch and van der Valk 1996; Campbell et al. 2002). NRCS criteria for selection in programs such as WRP and FWP are based on soil types chosen for hydric soil characteristics. Wetlands assessed in this research were developed on Glynwood clay loams, Pewamo silty clay and Wallkill variant silty clays, while the natural wetland was identified as Bono silty clay (Table 1). One effect of restoring depressional wetlands in agricultural areas may be the deposition of mineral soils eroded from adjoining fields. Although this has a positive effect in the reduction of non-point source pollution into adjoining streams and rivers, the mineral soils support fewer wetland species than organic soils and slow the recolonization of the wetland (Galatowitsch and van der Valk 1996; Luckeydoo et al. 2002). Wetlands developed near streams and rivers that inundate the sites on a seasonal basis may benefit from both the deposition of organic material and introduction of more diverse seed bank (Mitsch et al. 2005). However, the introduction of non-native seeds from upstream may be a negative effect of deposition in riparian areas.

NRCS wetland construction requires seeding of wetland and buffer areas with cool and warm season grasses, but allows for passive colonization of the area with wetland species through seed banks or various means of seed dispersal. Research has shown that seed banks of restored wetlands contain fewer species and fewer seeds than natural wetlands (Galatowitsch and van der Valk 1996). Degraded seed banks may favor non-native communities with low species richness that are dominated by cattails (*Typha* spp.) with willow (*Salix* spp.) and cottonwood (*Populus* spp.) (Spieles 2005; Reinartz and Wane 1993; Luckeydoo et al. 2002; Seabloom and van der Valk 2003; Balcombe et al. 2005; Fennessy and Roehrs 1997). There is also evidence that colonization of restored wetlands is rapid during the early years after development (Kellog and Bridgham 2002; Galatowitsch and van der Valk 1996). Research conducted after seeding wetlands with native wetland species early in their development demonstrated significant results in increasing species diversity and richness (Reinartz and Wane 1993; Mitsch et al. 2005).

3.2 Personal Observations

The fall of 2007, when this research was conducted, was an extremely dry season for east central Indiana. Precipitation at a monitoring station at Farmland, in an adjoining county, for the May to September period was 37 cm as compared to the 30-year average of 50 cm for the same time period. As a result, wetland areas that normally were saturated or contained standing water had dried to at least 15 cm below the surface. This affected the number and type of wetland plants observed at the sites, particularly emergent vegetation.

Identification of wetland vegetation to the species level requires a combination of experience and education. While I received considerable guidance from Dr. Ruch in both his aquatic botany class and his assistance in the identification of dried specimens from the wetland study sites, conducting a full-scale vegetative assessment requires considerable experience and expertise. A major advantage for less complicated assessments such as the ORAM is the lower level of botanical knowledge required. To familiarize myself with the ORAM method, I attended a two-day training workshop in May of 2007. The workshop, taught by John Mack and Mick Micacchion of the Ohio EPA, included both a training session on using the ORAM and a field session to practice the method on multiple sites in the Columbus Ohio area. The training for the ORAM, while limited to a two-day period, provided a base for understanding the concepts and processes of the rapid assessment method. The class I attended included individuals with a wide range of backgrounds and experience in wetlands identification but after training we were able to report similar scores for a wide variety of wetland sites. The development and acceptance of rapid assessment methods such as the ORAM that can be widely used is an important tool in wetland identification and management.

Unlike the Ohio EPA program, the Indiana Department of Environmental Management regulates only isolated wetlands not covered by Section 404 of the Clean Water Act. Indiana State Regulated Wetlands are divided into three classes of isolated wetlands. Class 1 wetlands are of low quality based on the amount of disturbance or human activity, low species diversity or high non-native or invasive species, or areas that do not support significant wildlife or aquatic habitat or do not have significant wetland hydrological function. Class III wetlands are minimally disturbed, have higher than minimal wetland habitat or function, or are a rare or ecologically important type of wetland. Class II wetlands meet neither Class I nor Class III definition.

NRCS programs are just one tool in the development and restoration of wetland habitat and ecology. Some landowners are highly interested in the preservation and restoration of wetlands, while others make judgments based on the economic value of easement payments compared to crop income. To continue expanding the wetland programs, it is important that the economic incentives keep pace with crop prices and that more be done to educate landowners on the benefits of wetlands on both the local and larger scale.

Given the relative simplicity and speed of the ORAM, it would be useful if it could be used by the NRCS as a development and management tool for the wetlands created under the WRP and Conservation Reserve Programs. Recording assessment values at several times over the length of the contract could provide information as to the effectiveness of wetland development, construction techniques, management, and enhancements. For instance, this research suggested that wetland construction which allowed water impoundment and provided for standing water or saturation created wetlands with higher quality and condition scores. Literature review also suggests that higher quality wetlands will develop based on early seeding with wetland species.

3.3 Recommendations for Future Research

Future research involving the NRCS wetlands and ORAM assessments should include the addition of other sites to more accurately evaluate the relationships observed in the current research. Additional site assessments may reduce the variability seen in results based on the age of the wetland and may confirm a relationship between age and assessment scores. It would also be valuable to assess the wetlands during a period of higher than normal precipitation to compare to the drier than normal conditions in 2007. In addition, it would be interesting to conduct assessments of the same sites over a period of years to determine which wetland construction practices yield the best results in terms of wetland quality as determined by assessment scores.

With the development of floristic quality indices for a variety of regions, it would be interesting to compare overlapping Coefficients of Conservatism in the Eastern Cornbelt Plains Ecoregion. Rothrock has done comparisons of the Chicago area Coefficients of Conservatism values with his own Floristic Quality Index (2004), and the FQAI developed by Andreas et al. (2004) can be applied to the whole Eastern Cornbelt Plains Ecoregion.

In general the NRCS approach to wetland construction is to focus on preliminary criteria for siting a wetland and to recommend basic plantings such as cool and warm season grasses. This research identified wetland vegetation appearing after a short period of time following construction. Potential research possibilities could examine the source of the wetland vegetation including distance to identified wetlands, or investigation of the seed bank in the soil available after extended periods of agricultural use. Finally, it would be useful for both conservation planning and water quality issues to combine information such as soils and watersheds to develop large-scale plans which target potential wetland developments with the maximum benefits.

