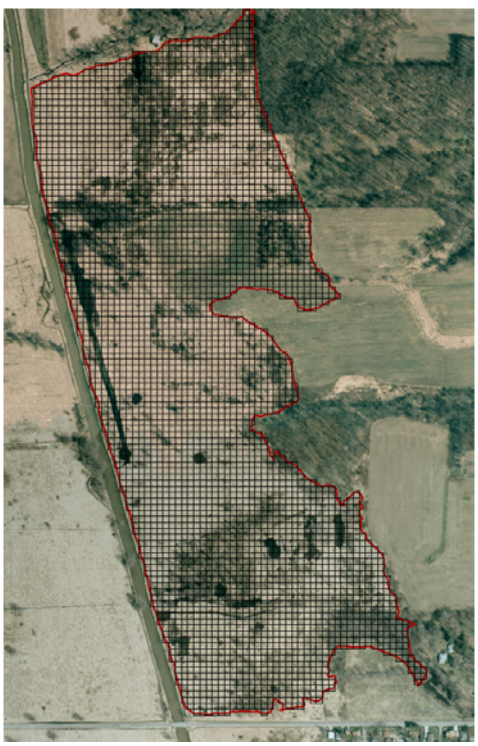
State of Ohio
Environmental Protection Agency

Wetland Ecology Group
Division of Surface Water

INTEGRATED WETLAND ASSESSMENT PROGRAM.
Part 6: Standardized Monitoring Protocols and Performance Standards for Wetland Creation, Enhancement and Restoration, Version 1.0

Ohio EPA Technical Report WET/2004-6



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Appropriate Citation:

Mack, John J, M. Siobhan Fennessy, Mick Micacchion and Deni Porej. 2004. Standardized monitoring protocols, data analysis and reporting requirements for mitigation wetlands in Ohio, v. 1.0. Ohio EPA Technical Report WET/2004-6. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio.

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ACKNOWLEDGMENTS

This report would not have been possible without the encouragement and support of Richard Sumner and Sue Elston (U.S. EPA) and the input and reviews of Mick Micacchion, Randy Bournique and the staff of the 401 Water Quality Certification Section (Jeff Boyles, Pete Clingan, Art Coleman, Laura Fay, Dan Osterfeld, Mike Smith) This project was funded in part by Wetland Program Development Grant No. CD975350, Region 5, U.S Environmental Protection Agency.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTEGRATED WETLAND ASSESSMENT PROGRAM. PART 6: STANDARDIZED MONITORING PROTOCOLS AND PERFORMANCE STANDARDS FOR WETLAND CREATION, ENHANCEMENT AND RESTORATION, VERSION 1.0

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ABSTRACT

A condition-based approach to assessing functional replacement for wetland mitigation has been developed using a reference wetland data set of natural wetlands that includes data from the major wetland types that span a gradient of human disturbance. From this data set wetland program tools were developed 1) multimetric biological indices (IBIs) and hydrological and biogeochemical indicators; 2) a rapid (condition-based) wetland assessment tool (Ohio Rapid Assessment Method for Wetlands); and 3) a wetland classification scheme based on landscape position and dominant vegetation that accounts for variability in ecosystem processes (functions) and ecological services (values) of different types of natural wetlands. Ensuring functional replacement occurs in a several step process. First, as part of permit application, the HGM class and dominant plant community of the impacted wetland(s) are determined. This determination accounts for the ecosystem processes (functions) and ecological services (values) of different wetland types without the necessity of developing a comprehensive list of those functions and values. Second, the condition of the impacted wetland is assessed with the rapid condition tool (ORAM v. 5.0) or a wetland IBI providing a measure of "functional capacity." Third, the size of the wetland to be impacted is determined and appropriate mitigation ratios are applied. Fourth, any residual moderate to high functions or values the impacted wetland(s) may still be providing, despite moderate to severe degradation, are evaluated using checklist with a narrative discussion. Finally, requirements for mitigation are specified in the permit. If there is 1) replacement by size of the impacted wetland, 2) replacement of the type of wetland impacted, 3) and replacement of the quality of the impacted wetland as measured by quantitative, condition-based ecological performance targets, then there is very strong assurance that functional replacement is occurring since there was "no net loss" of wetland acreage, a mitigation wetland of same HGM class and dominant plant community was created with functions and ecological services equivalent to the impacted wetland, and a mitigation wetland was created of equivalent "quality" as measured by biological (e.g. IBIs), hydrological, and biogeochemical indicators (and therefore of equivalent functional performance). Fundamentally, the above approach is strongly data-driven and it follows then that meaningful and adequate mitigation monitoring is absolutely necessary to determine whether the mitigation wetland has "succeeded" or "failed." Performance standards, quantitative monitoring, and data analysis techniques were developed for wetland size, basin morphometry, perimeter:area ratio, hydrologic regime, basic vegetation establishment, woody species establishment (successional trends), soil chemistry, and wetland IBIs.

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1.0 BACKGROUND

1.1 Introduction

Compensatory mitigation is one of the key components of state and federal wetland regulatory programs. It is a fundamental premise (assumption) that unavoidable, unminimizable impacts causing loss of wetland acreage and function can be mitigated for by creating, enhancing or restoring wetlands elsewhere (on site, in the same watershed, in the state, at a wetland bank, etc.). There continues to be much debate, both scientifically and from a policy perspective whether this assumption is valid at all, or only valid for certain types and classes of wetlands (e.g. Fennessy and Roehrs 1997; Mitsch et al. 1998; Bedford 1999; Bedford 1996; NRC 2001).

An intensive review and assessment of wetland creation projects was recently published by the Committee on Mitigating Wetland Losses conducted by the National Academy of Sciences National Research Council (NRC 2001). The committee concluded that "...the goal of no net loss of wetlands is not being met for wetland functions by the mitigation program, despite progress in the last 20 years" (NRC 2001). Documenting mitigation wetland performance (or lack thereof) is a critical piece of information for implementing a wetland regulatory program in order to 1) evaluate programmatic success, 2) initiate changes in permit requirements or the use of current approval criteria if it is determined that performance and functional replacement are not occurring, and 3) begin to address the larger issues of landscape level effects of constructing wetlands that may or may not have been prevalent hydrogeomorphically or vegetatively in a particular region (Bedford 1996). The fundamental issue then is how to obtain functional replacement of the impacted wetland and how to measure if such replacement has occurred.

1.2 Condition-based approach to functional replacement

It is difficult and time consuming to separately quantify the functions of each wetland pre- and post- impact in the context of a regulatory permit program. This function by function may ultimately explain the limited extent that such approaches have been adopted. In contrast, an approach that uses condition-based wetland assessment tools (e.g. an Index of Biotic Integrity or IBI) derived from a reference wetland data set is highly suited to determining if functional replacement has occurred, and avoids the detailed specification of functions for each permitted impact.[4] The goal of an IBI is to measure the ecological integrity (condition) of the wetland, with integrity being defined as deviation or lack thereof from regional reference (least impacted) conditions. An IBI typically measures "structural" attributes of the biological community and makes the assumption that if structural condition is good (or excellent or degraded) then the functional processes that support these structures are also operating at good (or excellent or degraded) levels (Stevenson and Hauer 2002). Other data (chemical, physical and landscape) are also collected but only biological attributes are included in the IBI. By keeping biological information separate from physical, chemical or landscape information, it is easier to evaluate causal mechanisms and IBIs are arguably more transparent and easier to explain than methods which incorporate different types of data into untested logic models. The IBI approach has a proven record of being able to measure restoration and improvement of other aquatic resources like streams, lakes, and reservoirs.

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[4] Resident biological communities inhabit wetlands continuously or for significant portions of their life cycles, e.g. breeding or larval stages, and are integrators of the prevailing and past chemical, physical and biological history of the wetland (Ohio EPA 1988).

A condition-based approach to functional replacement has, as its foundation, a reference wetland data set of natural wetlands that includes data from the major wetland types and from wetlands that span a gradient of human disturbance.[5] From this data set several wetland program tools are developed 1) multimetric biological indices (IBIs) and hydrological and biogeochemical indicators; 2) a rapid (condition-based) wetland assessment tool calibrated using the IBIs (Ohio Rapid Assessment Method for Wetlands); and 3) a wetland classification scheme based on landscape position and dominant vegetation that accounts for variability in ecosystem processes (functions) and ecological services (values) of different types of natural wetlands (Mack 2001; Micacchion 2004; Knapp 2004; Fennessy et al. 2004; Mack 2004a, b, c).