3.4 Conclusions

Assessments of the NRCS wetlands produced a wealth of information on the quality and function of a variety of wetlands. The WRP wetlands provide important habitat and with committed landowners should continue to develop. The FWP wetlands, while not of the highest quality, have the potential to develop over the life of the program. It will be interesting to see if the numbers of wetland species increase while the expansion of non-natives species decreases. Evaluation of the ORAM method does show that it can provide a simple and quick measurement of the condition of a wetland that compares favorably with other more extensive assessment methods. The ORAM can be an important tool for monitoring, maintenance, and enhancement of wetlands created under programs like the NRCS Wetland Reserve Program and Conservation Reserve Program.

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APPENDIX A. SITE DATA SHEETS

Location: Site 1
Wetland Type: Impoundment
Date: 9-24-07

Plot Size: 20 m x 50 m
Intensive Modules: 4
Plot Area: 0.1 ha

Species	C of C	Native	Family	Indicator	Lifeform	Habit	Group	Shade Tolerance	Total Cover	Rel. Cover
Agrimonia parviflora	2	Native	Rosaceae	FAC	forb	pe	dicot	shade	0.0001	0.0054
Ambrosia artemisiifolia	0	Native	Amaranthaceae	FACU	forb	an	dicot	full	0.0751	4.0292
Arctium minus	0	Adventive	Asteraceae	FACU	forb	bi	dicot	advent	0.0052	0.2790
Bidens aristosa	4	Native	Asteraceae	FACW	forb	an	dicot	full	0.0801	4.2974
Calystegia sepium	1	Native	Convolvulaceae	FAC	forb	pe	dicot	full	0.0002	0.0107
Cirsium discolor	4	Native	Asteraceae	UPL	forb	pe	dicot	full	0.0001	0.0054
Cornus obliqua	2	Native	Cornaceae	FACW	shrub	pe	dicot	full	0.0753	4.0399
Daucus carota	0	Adventive	Apiaceae	UPL	forb	bi	dicot	advent	0.0101	0.5419
Dipsacus fullonum	0	Adventive	Dipsacaceae	FACU	forb	bi	dicot	advent	0.0051	0.2736
Echinochloa crus-galli	0	Adventive	Poaceae	FACU	grass	an	monocot	advent	0.1	5.3651
Echinochloa muricata	3	Native	Poaceae	FACW	grass	an	monocot	advent	0.175	9.3889
Eleocharis ovata	9	Native	Cyperaceae	OBL	sedge	an	monocot	full	0.005	0.2683
Geum laciniatum	2	Native	Rosaceae	FAC	forb	pe	dicot	shade	0.0003	0.0161
Geum vernum	2	Native	Rosaceae	FACU	forb	pe	dicot	shade	0.0102	0.5472
Helianthus sp.	*	ND	Asteraceae	ND	forb	pe	dicot	ND	0.0103	0.5526
Juncus effusus	1	Native	Juncaceae	FACW	forb	pe	monocot	full	0.015	0.8048
Leersia virginica	4	Native	Poaceae	FACW	grass	pe	monocot	shade	0.46	24.6794
Mimulus alatus	6	Native	Scrophulariaceae	OBL	forb	pe	dicot	full	0.0001	0.0054
Penthorum sedoides	2	Native	Saxifragaceae	OBL	forb	pe	dicot	full	0.0051	0.2736
Poaceae sp.	*	ND	Poaceae	ND	grass	ND	monocot	ND	0.055	2.9508
Polygonum pensylvanicum	0	Native	Polygonaceae	FACW	forb	an	dicot	full	0.0051	0.2736
Populus deltoides	3	Native	Salicaceae	FAC	tree	W	dicot	tree	0.015	0.8048
Prunella vulgaris	0	Native	Lamiaceae	FACU	forb	pe	dicot	partial	0.0011	0.0590
Rosa multiflora	0	Adventive	Rosaceae	FACU	shrub	W	dicot	advent	0.0001	0.0054
Salix exigua	1	Native	Salicaceae	OBL	shrub	W	dicot	full	0.0051	0.2736
Salix nigra	2	Native	Salicaceae	FACW	tree	W	dicot	tree	0.2502	13.4235
Solidago canadensis	1	Native	Asteraceae	FACU	forb	pe	dicot	full	0.055	2.9508
Sorghastrum nutans	5	Native	Poaceae	UPL	grass	pe	monocot	full	0.085	4.5603
Symphyotrichum novae-angliae	2	Native	Asteraceae	FACW	forb	pe	dicot	full	0.015	0.8048
Symphyotrichum pilosum	1	Native	Asteraceae	UPL	forb	pe	dicot	full	0.335	17.9731
Toxicodendron radicans	1	Native	Anacardiaceae	FAC	vine	W	dicot	partial	0.01	0.5365
sum C of C	58								1.8639	100.0000
FQAI N	29									
FQAI score	10.8									

Location: Site 1
Wetland Type: Impoundment
Date: 9-24-07

Plot Size: 20 m x 50 m
Intensive Modules: 4
Plot Area: 0.1 ha

# Non-woody Perennial:	15	Annual:		6	Ratio	0.4	
C of C 6 - 10 % cover	0.0051	total%	1.8639		% rel	0.0027	
C of C 0 - 2 % cover	0.9783	total%	1.8639		% rel	0.5248	

Emergent Metrics	**#**	**Score**
1. # of carex	0	0
2. # of native dicots	19	7
3. # of native wetland shrubs	2	3
4. # of FACW and OBL	13	3
5. Ratio of annual to perennial	0.3889	3
6. FQAI	10.8	3
7. Rel. cover of CofC 6-10	0.0027	0
8. Rel. cover of CofC 0-2	0.5249	3
9. Rel. cover of invasives	0	10
10. Standing biomass	NA	NA
Total VIBI		**32**