In the context of a permit application, functional replacement of the impacted wetland is a several step process. First, as part of permit application, the HGM class and dominant plant community of the impacted wetland(s) must be determined. Specifying the type of wetland will account for different ecosystem processes (functions) and ecological services (values) of different wetland types without the necessity of developing a comprehensive list of those functions and values. Second, the condition of the impacted wetland is assessed with the rapid condition tool (ORAM v. 5.0) or a wetland IBI. This provides a measure of "functional capacity" since "good" condition equates to "good" functioning. Third, the size of the wetland to be impacted is determined. Mitigation ratios (Ohio Administrative Code 3745-1-54) are then used to determine the *amount* of mitigation required. Fourth, any residual moderate to high functions or values the impacted wetland(s) may still be providing, despite moderate to severe degradation, can be evaluated using checklist approach with a narrative discussion (if necessary, a more detailed quantification of residual functions can be performed).[6] Finally, requirements for mitigation are specified in the permit. As part of the mitigation process mitigation occurs at ratios specified by rule with a minimum of 1:1 replacement; replacement is "in-kind" with "in-kind" determined by the HGM class and dominant

[5] The HGM approach, as typically developed and practiced, does this by taking a function by function approach (although Smith et al. (1995) state that "ecological integrity" is super-function at top of nested functional process hierarchy). In the HGM approach simple logic models (Smith et al. 1995, Brinson 1993) are developed to infer functional performance. Typically data from flora and faunal communities, water and soil chemistry, land use information, etc. is collected from wetland and this information is included in untested logic models which, when summed, produce a functional capacity index score. Scores and models are developed and calibrated using regional "reference standard" data sets. Reference standard sites are generally best remaining and/or least impacted examples of that type of wetland. A common misconception is that HGM actually measures wetland "functions" directly; instead, HGM almost always measures structural attributes (flora, fauna, physical features, etc.) of wetland and uses the *condition* of these structural attributes in comparison to reference standard conditions to *infer* functional performance. Biotic, abiotic, and sometimes even landscape level attributes are often included in the logic models.

[6] To summarize the first four steps discussed above: 1) classification by HGM class and dominant plant community provides assurance that the functions and values unique to that wetland type are accounted for; 2) using a condition-based assessment provides a measure of existing ecological condition; "functional" performance is then inferred from level of condition, i.e. good condition = good functional performance, excellent condition = excellent functional performance, poor condition = poor functional performance, etc.; and 3) evaluation of any residual functions or ecological services (values) provides safeguard against situation where moderate to severely degraded wetlands still have a single "good" remaining function or value.

vegetation of the impacted wetland; and mitigation performance is determined by achievement of equivalent or greater "quality" as the impacted wetland as measured by biological, hydrological, and biogeochemical indicators derived from reference wetland data sets. These indicators then become quantitative performance standards and mitigation monitoring is then tailored to collect data necessary to determine if the standards have been met.

In conclusion, if there is 1) replacement by size of the impacted wetland, 2) replacement of the type of wetland impacted (same landscape position and dominant plant community, 3) and replacement of the quality of the impacted wetland as measured by quantitative, condition-based ecological performance targets, then there is very strong assurance that functional replacement is occurring since there was "no net loss" of wetland acreage, a mitigation wetland of same HGM class and dominant plant community was created with functions and ecological services equivalent to the impact wetland, and a mitigation wetland was created of equivalent "quality" as measured by biological, hydrological, and biogeochemical indicators (and therefore of equivalent functional performance). Fundamentally, the above approach is strongly data-driven and it follows then that meaningful and adequate mitigation monitoring is absolutely necessary to determine whether the mitigation wetland has "succeeded" or "failed."

1.3 Investigating Structure and Function of Natural and Mitigation Wetlands

The National Research Council (NRC 2001) made multiple recommendations with the goal of improving the success of wetland mitigation 1) consider both the structure and function of wetland ecosystems, and the relationship between the them; 2) use reference wetlands as a model for the dynamics of created or restored sites; 3) emphasize that hydrological variability is important in the structure and function of mitigation wetlands; 4) require the measurement of a broader range of functions for mitigation projects; 5) broaden the science and technology of wetland restoration and creation to include sites that differ in degree of disturbance and restoration effort; 6) construct self-sustaining mitigation wetlands; and 7) avoid the destruction of wetlands that are particularly hard to restore.[7]

In response to these recommendations, major studies of natural and mitigation wetlands in Ohio were undertaken (Fennessy et al. 2004; Porej 2003, 2004).

Ohio EPA undertook a comprehensive investigation of the biota (structure) and biogeochemical cycles (processes or functions) of a population of natural and mitigation wetlands using a study design that incorporated the first four of the recommendations listed above (Fennessy et al. 2004). The objectives of this study were four-fold:

1. To demonstrate the efficacy of using floral and faunal community-based indicators to assess the performance of mitigation wetlands;

2. To investigate the linkages between flora and faunal community structural attributes and ecosystem processes in natural and mitigation wetlands;

3. To investigate the biological and physical characteristics, and biogeochemical cycles of the wetlands in order to assess the condition of mitigation sites as compared to natural sites;

[7] This last recommendation has been incorporated into Ohio's wetland water quality standards since 1998 where high quality or rare wetland types receive the highest level of regulatory protection.

4. To identify simple, cost-effective biogeochemical indicators for use in mitigation monitoring. that can be translated to performance standards.

Intensive fieldwork was conducted at natural and mitigation wetlands in order to collect data on various wetland ecosystem components (e.g. hydrology, soil, plant community composition and productivity, macroinvertebrate and amphibian community composition, decomposition, and nutrient cycling). Where possible, this fieldwork was supplemented by Ohio EPA's larger reference wetland data set. Fennessy et al. (2004) found that the mitigation wetlands, in terms of their structure and function, formed a separate population from the natural wetlands, indicating the creation of a new subclass of wetlands on the landscape. Major differences included deeper surface water at the mitigation sites; greater depth to ground water at the mitigation sites; substantially reduced soil nutrient pools at mitigation sites; significantly different movement of nutrients in terms of rates and quantities between natural and mitigation sites; reduced nutrient availability that propagates throughout the mitigation systems and appears to set a limit on ecosystem development; and significantly different compositions of plant, amphibian, and macroinvertebrate communities.

Fennessy et al. (2004) concluded that biological and biogeochemical indicators were effective in their ability to reflect ecological condition and measure mitigation wetland performance. Practical indicators in terms of cost, time, and information gained included soil chemical and physical characteristics especially soil organic carbon and soil nitrogen content and percent solids in the soil or bulk density; hydrological characteristics including mean depth to ground water and percent time water is found in the root zone (i.e. greater than -30cm) (as compared to a natural reference ecosystem of similar hydrogeomorphic class); and multimetric indices developed from natural reference wetland data sets.

In a second investigation, Porej (2004) developed predictive models based on landscape (%forest cover) and wetland characteristics (amount of shallow zones in wetland, presence of predatory fish) for Ohio amphibian species using Ohio EPA's existing reference wetland data set and data collected from 48 mitigation sites. Porej (2004) found that the "amount of forest cover within the core zone [200m of the wetland] was included in the most parsimonious models for overall salamander diversity, and individual models for presence of spotted salamanders, Jefferson salamander complex (*Ambystoma jeffersonianum*), smallmouth salamanders (*Ambystoma texanum*) and wood frogs" (Porej 2004, p. 41). Land use beyond 200m (e.g. %forest, road density, etc.) was also important for overall salamander diversity, red-spotted newts, tiger salamanders, and wood frogs (Porej 2004).

In addition to land use factors, Porej (2004) found that the absence of "littoral" shallows in the wetland and the presence of predacious fish species altered amphibian populations in natural and mitigation wetlands (Porej 2004). Overall amphibian diversity was significantly higher for wetlands *with* shallows and *without* predacious fish than for wetlands that had predacious fish, lacked shallows or had some combination of these factors (Porej 2004). The amphibian community structure was also different with certain species thriving, e.g. bullfrog (*Rana catesbeiana*), green frog (*Rana clamitans*), and toads (*Bufo* spp.), and others highly reduced or lacking altogether, e.g. spring peeper (*Rana pipiens*), western chorus frog (*Rana triseriata*), and most salamanders. Porej (2004) found equivalent levels of amphibian richness but clear tradeoffs in amphibian assemblages, with the 48 mitigation wetlands he studied virtually lacking in forest dependent amphibian species.

Porej (2003) surveyed 111 mitigation projects permitted by Ohio EPA. He found almost 50% of permitted wetland impacts in Ohio are to forested wetlands, although virtually all mitigations attempted were emergent communities. Porej (2003, 2004) also found that only 54% of small mitigation wetlands (<1 ha) *had* shallows and *lacked* predatory fish and only 23% of larger mitigation wetlands (> 1 ha) *had* shallows and *lacked* predatory fish. Habitat features like vegetation type and abundance are known to strongly influence amphibian richness and the availability of breeding sites (Richter and Azous 1995); Pechmann et al. (2001). Porej (2003) also found that multiple impacts to small wetlands were being consolidated into a single larger mitigation wetland resulting in a loss of wetland perimeter length and "edge" habitats where much floral and faunal activity occurs. Presence of shallows and emergent vegetation also had a marked effect on bird assemblages with wetlands having 50% or more of their area with vegetated shallows and heterogeneous habitats (mix of vegetation, open water, mud flats, etc.) having the most diverse assemblages of birds (Porej 2004).