Location: Site 3
Wetland Type: Depression
Date: 9-11-07

Plot Size: 20 m x 50 m
Intensive Modules: 4
Plot Area: 0.1 ha

Species	C of C	Nativity	Family	Indicator	Form	Habit	Group	Shade	Total Cover	Rel. Cover
Acer rubrum	2	Native	Aceraceae	FAC	tree	W	DI	Tree	0.0001	0.0000
Ambrosia artemisiifolia	0	Native	Asteraceae	FACU	forb	AN	DI	Full	0.0002	0.0001
Bidens cernua	3	Native	Asteraceae	OBL	forb	AN	DI	Full	0.8000	0.2971
Bidens frondosa	2	Native	Asteraceae	FACW	forb	AN	DI	Full	0.2600	0.0966
Carya ovata	6	Native	Juglandaceae	FACU	tree	W	DI	Tree	0.0750	0.0279
Cornus drummondii	3	Native	Cornaceae	FAC	shrub	W	DI	Partial	0.0051	0.0019
Dichanthelium acuminatum	2	Native	Poaceae	FAC	grass	PE	DI	Full	0.0001	0.0000
Echinochloa crus-galli	0	Adventive	Poaceae	FACU	grass	AN	MO	Advent	0.0550	0.0204
Eleocharis ovata	9	Native	Cyperaceae	OBL	sedge	AN	MO	Full	0.0100	0.0037
Euthamia graminifolia	2	Native	Asteraceae	FAC	forb	PE	DI	Full	0.0001	0.0000
Fraxinus pennsylvanica	6	Native	Oleaceae	FACU	tree	W	DI	Tree	0.0053	0.0020
Leersia virginica	4	Native	Poaceae	FACW	grass	PE	MO	Shade	0.0001	0.0000
Lemna minor	*	Native	Lemnaceae	OBL	forb	AN	M	Full	0.1200	0.0446
Bryophyte/ liverwort	*	ND	ND	ND	moss	ND	bryophyte	bryophyte	0.0050	0.0019
Lycopus americanus	3	Native	Lamiaceae	OBL	forb	PE	DI	Full	0.0550	0.0204
Oenothera biennis	1	Native	Onagraceae	FACU	forb	BI	DI	Full	0.0002	0.0001
Panicum dichotomiflorum	0	Native	Poaceae	FACW	grass	AN	MO	Full	0.0350	0.0130
Penthorum sedoides	2	Native	Saxifragaceae	OBL	forb	PE	DI	Full	0.0001	0.0000
Poa sp	*	ND	Poaceae	ND	grass	ND	MO	ND	0.0001	0.0000
Polygonum pensylvanicum	0	Native	Polygonaceae	FACW	forb	AN	DI	Full	0.0150	0.0056
Populus deltoides	3	Native	Salicaceae	FAC	tree	W	DI	Tree	0.2151	0.0799
Potamogeton natans	8	Native	Potomagetonaceae	OBL	forb	PE	MO	Full	0.0001	0.0000
Quercus rubra	6	Native	Fagaceae	FACU	tree	W	DI	Tree	0.0100	0.0037
Rosa multiflora	0	Adventive	Rosaceae	FACU	shrub	W	DI	Advent	0.0050	0.0019
Salix amygdaloides	3	Native	Salicaceae	FACW	tree	W	DI	Tree	0.0000	0.0000
Salix nigra	2	Native	Salicaceae	FACW	tree	W	DI	Tree	0.9201	0.3417
Scirpus atrovirens	1	Native	Cyperaceae	OBL	sedge	PE	MO	Full	0.0001	0.0000
Setaria pumila	0	Adventive	Poaceae	ND	grass	ND	MO	Advent	0.0002	0.0001
Sphenopholis obtusata	4	Native	Poaceae	FAC	grass	PE	MO	Full	0.0001	0.0000

Location: Site 3
Wetland Type: Depression
Date: 9-11-07

Plot Size: 20 m x 50 m
Intensive Modules: 4
Plot Area: 0.1 ha

Symphyotrichum pilosum	1	Native	Asteraceae	UPL	forb	PE	DI	Full	0.0050	0.0019
Taraxacum officinale	0	Adventive	Asteraceae	UPL	forb	PE	DI	Advent	0.0100	0.0037
Toxicodendron radicans	1	Native	Anacardiaceae	FAC	vine	W	DI	Partial	0.0050	0.0019
Typha angustifolia	0	Adventive	Typhaceae	OBL	forb	PE	MO	Advent	0.0051	0.0019
Ulmus rubra	3	Native	Ulmaceae	FAC	tree	W	DI	Tree	0.0001	0.0000
Vernonia gigantea	8	Native	Asteraceae	FAC	forb	PE	DI	Full	0.0001	0.0000
Wolffia sp	*	Native	Lemnaceae	OBL	forb	AN	MO	Full	0.0750	0.0279
									2.6924	1.0000

Sum of C of C	85
FQAI N	32
FQAI Score	15.0

# Non-woody Perennial:	12	# Annual:	9		Ratio	0.75	
C of C 6 - 10 % cover	0.0151	total%	2.6924	% rel	0.005608379		
C of C 0 - 2 % cover	0.3961	total%	2.6924	% rel	0.147117813		
Invasives - % cover	0.0051	total%	2.6924	% rel	0.001894221		

Emergent Metrics	**#**	**Score**
1. # of carex	0	0
2. # of native dicots	21	7
3. # of native wetland shrubs	0	0
4. # of FACW and OBL	15.0	3
5. Ratio of annual to perennial	0.75	0
6. FQAI	15	7
7. Rel. cover of CofC 6-10	0.0056	0
8. Rel. cover of CofC 0-2	0.1471	10
9. Rel. cover of invasives	0.0019	10
10. Standing biomass	NA	NA
VIBI Total		**37**

Location: Site 3
Wetland Type: Depression
Date: 9-11-07

Plot Size: 20 m x 50 m
Intensive Modules: 4
Plot Area: 0.1 ha

Species	C of C	Nativity	Family	Indicator	Form	Habit	Group	Shade	Total Cover	Rel. Cover
Amaranthus tuberculatus	1	Native	Amaranthaceae	FACW	forb	AN	DI	full	0.0001	0.0000
Ambrosia artemisiifolia	0	Native	Asteraceae	FACU	forb	AN	DI	full	0.0002	0.0001
Bidens frondosa	2	Native	Asteraceae	FACW	forb	AN	DI	full	0.185	0.0478
Cyperus odoratus	4	Native	Cyperaceae	FACW	sedge	AN	MO	full	0.0751	0.0194
Echinochloa crus-galli	0	Adventive	Poaceae	FACU	grass	AN	MO	advent	0.0951	0.0246
Echinochloa muricata	3	Native	Poaceae	FACW	grass	AN	MO	full	0.0002	0.0001
Eleocharis ovata	9	Native	Cyperaceae	OBL	sedge	AN	MO	full	2.7	0.6983
Erigeron annuus	0	Native	Asteraceae	FACU	forb	AN	DI	full	0.02	0.0052
Euthamia graminifolia	2	Native	Asteraceae	FAC	forb	PE	DI	full	0.01	0.0026
Geum laciniatum	2	Native	Rosaceae	FAC	forb	PE	DI	shade	0.03	0.0078
Oenothera biennis	1	Native	Onograceae	FACU	forb	BI	DI	full	0.085	0.0220
Panicum dichotomiflorum	0	Native	Poaceae	FACW	grass	AN	MO	full	0.0152	0.0039
Polygonum pensylvanicum	0	Native	Polygonaceae	FACW	forb	AN	DI	full	0.1601	0.0414
Populus deltoides	3	Native	Salicaceae	FAC	tree	W	DI	tree	0.45	0.1164
Salix exigua	1	Native	Salicaceae	OBL	shrub	W	DI	full	0.0001	0.0000
Setaria faberi	0	Adventive	Poaceae	UPL	grass	AN	MO	advent	0.01	0.0026
Setaria pumila	0	ND	Poaceae	ND	grass	ND	MO	advent	0.0001	0.0000
Sida spinosa	0	Adventive	Malvaceae	UPL	forb	AN	DI	advent	0.0002	0.0001
Solidago canadensis	1	Native	Asteraceae	FACU	forb	PE	DI	full	0.01	0.0026
Symphyotrichum pilosum	1	Native	Asteraceae	UPL	forb	PE	DI	full	0.02	0.0052
Typha angustifolia	0	Adventive	Typhaceae	OBL	forb	PE	MO	advent	0.0001	0.0000
									3.8665	1.0000
sum of C of C	30									
FQAI N	21									
FQAI score	6.6									

Location: Site 3 | Plot Size: 20 m x 50 m
Wetland Type: Depression | Intensive Modules: 4
Date: 9-11-07 | Plot Area: 0.1 ha

# Non-woody Perennial:	5	# Annual:	12			Ratio	2.4
C of C 6 - 10 % cover	2.7	total%	3.8665	% rel	0.698305961		
C of C 0 - 2 % cover	0.6412	total%	3.8665	% rel	0.165834734		
Invasives - % cover	0.0001	total%	3.8665	% rel	2.58632E-05		

Emergent Metrics	**#**	**Score**
1. # of carex	0	0
2. # of native dicots	12	3
3. # of native wetland shrubs	1	0
4. # of FACW and OBL	9	0
5. Ratio of annual to perennial	2.4	0
6. FQAI	6.6	0
7. Rel. cover of CofC 6-10	0.6983	10
8. Rel. cover of CofC 0-2	0.1658	10
9. Rel. cover of invasives	0.0000	10
10. Standing biomass	NA	NA
VIBI total		**33**

Location: Site 4
Wetland Type: Depression
Date: 9-16-07

Plot Size: 20 m x 50 m
Intensive Modules: 4
Plot Area: 0.1 h

Species	C of C	Nativity	Family	Indicator	Form	Habit	Group	Shade	Total Cover	Rel. Cover
Abutilon theophrasti	0	adventive	Malvaceae	UPL	forb	AN	DI	advent	0.0002	0.000
Agrostis gigantea	0	adventive	Poaceae	FACW	grass	PE	MO	advent	0.18	0.053
Amaranthus tuberculatus	1	native	Amaranthaceae	FACW	forb	AN	DI	full	0.0003	0.000
Ambrosia artemisiifolia	0	native	Asteraceae	FACU	forb	AN	DI	full	0.0401	0.012
Ambrosia trifida	0	native	Asteraceae	FAC	forb	AN	DI	full	0.0851	0.025
Calystegia sepium	1	native	Convolvulaceae	FAC	forb	PE	DI	full	0.0001	0.000
Chamaesyce maculata	0	native	Euphorbiaceae	FACU	forb	AN	DI	full	0.001	0.000
Chenopodium album	0	adventive	Chenopodiaceae	FACU	forb	AN	DI	advent	0.0003	0.000
Cirsium sp.	*	ND	Asteraceae	ND	forb	ND	DI	ND	0.04	0.012
Daucus carota	0	adventive	Apiaceae	UPL	forb	BI	DI	advent	0.01	0.003
Euthamia graminifolia	2	native	Asteraceae	FAC	forb	PE	DI	full	0.0001	0.000
Oenothera biennis	1	native	Onafraceae	FACU	forb	BI	DI	full	0.0001	0.000
Physalis sp.	*	ND	Solanaceae	ND	forb	ND	DI	ND	0.0001	0.000
Polyganum lapathifolium	1	native	Polygonaceae	FACW	forb	AN	DI	full	0.02	0.006
Polygonum pensylvanicum	0	native	Polygonaceae	FACW	forb	AN	DI	full	0.11	0.032
Setaria faberi	0	adventive	Poaceae	UPL	grass	AN	DI	advent	2.745	0.810
Solidago canadensis	1	native	Asteraceae	FACU	forb	PE	DI	full	0.12	0.035
Symphyotrichum pilosum	1	native	Asteraceae	UPL	forb	PE	DI	full	0.0351	0.010
Tridens flavus	1	native	Poaceae	FACU	grass	PE	MO	full	0.0001	0.000
Vernonia gigantea	8	native	Asteraceae	FAC	forb	PE	DI	full	0.0005	0.000
sum C of C	17								3.3881	1.000
FQAI N	18									
FQAI score	4.0									