1.4 Mitigation Performance and Monitoring

Fundamentally, mitigation monitoring is no different from the experimental design and hypothesis testing that is basic to any scientific study. The goal of monitoring is to collect sufficient data to answer the hypothesis: has the mitigation wetland met the performance goal within the monitoring period. As recommended by the NRC (2001), the performance standards developed for mitigation monitoring in Ohio include a broad range of structural and functional measures. They were developed using reference wetlands as a model for the dynamics of created or restored sites, and require quantitative hydrologic monitoring in order to assure natural hydrologic regimes are established. The approach to mitigation monitoring taken here was outlined more than decade ago in *An Approach to Improving Decision Making in Wetland Restoration and Creation* (Chapters 4 and 5, Kentula et al. 1992): data from key indicators is collected over time and plotted against performance curves derived from natural reference wetland data sets. The results of Fennessy et al. (2004) as well Porej (2003, 2004), Porej et al. (2004), Micacchion (2004), and Mack (2004a, 2004b, 2004c) have been translated into the standardized performance and monitoring protocols presented in this report. The standards can be broken into several categories.

1.4.1 Size (No Net Loss of Wetland Acreage)

Much attention on wetland mitigation has focused on the "no net loss" of wetland acreage (quantity of wetlands) as part of the wetland permitting programs. Since the amount of wetlands on the landscape is associated with their function and ecological integrity, the performance standards include a requirement that mitigation project create the appropriate number of wetland acres.

1.4.2 Consolidation and Morphometry

An unexpected outcome of mitigation ratios has been the consolidation of impacts from multiple small wetlands into single large individual mitigations or at large contiguous mitigation banks. To the extent that the structure and function of small wetlands is in part due to their size and higher interaction between the upland and wetland border (i.e. more edge, less center), consolidation can result in lack of functional replacement for these wetland types (frequently small depressions often called vernal pools). The ratio of wetland perimeter length is required as a performance (or design) standard, with mitigations needing to have 75% of the perimeter length of the impacted wetlands, unless the consolidation of certain types of very small impacts makes sense ecologically and/or pragmatically.

In addition to consolidation, a frequent flaw in mitigation design is to produce what is in effect a steep-sided pond with little or no shallows (Porej 2003). Vegetated shallows are important for floral and faunal diversity and are nearly always present in natural wetlands. Because of this, a basin morphometry is required as a performance (design) standard, with more the 50% of the perimeter of the mitigation wetland having slopes of 15:1 or shallower.

1.4.3 Hydrology

Despite being considered the master factor determining or affecting virtually every aspect of a wetland (Mitsch and Gosselink 2000), hydrology is rarely quantitatively studied in mitigation monitoring. Lack of hydrologic monitoring and standards is a critical failing. Quantitative hydrologic monitoring is required at all mitigation projects. Lack of hydrologic equivalence and the creation of hydrologically atypical wetlands has frequently been pointed to as a significant flaw in current wetland creation and restoration efforts (NRC 2001; Bedford 1996, 1999). The performance standard requires the mitigation project to create or restore a hydrologic regime equivalent to the regime of a natural wetland of that hydrogeomorphic (HGM) class and to compare hydrologic indicators and hydrographs of the mitigation wetland to natural reference hydrologic data.

1.4.4 Biogeochemistry

The importance of soil chemistry and especially soil organic carbon in wetland ecosystems processes has been observed in many studies (Fennessy et al. 2004 and others). Fennessy et al. (2004) found that soil carbon and nitrogen were excellent biogeochemical indicators of more complex (and difficult to measure) ecosystem processes. Sampling procedures for basic soil chemistry data are relatively simple and analytical costs are very low. Soil chemistry monitoring for basic soil nutrient parameters and soil organic carbon and/or nitrogen are required as performance standards.

1.4.5 Basic Vegetation Establishment

In terms of their role in ecosystem processes of wetlands, plants can almost be considered a physical feature like soil or water in addition to being living organisms (Cronk and Fennessy, 2001). Natural of wetlands of moderate to high ecological integrity are dominated by perennial native hydrophytic vegetation and have low abundances of invasive species, especially the following aggressive invasive species: *Lythrum salicaria, Phalaris arundinacea, Phragmites australis, Rhamnus frangula, Typha angustifolia,* and *Typha* x*glauca*. Establishment of more than high cover (>75%) of perennial native hydrophytes[8] and very low amounts of cover of invasive species (<5%) are required as performance standards. Active management to control invasives during the monitoring period will enable the <5% goal to be met and ensure that native perennial species can become established and provide competitive exclusion benefits for invasive colonization after the monitoring period has ended.

1.4.6 Woody Vegetation Establishment

Given that over 50% of permitted impacts in Ohio have been for forested wetlands (Porej 2003), and that Ohio law requires in-kind replace

[8] Relative cover of *just* OBL and FACW woody and perennial native species is 65.6%, 73.5% and 81.4% for Category 1, 2 and 3 wetlands, respectively based on Ohio EPA's reference wetland data set, so the goal of 75% cover of perennial OBL, FACW *and* FAC species can be considered a highly realistic minimum vegetation establishment standard.

for forested impacts (OAC 3745-1-50), it is surprising that there is little monitoring and no performance measures to determine whether forest succession has begun and is likely to proceed to the future establishment of wetland shrub or forest communities. Since woody stem data needed to evaluate successional trends is required to be collected as part of the Vegetation IBI (see below), this performance standard requires additional data analysis but no additional monitoring.

1.4.7 Measures of Ecologic Condition

1.4.7.1 Vegetation Index of Biotic Integrity (VIBI)

As a potential indicator taxa to measure the biological integrity of wetlands, vascular plants are large, obvious, important components of wetland ecosystems with a well understood taxonomy, that can be cost effectively sampled using well-developed sampling methods (Fennessy et al. 2001). The Vegetation IBI includes metrics relating to taxonomic composition, community structure, and ecosystem processes and has been demonstrated to consistently and reliably assessed wetland condition across the whole range of wetland types and throughout Ohio ecological regions (Mack 2004b; Fennessy et al. 2004). A VIBI score specific to the wetland type (HGM class, plant community), location (ecoregion), and quality will be a required performance goal for most mitigations.

1.4.7.2 Amphibian Index of Biotic Integrity (AmphIBI)

Amphibians are keystone species that prey on insects, invertebrates, other amphibians and detritus. They also serve as a food source for predacious invertebrates, other amphibians, reptiles, birds, mammals and fish. Additionally, amphibians are well recognized as sensitive indicators of environmental conditions, and many amphibian species are dependent on wetlands to provide habitat for some or all of their life stages (Wake 1991, Griffiths and Beebe 1992). The AmphIBI will be used as a performance goal for depressional wetland forest mitigations (i.e. vernal pools) including vernal pool shrub swamps in a forest matrix.

1.4.7.3 Other Measures of Condition, Function, or Value

The measures of condition (VIBI, AmphIBI) proposed for use here are obviously not the only taxa groups (e.g. birds, fish, mammals, macroinvertebrates, bryophytes etc.) that could be monitored. In addition, more traditional measurements of individual ecological services (values) that wetlands provide (e.g. flood storage, recreation, water quality improvement, etc.) can also be used as performance standards depending on the particular purposes and goals of a mitigation project. Additional monitoring and performance standards can be developed on a case by case basis.

1.5 Using the Standardized Mitigation Performance Standards and Monitoring Protocols

These performance standards and monitoring protocols are designed to be used on a case-by-case basis in order to meet the needs and purposes of particular wetland creation, restoration, or enhancement projects. Alternative, modified, or additional performance standards may be developed depending on the project needs or purposes. When alternative, modified, or additional performance goals are developed, monitoring requirements should be carefully reviewed to ensure that the type and amount of data need to determine conformance with the performance standard is collected.

Basic to this approach to mitigation performance is the use of at least one wetland IBI and/or an equivalent measure of wetland condition using a different taxa group. For most individual mitigation projects and mitigation banks, minimum standards would include size, morphometry, hydrology, basic vegetation establishment, soil chemistry and the VIBI and/or AmphIBI. Restoration or creation projects with unique or highly site specific project purposes may include modified or substitute standards. For example, a wetland creation project with the primary purpose to create habitat for migratory birds should include performance goals and monitoring of bird usage during migration periods. Mitigation projects with goal to increase some specific wetland function or value like flood storage or water quality improvement would include standards and monitoring to determine the amount of that function or value created or restored. There may be a few instances where integrative measures of wetland condition provided by wetland IBIs are not necessary. But for most applications, the necessary approach will be to compare the performance of the mitigation wetland on the hydrologic, biogeochemical, and ecologic indicators to the levels of performance of natural reference wetlands with the overall goal of obtaining monitoring data sufficient to ensure a data-driven performance evaluation process.

2.0 PERFORMANCE STANDARDS FOR WETLAND CREATION, RESTORATION, AND ENHANCEMENT

2.1 General standards

2.1.1 Acreage

At least ____ hectares (acres) of the mitigation wetland(s) shall meet all three criteria in the 1987 Delineation Manual (hydric soils, dominance by hydrophytes, and wetland hydrology) sufficient to be classified as jurisdictional wetlands by the end of the monitoring period. Areas of unvegetated open water in excess of 10% of the maximum surface area (See 2.1.1.1 below) and other non wetland areas (e.g. large upland areas not including microtopographic features like hummocks and tussocks) shall be deducted from the maximum surface area to determine the actual area of "wetlands" at the mitigation site.[9]

2.1.2 Basin morphometry

The mitigation wetland shall have side slopes of 15:1 (horizontal:vertical) or shallower (e.g. 20:1) for the first 15 meters measured perpendicular from the upland edge for 50% or more of perimeter. In no event may any 5 meter segment of the first 15 meters have a side slope steeper than 15:1.