# Non-woody Perennial:	7	# Annual:	9		Ratio	1.285714286

C of C 6 - 10 % cover	0.0005	total%	3.3881	% rel	0.000147575
C of C 0 - 2 % cover	3.3475	total%	3.3881	% rel	0.988016883
Invasives - % cover	0.0001	total%	3.3881	% rel	2.95151E-05

Location: Site 4
Wetland Type: Depression
Date: 9-16-07

Plot Size: 20 m x 50 m
Intensive Modules: 4
Plot Area: 0.1 h

Emergent Metrics	#	Score
1. # of carex	0	0
2. # of native dicots	12	3
3. # of native wetland shrubs	0	0
4. # of FACW and OBL	4	0
5. Ratio of annual to perennial	1.2860	0
6. FQAI	4.0	0
7. Rel. cover of CofC 6-10	0.0002	0
8. Rel. cover of CofC 0-2	0.988	0
9. Rel. cover of invasives	0	10
10. Standing biomass	NA	NA
VIBI total		**13**

Location: Site 5
Wetland Type: Riverine Depression
Date: 9-12-07

Plot Size: 50 m x 50 m
Intensive Modules: 4
Plot Area: 0.1 ha

Species	C of C	Nativity	Family	Indicator	Form	Habit	Group	Shade	Total Cover	Rel. Cover
Abutilon theophrasti	0	Adventive	Malvaceae	UPL	forb	AN	DI	Advent	1.635	0.453
Ambrosia artemisiifolia	0	Native	Asteraceae	FACU	forb	AN	DI	Full	0.66	0.183
Cephalanthus occidentalis	6	Native	Rubiaceae	OBL	shrub	W	DI	Full	0.26	0.072
Chenopodium album	0	Adventive	Chenopodiaceae	FACU	forb	AN	DI	Advent	0.005	0.001
Fraxinus pennsylvanica	3	Native	Oleaceae	FACW	tree	W	DI	Tree	0.0201	0.006
Gleditsia tricanthos	4	Native	Caesalpinaceae	FAC	tree	W	DI	Tree	0.0052	0.001
Polygonum pensylvanicum	0	Native	Polygonaceae	FACW	forb	AN	DI	Full	0.0802	0.022
Polygonum persicaria	0	Adventive	Polygonaceae	FACW	forb	AN	DI	Advent	0.0001	0.000
Quercus rubra	6	Native	Fagaceae	FACU	tree	W	DI	Tree	0.1851	0.051
Setaria pumila	0	ND	Poaceae	ND	grass	ND	MO	Advent	0.35	0.097
Sida spinosa	0	Adventive	Malvaceae	UPL	forb	AN	DI	Advent	0.385	0.107
Xanthium strumarium	0	Adventive	Asteraceae	FAC	forb	AN	DI	Advent	0.01	0.003
Zea mays	0	Adventive	Poaceae	UPL	grass	AN	MONO	Advent	0.01	0.003
sum C of C	19								3.6057	1.000
FQAI N	13									
FQAI score	5.3									

# Non-woody Perennial:	0	# Annual:	8		Ratio	#DIV/0!
C of C 6 - 10 % cover	0.0005	total%	3.6057	% rel	0.000138669	
C of C 0 - 2 % cover	3.1353	total%	3.6057	% rel	0.869539895	
Invasives - % cover	0	total%	3.6057	% rel	0	

Location: Site 5
Wetland Type: Riverine Depression
Date: 9-12-07

Plot Size: 50 m x 50 m
Intensive Modules: 4
Plot Area: 0.1 ha

Emergent Metrics	**#**	**Score**
1. # of carex	0	0
2. # of native dicots	6	0
3. # of native wetland shrubs	1	0
4. # of FACW and OBL	4	0
5. Ratio of annual to perennial species	0	0
6. FQAI	5.3	0
7. Rel. cover of CofC 6-10	0.0001	0
8. Rel. cover of CofC 0-2	0.8695	0
9. Rel. cover of invasives	0	10
10. Standing biomass	NA	NA
VIBI total		**10**

Location: Site 6
Wetland Type: Riverine Depression
Date: 10-20-07

Plot Size: 5 m x 50 m
Intensive Modules: 2
Plot Area: 0.025 ha

Cover: Mod 6-10: shrub

Species	C of C	Native	Family	Indicator	Form	Habit	Group	Shade	Cover	Rel. Cover
Acer rubrum	2	Native	Aceraceae	FAC	tree	W	DI	tree	1.3851	0.2900
Acer saccharinum	3	Native	Aceraceae	FACW	tree	W	DI	tree	0.0100	0.0021
Ageratina altissima	3	Native	Aceraceae	FACU	forb	PE	DI	shade	0.0050	0.0010
brown moss	*	ND	ND	ND	moss	ND	bryophyte	bryophyte	0.0001	0.0000
Cephalanthus occidentalis	6	Native	Rubiaceae	OBL	shrub	W	DI	full	2.9250	0.6124
Cinna arundinacea	4	Native	Poaceae	FACW	grass	PE	MO	shade	0.0001	0.0000
Cornus drummondii	3	Native	Cornaceae	FAC	shrub	W	DI	partial	0.0002	0.0000
Fraxinus nigra	7	Native	Oleaceae	FACW	tree	W	DI	tree	0.0201	0.0042
Fraxinus pennsylvanica	3	Native	Oleaceae	FACW	tree	W	DI	tree	0.3750	0.0785
Geum canadense	2	Native	Rosaceae	FACU	forb	PE	DI	shade	0.0050	0.0010
Pilea pumila	2	Native	Urticaceae	FACW	forb	AN	DI	partial	0.0001	0.0000
Populus deltoides	3	Native	Salicaceae	FAC	tree	W	DI	tree	0.0100	0.0021
Populus heterophylla	9	Native	Salicaceae	FACW	tree	W	DI	tree	0.0200	0.0042
Quercus rubra	6	Native	Fagaceae	FACU	tree	W	DI	tree	0.0200	0.0042
Ribes americanum	4	Native	Grossulariaceae	FACW	shrub	W	DI	partial	0.0001	0.0000
Symphyotrichum shortii	4	Native	Asteraceae	UPL	forb	PE	DI	shade	0.0001	0.0000
Toxicodendron radicans	1	Native	Anacardiaceae	FAC	vine	W	DI	partial	0.0001	0.0000
									4.7760	1.0000

sum C of C	62
FQAI N	16
FQAI score	15.5

Location: Site 6
Wetland Type: Riverine Depression
Date: 10-20-07

Plot Size: 5 m x 50 m
Intensive Modules: 2
Plot Area: 0.025 ha

Shrub Metric	#	Score
# carex	0	0
# native dicot	15	7
# native shrub	3	7
# hydrophytes	8	0
# seedless vascular	1	3
FQAI	15.5	7
rel bryophyte	2.0938E-05	0
rel sensitive	0.62	10
rel tolerant	0.291	0
Mean importance	0.0316	3
TOTAL		**37**

Location: Site 6 - Forest
Wetland Type: Riverine Depression
Date: 10-20-07

Plot Size: 10 m x 50 m
Intensive Modules: 2
Plot Area: 0.05 ha

Frequency: number of dbh size classes a species has stems
Relative frequency: number of dbh classes with stems of that species/ all dbh size classes (12)

Species	**Frequency**	**Rel freq**
Acer rubrum	9	0.7500
Carpinus caroliniana	6	0.5000
Cephalanthus occidentalis	6	0.5000
Cercis canadensis	1	0.0833
Cornus drummondii	5	0.4167
Crataegus mollis	1	0.0833
Fraxinus nigra	1	0.0833
Fraxinus pennsylvanica	7	0.5833
Populus deltoides	2	0.1667
Quercus rubra	7	0.5833
Standing Dead	5	0.4167
Ulmus rubra	10	0.8333

Location: Site 6 - Forest
Wetland Type: Riverine Depression
Date: 10-20-07

Plot Size: 10 m x 50 m
Intensive Modules: 2
Plot Area: 0.05 ha

Dominance: stems per ha. per size class * basal area size class midpoint (12 classes with shrub clumps)

Species	**c1**	**midpt**	**c2**	**midpt**	**c3**	**midpt**	**c4**	**midpt**	**c5**	**midpt**	**c6**	**midpt**
									10-		**15-**	
Acer rubrum	**0-<1**	**0.5**	**1-<2.5**	**1.125**	**2.5-<5**	**3.75**	**5-<10**	**7.5**	**<15**	**12.5**	**<20**	**17.5**
Carpinus caroliniana	8	80		0	5	375	8	1200	4	1000	1	350
Cephalanthus occidentalis	3	30	1	22.5		0	4	600	3	750		0
Cercis canadensis	38	380		0	3	225	5	750	2	500	1	350
Cornus drummondii		0		0		0	1	150		0		0
Crataegus mollis	71	710	16	360	7	525	20	3000		0		0
Fraxinus nigra		0		0	1	75		0		0		0
Fraxinus pennsylvanica		0		0		0		0		0		0
Populus deltoides	47	470	2	45	5	375	7	1050	1	250		0
Quercus rubra		0		0		0		0		0		0
Standing Dead	9	90	1	22.5	1	75	4	600	1	250		0
Ulmus rubra		0		0		0	5	750	1	250	1	350
	12	120	2	45	2	150	5	750	10	2500	3	1050

Species	**c7**	**midpt**	**c8**	**midpt**	**c9**	**midpt**	**c10**	**midpt**	**c11**	**midpt**	**Dom**	**Rel**
	20-		**25-**		**30-**		**35-**		**>40**			
Acer rubrum	**<25**	**22.5**	**<30**	**27.5**	**<35**	**32.5**	**<40**	**37.5**	**all**			**Dom**
Carpinus caroliniana		0	2	1100	1	650		0	6	13536	18291	0.1773
Cephalanthus occidentalis		0		0	1	650	1	750			2802.5	0.0272
Cercis canadensis		0		0		0		0			2205	0.0214
Cornus drummondii		0		0		0		0			150	0.0015
Crataegus mollis		0		0		0		0			4595	0.0445
Fraxinus nigra		0		0		0		0			75	0.0007
Fraxinus pennsylvanica		0		0		0		0	6	7284	7284	0.0706
Populus deltoides		0		0		0	2	1500	12	14023	17713	0.1717
Quercus rubra	1	450		0		0		0	9	23400	23850	0.2312
Standing Dead		0		0		0		0	1	800	1837.5	0.0178
Ulmus rubra		0	1	550		0		0	1	820	2720	0.0264
	3	1350	2	1100	1	650	2	1500	10	12420	21635	0.2097
											103158	1.0000

Location: Site 6 - Forest
Wetland Type: Riverine Depression
Date: 10-20-07

Plot Size: 10 m x 50 m
Intensive Modules: 2
Plot Area: 0.05 ha

Size class density: number of stems in that size class in stems per hectare
Relative size class density: number of stems in that size class/ total number of stems

Species		c5 density		c6 density		c7 density	
		stems	stems/ha	stems	stems/ha	stems	stems/ha
Acer rubrum		4	80	1	20		
Carpinus caroliniana		3	60		0		
Cephalanthus occidentalis		2	40	1	20		
Cercis canadensis		0	0		0		
Cornus drummondii		0	0		0		
Crataegus mollis		0	0		0		
Fraxinus nigra		0	0		0		
Fraxinus pennsylvanica		1	20		0		
Populus deltoides		0	0		0		
Quercus rubra		1	20		0		
Standing Dead		1	20	1	20		
Ulmus rubra		10	200	3	60	3	60
	TOTAL	**22**	**440**	**6**	**120**		