2.1.3 Perimeter:Area ratio

The perimeter length of the mitigation wetland shall be greater than or equal to 75% of the perimeter length of the impacted wetland(s). This shall be determined using the following calculation:

$$\text{Perimeter}_{impact} * 0.75 \; \# \; \text{Perimeter}_{mitigation}$$

where, Perimeter $_{impact}$ = the perimeter length of the impacted wetland(s), P $_{mitigation}$ = the perimeter length of the mitigation wetland(s).

2.1.4 Characteristic hydrologic regime

A hydrologic regime equivalent to the regime of a natural wetland of that hydrogeomorphic (HGM) class (Table 1A) shall be established as determined by comparing the characteristics of the hydrologic regime at the mitigation wetland to the values and hydrographs in Table 2 and Figures 2 to 7.

[9] These non-wetland areas can be included in whole or part if the permit, certification, or approved mitigation plan specifically allows their inclusion.

2.2 Ecological standards - Vegetation

2.2.1 Unvegetated open water

The mitigation wetland shall have less than 10% of its total area as "unvegetated open water" as determined by quantitative vegetation data collected at the site and an overall visual assessment of the entire mitigation area. "Unvegetated open water" is defined as inundated areas where there is no or minimal native rooted aquatic bed (e.g. *Nuphar advena, Nymphaea odorata, Brasenia schreberi, Potamogeton* spp.) or native submersed or floating non-rooted aquatic bed vegetation (e.g. *Utricularia* spp., *Elodea* spp., *Ceratophyllum* spp. and the aquatic liverworts *Riccia fluitans* and *Ricciocarpos natans* excluding species in the Lemnaceae other than *Spirodela polyrhiza* and *Lemna trisulca*) growing in the area of inundation, but does not include inundated areas where there is a closed canopy of trees or shrubs over the area of inundation.

2.2.2 Native wetland species establishment

The mitigation wetland shall have greater than 75% of its total area vegetated with native, perennial hydrophytes (FAC, FACW, OBL).

2.2.3 Invasive species

The mitigation wetland shall have less than 5% of its total area vegetated with invasive species (nonnative species and the invasive native species *Phalaris arundinacea* and *Phragmites australis*).

2.2.4 Ecological condition

2.2.4.1 Vegetation IBI score

The mitigation wetland shall achieve the minimum Vegetation IBI score for that type of wetland (HGM class, Plant Community, Ecoregion) (Table 3). This score shall be achieved by the end of the monitoring period unless the monitoring data demonstrates that the wetland is on a clear trajectory to achieve the appropriate score within 2 years of end of the monitoring period (Table 4 and Figures 8 to 15). If data necessary to calculate the Vegetation IBI is only collected, or is only required to be collected, at the end of the monitoring period, the score shall be achieved by end of the monitoring period.

2.2.4.2 Intermediate community goals

Where the mitigation requires the development of wetland forest communities, the Vegetation IBI score for an intermediate community type, e.g. a shrub swamp, may be approved as the performance goal. In this situation, the VIBI for the intermediate community (e.g. VIBI-SHRUB) and the final community (VIBI-FOREST) should both be calculated, but the minimum score from the VIBI of the intermediate community will be used to determine achievement of the minimum VIBI score as an intermediate successional step to wetland forest.

2.2.5 Establishment of woody vegetation

2.2.5.1 Shrub swamp

Woody vegetation in the types and amounts equivalent to natural shrub swamps shall be established by the end of the monitoring period, unless the monitoring data demonstrates that the wetland is on a clear trajectory to develop woody vegetation in the types and amounts equivalent to natural shrub swamps within 2 years of end of the monitoring period. This demonstration shall evaluate characteristics of the woody species in the mitigation wetland (stem counts, basal area, importance values, etc.) over time and include, at a minimum, simple predictive models (e.g. linear regression) demonstrating the wetland has become a shrub swamp (or will within 2 years of the end of the monitoring period) and if current trends continue will continue to develop mature shrub swamp characteristics (see Figures 16 to 23).

2.2.5.2 Swamp forest

Woody vegetation in the types and amounts equivalent to natural wetland forests shall be established by the end of the monitoring period, or the woody stem data collected over the monitoring period shall demonstrate that if current successional trends continue a wetland forest community will become fully developed. This demonstration shall evaluate characteristics of the woody species in the mitigation wetland (stem counts, basal area, importance values, etc.) over time and include, at a minimum, simple predictive models (e.g. linear regression) demonstrating the wetland is on an ecological trajectory towards becoming a wetland forest (see Figures 16 to 23).

2.3 Characteristic amphibian community

The mitigation wetlands shall have an Amphibian IBI score of 20 - 39 (Category 2) or 40 - 50 (Category 3) calculated in accordance with the methods outlined in *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 7: Amphibian Index of Biotic Integrity (AmphIBI) for Ohio Wetlands,* Ohio EPA Technical Report WET/2004-7. The mitigation wetland shall achieve the Amphibian IBI score by the end of the monitoring period or the monitoring data submitted by the applicant shall demonstrate that the wetland is on a clear trajectory to achieve the appropriate score within 2 years of end of the monitoring period. At a minimum, trajectory is determined by fitting a regression line to the Amphibian IBI scores calculated during the monitoring period and comparing the slope of that line to Figure 24. If data necessary to calculate the Amphibian IBI is only collected, or is only required to be collected, at the end of the monitoring period, the score shall be achieved by end of the monitoring period.

2.4 Ecologic standards - Other taxa groups

Performance standards using other taxa groups, e.g. breeding bird use or macroinvertebrate communities, may be developed and used on a case by case basis depending on the particular goals of a mitigation project.

2.5 Characteristic soil chemistry processes

Median values of the soil chemistry parameters listed in the Table 5 shall be substantially achieved at the time construction is completed by sampling *in situ* soils or soils that are placed during construction. Alternatively, median values of the soil chemistry parameters listed in the Table 5 shall be achieved by the end of the monitoring period or the monitoring data submitted by the applicant shall demonstrate that the wetland is an a clear trajectory to achieve those values within 2 years of end of the monitoring period.

2.6 Ecological services (functions and values)

If the mitigation involves the restoration, creation, or enhancement of specific wetland ecological services (functions or values), e.g. the creation of endangered species habitat, increasing flood storage in a watershed, creating migratory waterfowl habitat, etc., performance and success shall be quantitatively measured using methods appropriate to evaluating whether the specific function or value was created and to what extent.

3.0 MONITORING EVENTS AND MONITORING PERIOD

It has become hardened into tradition in most wetland programs at the state and federal level that the standard monitoring period is 5 years with annual monitoring events. Ohio's Wetland Water Quality Standards Rules presently state, "...The director shall require the applicant to conduct ecological monitoring of the compensatory mitigation project and submit annual reports detailing the results of the ecological monitoring for a period of *at least five years* following construction of the compensatory mitigation..." (emphasis added) (Ohio Administrative Code Rule 3745-1-54(E)(1)(e)). While there may be some types of mitigations where 5 years is a sufficient period, the scientific consensus is shifting towards longer (5-10+) years necessary to determining the ecological trajectory of a restoration (D'Vanzo 1990, Confer and Niering 1992, Mitsch and Wilson 1996, NRC 2001, Petranka et al. 2003).

The actual monitoring period should be determined on a case-by-case for every permit application, but the preferred period is10 years. The 10 year period should be used for all mitigation banks and for forest mitigations. Mitigations where the goal community is marsh or shrub swamp may still be able to justify a 5 year period, although if the data does not demonstrate achievement of the performance goals at the end of the period, the site will not be released from monitoring and monitoring period will be extended. The director may reduce or increase the monitoring period "...based on the effectiveness of the compensatory mitigation project" (OAC Rule 3745-1-54(E)(1)(e)).

The basic approach is to perform quantitative monitoring on a biennial basis with other activities scheduled during off years. If a 5 year monitoring period is used the main monitoring events would occur in years 1, 3 and 5 (Table 6a); for a ten year monitoring period, the main monitoring events would occur in years 1, 3, 5, 7, and 9 (Table 6b). Although there is considerable flexibility in the actual timing of sampling activities in any given monitoring year, Table 7 summarizes a conceptual schedule of activities for a typical monitoring event year.

4.0 STANDARDIZED MONITORING PROTOCOLS TO DETERMINE CONFORMANCE WITH PERFORMANCE STANDARDS

The following sections outline standardized and recommended sampling procedures for various taxa (plants, birds, amphibians, macroinvertebrates), chemistry (soil, water), hydrology, and physical characteristics of the mitigation wetland (soil, microtopography, woody debris, etc.). The purpose of data collection using these standardized methods is to collect data sufficient to determine conformance with the performance standards mitigation specified in Section 2.0. Table 8 summarizes performance standard, monitoring protocol, and data analysis procedures for monitoring data. Note how each standard (Section 2.0) lines up with a monitoring protocol (Section 4.0), and a data analysis procedure (Section 6.0).

4.1 Monitoring for general standards

4.1.1 Actual Acreage

Procedures outlined in the 1987 Corps of Engineers Delineation Manual (or successor documents) for delineating natural wetlands should be used to delineate the mitigation wetland boundaries. The boundary should be mapped using geographic positioning system (GPS) instruments. The delineated boundary is the maximum wetland acreage at the mitigation site. Acreage is reported in hectares with acres in parenthesis.

In addition to determining the outer boundary of the mitigation wetland (maximum acreage), the amount of acreage within the boundary that is "wetland" shall be estimated. Areas of unvegetated open water in excess of 10% of the wetland area (Section 4.2.1 below) and other non-wetland areas shall be deducted from the maximum surface area to determine the actual area of "wetland" at the mitigation site as follows: 1) upland areas (not including microtopographic features like hummocks and tussocks) shall be mapped with a geographic positioning system (GPS) instrument and the acreage deducted from the maximum surface area; 2) areas of unvegetated open water shall be estimated using the procedures in Section 4.2.1 and any acreage >10% of the maximum surface area (after upland areas have been deducted) shall be deducted from the maximum surface area. Upland areas and unvegetated open water in excess of 10% can be included if specifically approved in the permit, certification, or approved mitigation plan.

4.1.2 Basin morphometry

The performance standard specifies that the mitigation wetland shall have side slopes of 15:1 (horizontal:vertical) or shallower (e.g. 20:1) for the first 15 meters measured perpendicular from the upland edge for more than 50% or more of perimeter, and in no event may any 5 meter segment of the first 15 meters have a side slope steeper than 15:1. Data to determine conformance with this performance standard may come from several sources. The minimum approach is measure at least 10 transects spaced evenly around the wetland perimeter (Figure 25). Each transect is 15 m long and perpendicular to the wetland edge. One end of a 15m line is staked at the ground surface at the upland edge. The other end is attached to a meter stick A line-level is attached to the line. The line is leveled at 5m, 10m, and 15m. If the height of the line on the meter stick is < 0.33m at 5m, < 0.67m at 10m, and <1m at 15m, the side slope is determined to be less than 15:1 (Figure 26). The number of transects with side slopes less than 15:1 is counted and divided by ten to determine whether at least 50% of the perimeter has side slopes of 15:1 or shallower. Alternative approaches include surveying the basin morphometry of wetland

4.1.3 Perimeter:Area ratio

The preferred monitoring data for this performance standard are maps of the impacted and mitigation wetland perimeters obtained from geographic positioning system instruments or other surveying methods showing the following: area of the impacted wetland(s), perimeter length of the impacted wetland(s), area of the mitigation wetland(s), perimeter length of the mitigation wetland(s). The perimeter:area ratio between impacted and mitigation wetland(s) is determined by the following equation:

$$\text{Perimeter}_{\textit{impact}} * 0.75 < \text{Perimeter}_{\textit{mitigation}}$$

where, Perimeter $_{impact}$ = the perimeter length of the impacted wetland (s), Perimeter $_{mitigation}$ = the perimeter length of the mitigation wetland(s). For example, three 1 acre wetlands were impacted with a combined perimeter length of 2405 feet (Figure 27). If a single mitigation wetland of 3 acres and a perimeter length of 1446 feet is constructed the perimeter ratio will be 58% and the performance standard is not met. In contrast, if a 1 acre and a 2 acre mitigation are constructed, the combined perimeter lengths of the mitigation wetlands are 80% of the impacted wetlands and the performance standard is met (Figure 27).

4.1.4 Hydrologic regime

The performance standard is to create or restore a hydrologic regime equivalent to the regime of a natural wetland of that hydrogeomorphic (HGM) class (Table 1A). Hydrologic regime refers to amount, duration, and source of water in the wetland. Determining conformance with the performance goal is determined by 1) Selecting a hydrogeomorphic class for the mitigation wetland and substantially creating or restoring the hydrologic regime for that class, i.e. the mitigation has a similar amount (areal extent and depth of inundation or saturation), duration of inundation or saturation, and source of water (precipitation, ground water, seasonal flooding, perennial connection to lake or stream, etc.) 2) collection of quantitative data to document the mitigation actually has the appropriate amount and duration of inundation or saturation. At a minimum, hydrologic data should be collected for the first 1-2 years post-construction based on the assumption that the site should hydrologically stabilize during that period. Monitoring should be resumed if significant alterations or changes are made to site such that earlier data and hydrographs are not reflective of current conditions.

Many individual mitigations are relatively small and consist of a single "basin", i.e. one overall topographic depression although there may be several discrete subareas of deeper inundation. The minimum approach is to install at least one staff gauge an area where there is persistent standing water and to record staff gauge levels *weekly* during the growing season (April through October).

In lieu of the time intensive approach of taking weekly manual staff gauge readings, it is strongly recommended that at least one automated shallow ground water level recorders be installed at the edge of the site[10] programmed to take twice daily readings. If automated readings are taken, staff gauges need only be read when the data logger is downloaded. The data from the water level recorders can be used to generate annual hydrographs (Figures 2 to 7) and calculate the statistics in Table 2.

Where the goal hydrologic regime of the mitigation site is seasonally to permanently saturated (to at most very shallowly inundated for short periods in the spring), monitoring surface inundation with staff gauges is inappropriate. Automated ground water level recorders, or a manually monitored network of shallow piezometers or soil tensiometers are the only way to determine the hydroperiod and depth to saturated soils.

Minimum hydrologic monitoring requirements are summarized in Table 9.

4.2 Monitoring for ecological standards - Vegetation

4.2.1 Unvegetated open water

Data for determining % unvegetated open water is collected as part of the vegetation survey (Section 4.2.6 below).

4.2.2 Native perennial hydrophytes

Data for determining % cover of native perennial hydrophytes is collected as part of the vegetation survey (Section 4.2.6 below).

4.2.3 Invasive species

Data for determining % cover invasive species (nonnative species and the invasive native species *Phalaris arundinacea* and *Phragmites australis*) is collected as part of the vegetation survey (Section 4.2.6 below).

4.2.4 Vegetation IBI

Data needed to calculate the Vegetation IBI score is collected as part of the vegetation survey (Section 4.2.6 below). Data reduction and calculation procedures are summarized in *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 9: Field Manual for the Vegetation Index of Biotic Integrity for Wetlands v. 1.3* (Mack 2004c).

4.2.5 Woody species establishment

Data needed to calculate the woody species establishments is collected as part of the vegetation survey (Section 4.2.5 below). Data reduction and calculation procedures are summarized in *INTEGRATED WETLAND*

[10] Ohio EPA has had good success using Remote Data Systems, Inc. (Whiteville, NC) water level recorders, although this is not an endorsement of their products and there are other equipment options available.

ASSESSMENT PROGRAM. Part 9: Field Manual for the Vegetation Index of Biotic Integrity for Wetlands v. 1.3 (Mack 2004c).

4.2.6.1 Basic Vegetation Survey Design for Single, Small, Relatively Homogenous Wetlands

The purpose of the basic vegetation survey design is to collect data sufficient to determine conformance with several performance standards including the Vegetation IBI, % cover of native perennial hydrophytes, % cover of invasive species, etc. This is the minimum design that should be used to monitor every mitigation wetland or every subarea of a mitigation wetland. While numerous vegetation sampling procedures exist (See e.g. Mueller-Dombois and Ellenberg 1974), it is recommended that for maximum comparability, that vegetation sampling and data reduction be performed in accordance with *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 9: Field Manual for the Vegetation Index of Biotic Integrity for Wetlands v. 1.3* or successor documents. If other methods are used, they should assure that the data specified in Table 10 is collected and that cover estimated is at the $100m^2$ level. Sampling of woody vegetation should ensure a minimum sampling area of $1000m^2$. The location and number of plots or transects will depend on the size of the mitigation wetland and the number of distinct plant communities.

The basic elements of the *Field Manual for the Vegetation Index of Biotic Integrity for Wetlands* (Mack 2004c) are summarized here. This method is a modification of the "Whitaker" plot (Schmida 1984). It is appropriate for most types of vegetation, flexible in intensity and time commitment, compatible with data from other methods, and provides information on species composition across spatial scales (Peet et al.1998). It also addresses the problem that processes affecting vegetation composition differ as spatial scales increase or decrease and that vegetation typically exhibits strong autocorrelation (Peet et al.1998). The basic sampling unit is a 10m x 10m "module." The most typical application of the method employs a set of 10 modules in a 20m x 50m layout (Figure 30) (standard plot, fixed plot). Within the site to be surveyed, these 20m x 50m grids are located such that the long axis of the plot is oriented to minimize the environmental heterogeneity within the plot. Once the plot is laid out, all species within the plot are identified, an aggregate wood stem count is made, and cover is estimated. In addition, four 10m x 10m modules are intensively sampled in a series of nested quadrats.

Detailed plot location rules are specified in *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 9: Field Manual for the Vegetation Index of Biotic Integrity for Wetlands v. 1.3*, but the basic rule is to locate plots in areas that are most representative of the site being sampled. The estimates, scores, and measurements obtained from the data collected in a properly positioned plot should be (and are assumed to be) representative of the mitigation wetland as a whole. Typical plot location situations are summarized in Figures 31 to 38. More specific plot location rules can be found in Mack (2004c).