Species		c5 rel den		c6 rel den		c7 rel den		Total	Rel den
		stems	stems/ha	stems	stems/ha	stems	stems/ha	Stem/ha	
Acer rubrum		80	0.0103	20	0.0026			700	0.0884
Carpinus caroliniana		60	0.0077	0	0.0000			260	0.0328
Cephalanthus occidentalis		40	0.0051	20	0.0026			1140	0.1439
Cercis canadensis		0	0.0000	0	0.0000			20	0.0025
Cornus drummondii		0	0.0000	0	0.0000			2320	0.2929
Crataegus mollis		0	0.0000	0	0.0000			20	0.0025
Fraxinus nigra		0	0.0000	0	0.0000			120	0.0152
Fraxinus pennsylvanica		20	0.0026	0	0.0000			1520	0.1919
Populus deltoides		0	0.0000	0	0.0000			200	0.0253
Quercus rubra		20	0.0026	0	0.0000			400	0.0505
Standing Dead		20	0.0026	20	0.0026			180	0.0227
Ulmus rubra		200	0.0257	60	0.0077	60	0.0077	1040	0.1313
	TOTAL	**440**	**0.0566**	**120**	**0.0154**		**0.0077**	7920	**1.0000**

Location: Site 6 - Forest
Wetland Type: Riverine Depression
Date: 10-20-07

Plot Size: 10 m x 50 m
Intensive Modules: 2
Plot Area: 0.05 ha

Frequency: number of dbh size classes a species has stems
Relative frequency: number of dbh classes with stems of that species/ all dbh size classes (12)
Size class density: number of stems in that size class in stems per hectare
Relative size class density: number of stems in that size class/ total number of stems
Dominance: number of stems/ha in each size class(density) * the midpoint of the size class,
add basal areas for each size class to get total dominance.
Relative dominance: basal area of a species/ basal area of all species.
Importance value: average of relative frequency, relative density, and relative dominance

Species	Rel freq	Rel den	Rel Dom	Imp Value
Acer rubrum	0.7500	0.0884	0.1773	0.3386
Carpinus caroliniana	0.5000	0.0328	0.0272	0.1867
Cephalanthus occidentalis	0.5000	0.1439	0.0214	0.2218
Cercis canadensis	0.0833	0.0025	0.0015	0.0291
Cornus drummondii	0.4167	0.2929	0.0445	0.2514
Crataegus mollis	0.0833	0.0025	0.0007	0.0289
Fraxinus nigra	0.0833	0.0152	0.0706	0.0564
Fraxinus pennsylvanica	0.5833	0.1919	0.1717	0.3157
Populus deltoides	0.1667	0.0253	0.2312	0.1410
Quercus rubra	0.5833	0.0505	0.0178	0.2172
Standing Dead	0.4167	0.0227	0.0264	0.1553
Ulmus rubra	0.8333	0.1313	0.2097	0.3915
	5.0000	1.0000	1.0000	2.3333

Location: Site 6 - Forest
Wetland Type: Riverine Depression
Date: 10-20-07

Plot Size: 10 m x 50 m
Intensive Modules: 2
Plot Area: 0.05 ha

Cover modules 1 - 5: Forest

Species	C of C	Nativity	Form	Indicator	Shade	Total Cover	Rel. cover
Acer rubrum	2	Native	tree	FAC	tree	0.7700	0.1230
Acer saccharinum	3	Native	tree	FACW	tree	0.3601	0.0575
brown moss	*	ND	moss	ND	bryophyte	0.0051	0.0008
Carpinus caroliniana	5	Native	sm tree	FAC	shade	0.0150	0.0024
Celtis occidentalis	4	Native	tree	FACU	tree	0.0101	0.0016
Cephalanthus occidentalis	6	Native	shrub	OBL	full	0.1950	0.0311
Cercis canadensis	3	Native	sm tree	FACU	shade	0.0001	0.0000
Cornus drummondii	3	Native	shrub	FAC	shade	0.7001	0.1118
Crataegus mollis	3	Native	sm tree	FACU	full	0.0051	0.0008
Fraxinus pennsylvanica	3	Native	tree	FACW	tree	1.2350	0.1972
Galium circaezans	4	Native	forb	UPL	shade	0.0001	0.0000
Galium concinnum	5	Native	forb	UPL	shade	0.0001	0.0000
Glechoma hederacea	0	adventive	forb	FACU	adventive	0.0051	0.0008
Leersia virginica	4	Native	grass	FACW	shade	0.0050	0.0008
Menispermum canadense	5	Native	vine	FACU	shade	0.0001	0.0000
Parthenocissus quinquefolia	2	Native	vine	FACU	shade	0.0002	0.0000
Phalaris arundinacea	0	adventive	grass	FACW	adventive	0.0001	0.0000
Populus deltoides	3	Native	tree	FAC	tree	1.5050	0.2404
Quercus palustris	5	Native	tree	FACW	tree	0.1950	0.0311
Quercus rubra	6	Native	tree	FACU	tree	0.2350	0.0375
Ribes cynosbati	3	Native	shrub	UPL	partial	0.0050	0.0008
Rosa multiflora	0	adventive	shrub	FACU	adventive	0.0050	0.0008
Symphyotrichum cordifolium	4	Native	forb	UPL	shade	0.0050	0.0008
Symphyotrichum lanceolatum	3	Native	forb	FACW	partial	0.0002	0.0000
Symphyotrichum shortii	4	Native	forb	UPL	shade	0.0150	0.0024
Toxicodendron radicans	1	Native	vine	FAC	partial	0.0100	0.0016
Ulmus rubra	3	Native	tree	FAC	tree	0.1751	0.0280
Ulmus thomasii	7	Native	sm tree	FACU	partial	0.8050	0.1286
Vicia cracca	0	adventive	forb	UPL	adventive	0.0001	0.0000
Total						6.2617	1.0000

Sum of C of C	91
FQAI N	28

Location: Site 6 - Forest
Wetland Type: Riverine Depression
Date: 10-20-07

Plot Size: 10 m x 50 m
Intensive Modules: 2
Plot Area: 0.05 ha

FQAI Score 17.2

	Metric Value	Score
Pole Timber Metric:	0.0797	10
Subcanopy IV Metric:	0.2147	10
Canopy Metric	0.2138	0

Forest Metric		**Score**
# of native shade species	10	3
# of seedless vascular plants	1	3
FQAI	17.2	3
Rel cover of Bryophytes	0.0008	0
Rel cover of shade tolerant hydrophytes	0.0008	0
Rel cover of sensitive	0.0311	0
Rel cover of tolerant	0.003	10
Rel den of sm trees (pole timber)	0.0797	10
Mean Importance of subcanopy sp	0.2147	10
Mean Importance of canopy sp	0.2138	3
Total		**42**