4.2.6.2 Random Vegetation Survey Design for Mitigation Banks and Larger Individual Mitigations

In addition to the basic vegetation survey design (Section 4.2.6.1), the random survey design is required for mitigation banks and larger individual mitigation sites because of the need for more accurate estimates of percent wetland, upland, unvegetated open water, native perennial hydrophyte cover, etc., and as a check on results of fixed plots. Basically, the random vegetation survey design takes a standard plot comprised of ten 10m x 10m modules and randomly locates the modules across area sampled. A geospatially referenced 10m x10m grid is created on a map of each site (Figure 39). Depending on the information available, existing maps can be geospatially referenced in ArcView™, the perimeters of the site or subareas of the site can mapped using geographic positioning system instruments and a grid created, or existing digital map files (CAD, shape, etc.) previously developed can be used to create the 10m x10m grid.

Each grid score is sequentially numbered and associated with the latitude and longitude at the center of the square, and a simple random sample is selected of at least twice the number of points needed. A map showing the selected points is produced (Figure 40). At each selected point, a 10m x10m plot is established with the plot centered on the point. The same data is collected in the plot as in the intensive module of a standard plot (Section 4.2.6.1). An efficient route from point to point should be developed to minimize crossing and re-crossing the area being sampled Additional information on this sampling protocol is found in Mack (2004c).

4.3 Monitoring for ecological standards - Amphibians

Monitoring for amphibians is performed using activity (funnel) traps in accordance with Micacchion (2004). Funnel traps can be used to sample both macroinvertebrate (Section 4.4.2) and amphibian communities. Funnel traps are constructed of aluminum window screen cylinders with fiberglass window screen funnels at each end. Funnel traps are similar in shape to commercially available minnow traps but with a smaller mesh-size. The aluminum screen cylinders are 45.7 cm (18 in) long and 20.3 cm (8 in) in diameter and are held together with wire staples. The base of the fiberglass screen funnels are 22.8 (9 in) diameter and are attached with wire staples to both ends of the cylinder such that the funnel directs inward. The funnels have a circular opening in the middle that is 4.5 cm (1.75 in) in diameter (Figure 41).

Each wetland is sampled three times between March and early July spaced approximately six weeks apart. Actual sampling dates depend on weather conditions for that year and geographic area of the state. Ten funnel traps are placed evenly around the perimeter of the wetland and the location is marked with flagging tape and numbered sequentially. Traps are set at the same location throughout the sample period (Figure 42). The late winter/early spring (March-early April) sample allows monitoring of adult ambystomatid salamanders, early breeding frog species and macroinvertebrates such as fairy shrimp, caddis fly larvae, some microcrustaceans and other early season taxa which are often present for a limited time. A middle spring sample (late April-mid May) is conducted in order to collect some adult frog species entering the wetland to breed, to sample early-breeding amphibian larvae and to sample for macroinvertebrates. A late spring/early summer (early June-early July) sampling is performed to collect relatively well developed amphibian larvae and macroinvertebrates.

Traps are unbaited and left overnight in the wetland for twenty-four hours in order to ensure unbiased sampling for species with diurnal and nocturnal activity patterns. Upon retrieval, the traps are emptied by everting the funnel and shaking the contents into a white collection and sorting pan. Organisms that can be readily identified in the field (especially adult amphibians and larger and easily identified fish) are counted and released. The remaining organisms are transferred to wide-mouth one liter plastic bottles and preserved with 95% ethanol. Laboratory analysis of the funnel trap macroinvertebrate and fish samples should follow standardized Ohio EPA procedures (Ohio EPA 1989).

4.4 Monitoring for other taxa groups

4.4.1 Wetland Bird Sampling

Methods used by Porej (2004) for extensive studies of mitigation wetlands in Ohio are recommended as protocols for performing quantitative surveys of wetland birds. Sites should be surveyed three times during the spring breeding period (May 1 to June 30) although actual dates may vary depending on the region of the state and weather patterns for that year. Where multiple sites are being monitored in the same year, the date and time of site visits should be randomized within each survey period. Point-count (Ralph et al. 1993, 1995) and call-response (playback) methods (Gibbs and Melvin 1997; Ribie et al. 1999) are recommended to survey birds. Surveys should be conducted from sunrise to 10:00AM at an array of 5 points established at each site prior to the first survey. The same survey points should be used throughout the monitoring period. Survey points should be placed in the emergent zone or at the wetland's edge when emergent vegetation is absent. A 50m radius circle (7853 m^2 or 1.94 acres) is surveyed around each point unless the survey point is located near the edge of the wetland.

All birds heard or seen within a 7-minute counting period at each survey point are recorded. During the middle 3-minutes, a tape player should be used to play back vocalizations of least bittern (*Ixobrychus exilis* Gmelin), Virginia rail (*Rallus limicola* Vieillot), sora (*Porzana carolina* L.), common moorhen (*Gallinula chloropus* L.), American bittern (*Botaurus lentginosus* Rackett), and pied-billed grebe (*Podiceps nigricollis* L.). Birds are counted if the flight of a bird originates or terminates within the plot boundary, including birds flushed as the survey point is approached. For active species like swallows, only the highest number observed at any point along the survey route is recorded.

Active nests, young, or proportions of records of at least one adult are used to determine breeding status. One adult must be present during at least two visits to be counted as a breeding species (Brown and Dinsmore 1986; Inman et al. 2002). Species nesting in colonies (e.g. herons, swallows) are also classified as "non-nesters" unless actual nesting colonies are observed at the site. Bird densities should be calculated as the average number of individuals recorded per site visit for each year, except for mallards, wood ducks and Canada geese. For mallards and wood ducks, the number of breeding pairs is used to estimate density (Dzubin 1969), and for Canada geese, the number of nests per site per year is used to estimate density. Individual counts are then averaged across five survey points for each study site for every bird species.

4.4.2 Macroinvertebrates

Sampling for macroinvertebrates can use the procedures outlined above for amphibians (Section 4.3) as discussed in the Wetland Invertebrate Community Index (WICI) (Knapp 2004). Depending on the goals, other sampling methods, e.g. light traps, sediment sampling, dip nets, etc.) may also be usable.

4.5 Characteristic biogeochemistry

4.5.1 Soil sampling

When using the basic vegetation survey design (Section 4.2.6.1), 5 soil samples (~ 250-500g) should be collected at each wetland using soil probe in a "Y- shaped" pattern in order to obtain a representative sample of the wetland soils (Figure 43). An additional soil sample should be collected from the center of each vegetation plot (for a total of six samples for the basic vegetation survey design in Section 4.2.6.1). When the random survey design (Section 4.2.6.2) is used, a soil sample should be collected from the center of each random and fixed plot in lieu of the Y-pattern (Figure 43). Samples are taken to a depth of approximately 10 cm from the soil surface layer. The specific location of each sample will depend on the wetland morphology and size. Soil samples should be placed into clean plastic bags, labeled with site name and date and packed in ice. Sample preparation should follow NCR-13 (NCR 1998). Samples should be analyzed for the pH, Bray[11] extractable phosphorus, exchangeable ions (calcium, magnesium, potassium), and cation exchange capacity using standard agronomic soil testing methods (NCR 1998) and also for total organic carbon (TOC), total nitrogen, and total solids (Table 11). Analysis for metals or organic compounds should be added on a case by case basis if they are a concern at the mitigation site.

4.5.2 Water sampling

A grab sample of surface water should be collected at every site for comparison to median values from natural wetlands. Samples should be preserved in the field and held at 4 °C until analysis for the following parameters: pH, ammonia-N, total Kjeldhal N, Nitrate-Nitrite-N, total phosphorus, total organic carbon, total suspended solids, totals solids, chloride, iron, magnesium, and potassium. Analysis for metals or organic compounds should be added on a case by case basis if they are a concern at the mitigation site.

4.6 Monitoring for Ecological Services or Specific Functions

In some instances a goal of wetland mitigation will be creation or restoration of a specific ecological service (function or value). For example, wetland mitigation may be undertaken to create or restore habitat for a specific endangered or threatened species. Or a goal of mitigation may be to replace a particular amount of flood storage capacity in a watershed. In this situation, specific monitoring (and performance goals) will be needed to determine whether the wetland is actually used by the endangered or threatened species, or to determine whether flood storage capacity was actually replaced. Adequate monitoring (and performance) will need to be developed on a case by case based on the literature and technical references available.

5.0 GENERAL DATA SUMMARY, ANALYSIS AND PRESENTATION

5.1 Introduction

Fundamental to evaluating the success (or failure) of a mitigation wetland is a clear presentation and analysis of the data collected over the monitoring period. Many monitoring reports submitted in the past were simple collations of raw data collected for that year with no summary statistics, or year by year trend analyses. It is even less common to see the simplest of graphs (e.g. parameter versus year) and statistical evaluations (e.g. simple linear regressions). General data summary and analysis procedures are presented in this section. Specific procedures for each performance standard are presented in Section 6.0.

5.2 General Data Analysis and Presentation

5.2.1 Descriptive and Graphical Methods

Standard exploratory data analysis methods should be used to analyze and present all data collected including standard descriptive statistics (mean, median, quartiles, minimum/maximum values, etc.) and graphical evaluation techniques such as histograms, boxplots, and scatterplots to identify outliers,

[11] The standard Bray extraction (P1 or weak Bray) is with dilute acid; the strong Bray extraction (P2) has 4 times the acid concentration of the weak Bray. In agronomic situations, the difference between strong and weak Bray is often considered to be the active reserve of P which becomes available as soils warm up in the spring which can increase bacterial activity and root growth.

trends in the data, skewness, curvilinear relationships, linear relationships, etc.

5.2.2 Control charts, performance curves and regression analysis

Given the collection of monitoring data over time, a basic approach taken here is the use of control charts and performance curves. This approach is ubiquitous in industrial settings where quality control is critical and has been recommended for addressing ecological performance of wetland mitigation since at least 1992 (Kentula et al. 1992). Performance curves for mitigation monitoring data are constructed by plotting monitoring data versus time. This allows trends over time to be easily observed and also allows the fitting of regression lines to the data. Figure 44 provides several examples of performance curves and how they can be used to evaluate monitoring data. Site A (Figure 44A) quickly improves such that a regression line fitted to three years of monitoring data in year 5 indicates that the site will achieve the performance standard before year 6 of monitoring. Additional data collected at Site A in years 7 and 9 shows the curve flattening out although Site A still achieves the performance standard by year 10. Site B (Figure 44B) has a more gradual increase in performance over the course of the monitoring period with regression lines at 5 and 9 years showing the same trend. Both Sites A and B would be released from monitoring because the performance goal was actually achieved. Site C (Figure 44C) has a similar gradual increase as Site B but at year 10 has not attained the performance standard; however, the regression line indicates the site will attain the goal within 2 years of the end of the monitoring period and Site C could also request to be released from monitoring (the site actually reaches the goal around year 13). Finally, Site D (Figure 44D) does not attain the performance goal by year 10 and the regression line indicates the site will not attain the performance goal by year 12, and in fact actual performance plateaus after year 10. The monitoring period for Site D should be extended and corrective action undertaken.

Generalized performance curves for VIBI and AmphIBI scores and for woody stem recruitment are provided in Figures 8 through 24. Table 3 summarizes the minimum slopes of regression lines needed to attain Wetland Habitat (WLH) (Category 2) quality. Performance curves from monitoring data like that shown in Figure 44 can be compared to the slopes in Table 4 and the general curves in Figures 8 through 24. Refer to Section 6.0 for a more detailed discussion of the use of this information.

5.2.3 Summary tables

Summary tables which include all data collected over the monitoring period should be used liberally. Raw data used to calculate indices or average values should be included in the Appendices. For example, a summary table could be used at a single site mitigation to summarize VIBI scores and metrics, soil chemistry data, and other physical parameter data over time (Table 12). Summary tables like this, which clearly and concisely present data from key performance parameters, are critical in aiding in the review of mitigation monitoring reports by staff from regulatory agencies.

Where multiple mitigation sites are included in the same report or multiple plots were used at a single site, data can be summarized in an expanded table to show data from multiple sites (Table 13). In addition to tabular presentation of data, performance curves of biological and chemical data used in determining performance (e.g. IBI scores, stem densities, soil organic carbon) should be presented to observe trends over time. Regression lines should be fitted to this data and p-values, R^2 values, F statistics, degrees of freedom, and regression equations reported e.g. (df = 4, F = 5.23, R^2 = 58.%, p =

0.076) and y = 0.64 + 1.2x.

5.2.3 Analysis of Variance

Analysis of variance (ANOVA) is a commonly employed statistical technique that determines whether means of two or more sampling distributions are significantly different from the expected value using an F-distribution. Tukey's multiple comparison test is a typical test used after obtaining a significant result from an ANOVA test to determine which means are significantly different from each other. If certain data sets depart seriously from the assumption of normality, nonparametric equivalents to the ANOVA and Tukey's multiple comparison test are available, e.g. Kruskal-Wallis Distribution-free Test for General Alternatives and the Critchlow-Fligner Multiple Comparison Test.

5.2.4 Multivariate methods

With the advent of powerful desktop computers, multivariate statistical methods have become readily available to ecologists and are widely used to detect similarities between floral and faunal communities as well as relating environmental measures to species assemblages. These methods do not divide communities or samples into discrete classes but rather array species assemblages and other variables along multiple axes. The distribution of points in this multi-dimensional statistical space reflects the degree of similarity. Commonly used multivariate techniques include Detrended Correspondence Analysis (DCA) and Principal Components Analysis (PCA) (Gauch 1982). For example, species presence and abundance data for each year of the monitoring period can be ordinated as if each year was a separate "site" to observe changes in species assemblages over time, e.g. shifts from assemblages dominated by annuals and tolerant plant species to assemblages dominated by perennials and more sensitive species. Where random plot data is collected (Section 4.2.6.2), presence and abundance and/or soil chemistry data can be ordinated to observe whether different plant communities are occurring at the site or to provide possible explanations (e.g. differences in soil chemistry) for differences between plots. Joint plots of environmental data can be included in ordinations of species presence and abundance (Figure 45). Other ordination techniques (constrained ordinations) like Canonical Correspondence Analysis (CCA) can simultaneous ordinate species presence and abundance data and look for significant multiple correlations with environmental parameters (ter Braak 1987).

6.0 ANALYSIS AND PRESENTATION OF MONITORING DATA TO DETERMINE PERFORMANCE

6.1 General Standards

6.1.1 Acreage

The performance standard for acreage (reported in hectares and acres) is to achieve a mitigation wetland that has the minimum area specified in the certification or permit as determined by the appropriate mitigation ratios (OAC Rule 3745-1-54). The primary monitoring requirement is to delineate the boundary using procedures outlined in the 1987 Corps of Engineers Delineation Manual (or successor documents) and to produce a map of the delineated boundary using geographic positioning system (GPS) instruments. A paper map should be created and included in the monitoring report. In addition, digital source files for the map should be submitted with the report (Arcview™ shape files with meta-data are the preferred format). The outer boundary of the mitigation wetland is the maximum surface area of the site. Areas of unvegetated open water in excess of 10% of the wetland area (Section 4.2.1) and other non-wetland areas should be deducted from the maximum surface area to determine the actual area of "wetland" at the mitigation site unless the permit, certification, or approved mitigation plan specifically allows their inclusion. Large upland areas (not including microtopographic features like hummocks and tussocks) should be mapped with a geographic positioning system (GPS) instrument and the acreage deducted from the maximum surface area.[12] Areas of unvegetated open water are estimated using the procedures in Section 4.2.1. Alternatively, where random plot data is collected (Section 4.2.6.2), estimates of %wetland, %upland, and %unvegetated open water for areas within the delineated boundary can be used to determine the actual wetland acreage of the mitigation wetland. Acreage data can be summarized in a table like Table 14 along with basin morphometry and perimeter:area ratio data.

6.1.2 Basin Morphometry

The performance standard requires that the mitigation wetland have side slopes of 15:1 (horizontal:vertical) or shallower (e.g. 20:1) for more than 50% or more of perimeter. The minimum approach is to measure at least 10 transects (15m) spaced evenly around the wetland perimeter (Figure 25) perpendicular to the wetland edge. The number of transects with side slopes less than 15:1 is counted and divided by 10 to determine whether at least 50% of the perimeter has side slopes of 15:1 or shallower. Data from the transects can be summarized in a table like Table 14 along with acreage and perimeter:area ratio data. If the basin morphometry is determined by surveying or other methods, appropriate plan views and cross sections should be submitted.

6.1.3 Perimeter:Area Ratio

Determining conformance with this performance goal will require that the perimeter lengths for each impacted wetland(s) and each mitigation wetland(s) be measured.[13] The perimeter length of the impacted wetland is multiplied by 0.75. The perimeter length of the mitigation wetland is then divided by the adjusted impacted wetland perimeter ($P_{impacted}$ * 0.75) to obtain the ratio of perimeter lengths for mitigation:impacted. If the ratio is > than 0.75 the, performance goal is met (Figure 27). Perimeter:area ratio data can be summarized with basin morphometry and perimeter:area ratio data in a table similar to Table 14.

6.1.4 Hydrologic Regime

The performance standard is to create or restore a wetland with a hydrologic regime equivalent to the hydrologic of a natural wetland of the same hydrogeomorphic (HGM) class (Table 1A). Determining conformance with this performance standard is a two step process.

6.1.4.1 Determining HGM class

The first step is to compare the hydrogeomorphic class of the mitigation wetland(s) to the hydrogeomorphic (HGM) class of the impacted wetland(s); or, if an alternative class different from the impacted wetland(s) was

[12] There may be instances where large areas of upland are not easily mapped without a significant expenditure of resources, e.g. where areas of wet meadow are interspersed with areas of upland grassland or old field, or in large forest complexes of wet woods and upland forest. In this situation, random plot data may provide the best estimate.