APPENDIX B. ORAM Metric Summary Sheet

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Metric 1 (max 6 pts)						
Size	2	3	3	3	3	3
Metric 2 (Max 14 pts)						
Avg. buffer width	12	12	11	9	7	14
Metric 3 (Max 30 pts)						
Sources of water	4	4	4	4	4	4
Connectivity	3	0	0	0	3	2
Maximum water depth	3	3	3	2	2	3
Duration of inundation/saturation	3	4	2	2	2	2
Modifications to natural regime	7	7	5	2	3	9.5
Metric 4 (Max 20 pts)						
Substrate/soil disturbance	3	3	2	2	2	4
Habitat development	5	6	3	2	2	7
Habitat alteration	6	6	3	2	2	7.5
Metric 5 (Max 10 pts)						
Special wetland community	0	0	0	0	0	5
Metric 6 (Max 20 pts)						
Wetland vegetation communities	5	8	2	1	3	6
Horizontal interspersion	3	4	2	1	1	1
Microtopography	2	8	0	0	3	7
Total	58	68	40	30	37	75

APPENDIX C. Metrics used for the VIBI

Type of Metric	VIBI-Emergent	VIBI-Shrub	VIBI-Forest
Richness	Carex species	Carex species	
Richness	Native dicots	Native dicots	
Richness			Native shade species
Richness	Native wetland shrub	Native wetland shrub	
Richness	Hydrophyte species	Hydrophyte species	
Richness ratio	Annual to perennial species		
Richness		Seedless vascular plants	Seedless vascular plants
Weighted richness index	FQAI score	FQAI score	FQAI score
Dominance ration		Relative cover of bryophytes	Relative cover of bryophytes
Dominance ratio			Relative cover of shade tolerant hydrophyte species
Dominance ratio	Relative cover of sensitive plant species	Relative cover of sensitive plant species	Relative cover of sensitive plant species
Dominance ratio	Relative cover of tolerant plant species	Relative cover of tolerant plant species	Relative cover of tolerant plant species
Dominance ratio	Relative cover of invasive graminoid species		
Density ratio			Relative density of small trees (pole timber)
Importance value		Mean importance value of native shade and facultative shade subcanopy	Mean importance value of native shade and facultative shade subcanopy
Importance value			Mean importance value of canopy species
Primary production	Mean standing biomass		

APPENDIX D. Metric Scores for the VIBI

Metric	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6-S**	**Site 6-F**
Carex species	0	0	0	0	0	0	
Native dicots	19	21	12	12	6	15	
Native shade species							10
Native wetland shrub	2	0	1	0	1	3	
Hydrophyte species	13	15	9	4	4	8	
Annual to perennial species ratio	0.389	0.075	2.4	1.286	0		
Seedless vascular plants						1	1
FQAI score	10.8	15.0	6.6	4.0	5.3	15.5	17.2
Relative cover of bryophytes						0	0.001
Relative cover of shade tolerant hydrophyte species							0.001
Relative cover of sensitive plant species	0.003	0.006	0.698	0	0	0.620	0.031
Relative cover of tolerant plant species	0.525	0.147	0.166	0.988	0.870	0.291	0.003
Relative cover of invasive graminoids	0	0.002	0	0	0		
Relative density of small trees (pole timber)							0.080
Mean importance value of native shade and facultative shade subcanopy						0.032	0.215
Mean importance value of canopy species							0.214
Mean standing biomass	NA	NA	NA	NA	NA		

APPENDIX E. Coded Metric Score Summary Sheet for the VIBI

Metric	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6-S	Site 6-F
Carex species	0	0	0	0	0	0	
Native dicots	7	7	3	3	0	7	
Native shade species						7	7
Native wetland shrub	3	0	0	0	0		
Hydrophyte species	3	3	0	0	0	0	
Annual to perennial species	3	0	0	0	10		
Seedless vascular plants						3	3
FQAI score	3	7	0	0	0	7	7
Relative cover of bryophytes						0	0
Relative cover of shade tolerant hydrophyte species							0
Relative cover of sensitive plant species	0	0	10	0	3	10	0
Relative cover of tolerant plant species	7	10	10	0	0	10	10
Relative cover of invasive graminoids	10	10	10	10	10		
Relative density of small trees (pole timber)							10
Mean importance value of native shade and facultative shade subcanopy						10	10
Mean importance value of canopy species							0
Mean standing biomass	NA	NA	NA	NA	NA		
Total	36	37	33	13	23	54	47

APPENDIX F. Coefficient of Conservatism Chart

Coefficient of Conservatism	Description of plants under this category
0	Plants with a wide range of ecological tolerances. Often these are opportunistic invaders of natural areas (e.g. *Phragmites australis*, *Phalaris arundinaceae*) or native taxa that are typically part of a ruderal community (e.g. *Polygonum pensylvanicum*, *Ambrosia artemisifolia*).
1-2	Widespread taxa that are not typical of (or only marginally typical of) a particular community like *Solidago Canadensis* or *Impatiens capensis.*
3-5	Plants with an intermediate range of ecological tolerances that typify a stable phase of some native community, but persist under some disturbance (*Asclepias incarnata*, *Ulmus rubra*, *Spartina pictinata).*
6-8	Plants with a narrow range of ecological tolerances that typify a stable or near "climax" community (e.g. *Goodyera pubescens*, *Veronicastrum virgincum, Cephalanthus occidentalis*)
9-10	Plants with a narrow range of ecological tolerances that exhibit relatively high degrees of fidelity to a narrow range of habitat requirements (e.g. *Potamogeton robbinsii, Cypripedium candidum*)

To obtain the FQAI index, the coefficient of conservation into a mathematical equation:

$$I = R / \sqrt{N}$$

Where: I = FQAI index
R = The sum of valuation coefficients for all plants recorded in the area
N = The number of different native species recorded

From: Andreas, B.K., J.J. Mack, and J.S. McCormac. 2004. Floristic quality assessment index (FQAI) for vascular plants and mosses for the State of Ohio. Wetland Ecology Group, Division of Surface Water, Ohio Environmental Protection Agency. 219 pp.