[13] The preferred monitoring data for this performance standard is a map of the impacted and mitigation wetland perimeters obtained from geographic positioning system instruments or other surveying methods showing the area of the impacted wetland, perimeter length of the impact wetland, area of the mitigation wetland, and perimeter length of the mitigation wetland. Perimeter length could be measured manually using a hip chain, but delineation of the mitigation wetland boundary using GPS instruments will provide accurate perimeter lengths in addition to area.

approved, compare the hydrogeomorphic class of the mitigation wetland(s) to the alternative approved class. The HGM classes are summarized in Table 1A; additional narrative descriptions are provided in Table 15. To complete the comparison, the HGM class for each impacted wetland and each mitigation wetland is listed in Table 16 (rows f, g, and h). It is common for many mitigation designs to use some form of berm or dike to impound water to greater or lesser degree. Mitigation wetlands with low berms (~ 1m or less) in depressional or riverine landscape positions *without* managed water control structures are equivalent to "depressions" or "riverine" HGM classes even though technically they could be considered "impoundments." Mitigation wetlands with higher berms or dikes, or berms and dikes with managed water control structures, are human impoundments (Table 1A, 15). Mitigation wetlands with berms or dikes, with or without water control structures, in riverine positions which hydrologically separate the mitigation wetland from natural fluctuations (e.g. seasonal floods) are "human impoundments" and are not equivalent to natural riverine mainstem, headwater, or channel wetlands.

6.1.4.2 Evaluating quantitative hydrologic data

The second step is to compare the quantitative hydrologic data collected at the mitigation wetland to average values and hydrographs in Table 2 and Figures 2 to 7. The basic approach to collecting quantitative data is to deploy automated ground water level recorders and staff gauges (Table 9), although alternative quantitative methods can be used (Section 4.1.4). This results in data similar to that listed in Table 16 (Hydrology data like that shown in Table 16 should be submitted electronically as a spreadsheet in the digital appendices to the monitoring report). The water level data is coded and the absolute value of difference between readings is calculated (Table 16). The following hydrologic indicators (Fennessy et al. 2004) should be calculated: percent time water is in the root zone (0 to -30 cm), mean ground water depth, and hydrologic flashiness. Percent time water is in the root zone (T_{root}) is calculated by summing the readings that are coded as "root zone" (Table 16) and dividing by the total number of all readings, or

$$T_{root} = N_{root} / N_{all}$$

where N_{root} = all readings where water level was > -30cm and N_{all} = all water level readings. Mean ground water depth (GW_z) is calculated by taking the average of all readings, or

$$GW_z = (\Sigma L_i) / n$$

where L_i = water level reading at interval I and n = all readings recorded. Hydrologic flashiness (H_f) is calculated by summing the absolute value of readings on day I from the preceding day's reading j, or

$$H_f = \Sigma |day_i - day_j| / n_{ij}$$

where day_i = water level reading on day I, day_j = water level reading preceding day j, and n_{ij} = number of values where day_i could be subtracted from day_j. These indicators are then compared to the values in Table 2.

Finally, an annual hydrograph should be constructed and compared to the typical hydrographs in Figures 2 to 7. The performance standard is met if based on a review of all of this information, i.e. HGM class, duration of hydrology, hydrologic indicators, hydrograph, the mitigation wetland appears to be hydrologically equivalent to the impacted wetlands unless an alternate hydrologic regime and/or HGM class is specifically approved in the certification, permit, and/or approved mitigation plan.

6.2 *Vegetation*

Vegetation data collection, reduction, and analysis methods are discussed in detail in *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 9: Field Manual for the Vegetation Index of Biotic Integrity for Wetlands v. 1.3* (Mack 2004c) and are not recapitulated here. Additional information not discussed in Mack (2004c) for how to use the vegetation data to determine conformance with the performance standards is discussed below.

6.2.1 *Unvegetated Open Water*

The performance standard specifies that the mitigation wetland shall have less than 10% of its wetland area as unvegetated open water unless a greater amount is specifically approved in the certification, permit, or approved mitigation plan. The estimates of the amount of unvegetated open water at a mitigation site are determined as follows:

1. Where only the basic vegetation survey design is used (typically a 20m x 50m sample plot with 4 intensive modules), the % unvegetated open water is recorded for each intensive module. These values are summed and divided by 4 to obtain an estimate of percent unvegetated open water. In addition, percent unvegetated open water should also be visually estimated for the entire wetland;

2. Where the random vegetation survey design is also used (Section 4.2.6.2), an estimate of the percent unvegetated open water at the mitigation site is obtained by summing the recorded values of percent unvegetated open water for each plot and dividing by the total number of random plots sampled;

3. In some situations it may be possible to map areas of unvegetated open water using geographic positioning system instruments.

To determine conformance with the performance goal (i.e. < 10% unvegetated open water), the estimates obtained above shall be used as follows:

Estimates obtained	**To determine conformance**
Fixed plot estimate + visual estimate	Use the higher of the two values
Fixed plot estimate + visual estimate + GPS map of unvegetated open water areas	Use GPS map estimate to determine conformance
Fixed plot estimate + visual estimate + random plot estimate	Use random plot estimate to determine conformance
Fixed plot estimate + visual estimate + random plot estimate + GPS map of unvegetated open water areas	User higher of random plot and GPS map estimates to determine conformance

The purpose of the visual estimate in conjunction with the estimate obtained from the sample plot is to provide a safeguard against incorrectly positioned sampled plots. For example in Figure 28, the intensive modules of a correctly positioned sample plot should focus on the open water zones of the mitigation wetland not the narrow edge dominated by emergent vegetation. In contrast, a sample plot for the mitigation wetland in Figure 29 would have the intensive modules centered in the emergent areas of the wetland.

6.2.2 *Native perennial hydrophytes*

The performance standard requires that the mitigation wetland shall have more than 75% of its total area vegetated by native, perennial hydrophytes (FAC, FACW, OBL). The estimate of the % cover of native, perennial hydrophytes is obtained as follows:

1. Where only the basic vegetation survey design is used (typically a 20m x 50m sample plot with 4 intensive modules), presence and percent cover is recorded for each species in the plot. The % cover of native, perennial hydrophytes is estimated by summing the relative cover (*See* Mack 2004c for calculating relative cover) of each perennial[14], vascular plant species that has a FAC, FACW, or OBL indicator status. If the % cover of native perennial hydrophytes is >75%, then the performance standard is met. In addition, percent cover of native perennial hydrophytes should also be visually estimated for the entire wetland;

2. Where the random vegetation survey design is also used (Section 4.2.6.2), the relative cover of each perennial native hydrophyte species is calculated for each random plot. The % cover of native, perennial hydrophytes is estimated by summing the relative cover of all hydrophytes in all random plots divided by the total number of random plots. If the % cover of perennial, native hydrophytes is >75%, then the performance standard is met.

To determine conformance with the performance goal (i.e. > 75% cover of native perennial hydrophytes), the estimates obtained above shall be used as follows:

Estimates obtained	To determine conformance
Fixed plot estimate + visual estimate	Use the lower of the two values
Fixed plot estimate + visual estimate + random plot estimate	Use random plot estimate to determine conformance

6.2.3 Invasive Species

Performance on this standard requires that invasive species[15] occupy less than 5% of the area of the mitigation wetland. The estimate of the % cover of invasive species is obtained as follows:

1. Where only the basic vegetation survey design is used (typically a 20m x 50m sample plot with 4 intensive modules), an estimate of the percent cover of invasive species is obtained by calculating and summing the relative cover of each invasive species. In addition, percent cover of invasive species should also be visually estimated for the entire wetland;

2. Where the random vegetation survey design is also used (Section 4.2.6.2 below), an estimate of the percent cover of invasive species at the mitigation site is obtained by summing the relative cover of each invasive species for all random plots and dividing by the total number of random plots sampled;

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[14] Appendix C in (Mack (2004c) lists the habit (perennial, annual, biennial, woody) of the flora of Ohio (See also Appendix A of Andreas et al. 2004). Although woody species are not strictly "perennials" in the sense that this term is used in floristic treatments, percent cover of woody species can be included in the calculation of this performance goal.

[15] An "invasive species" is any species listed as non-native in Ohio in Appendix C of Mack (2004c) (See also Appendix A of Andreas et al. 2004).

3. In some situations it may be possible to map monotypic stands of invasive species using geographic positioning system instruments.

To determine conformance with the performance goal (i.e. < 5% cover of invasive species), the estimates obtained above shall be used as follows:

Estimates obtained	To determine conformance
Fixed plot estimate + visual estimate	Use the higher of the two values
Fixed plot estimate + visual estimate + GPS map of unvegetated open water areas	Use GPS map estimate to determine conformance if mappable monotypic stands are present, otherwise use higher of visual or fixed plot estimate
Fixed plot estimate + visual estimate + random plot estimate	Use random plot estimate to determine conformance
Fixed plot estimate + visual estimate + random plot estimate + GPS map of unvegetated open water areas	User higher of random plot and GPS map estimates to determine conformance

6.2.4 Vegetation - Ecologic Standards

Detailed procedures for calculating the Vegetation IBI score can be found in *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 9: Field Manual for the Vegetation Index of Biotic Integrity for Wetlands v. 1.3* (Mack 2004c). The performance standard requires that the mitigation wetland achieve the minimum Vegetation IBI score for that type of wetland (HGM class, Plant Community, Ecoregion) as specified in Table 3. In order to properly use Table 3, the user *must* have correctly determined the HGM class, plant community, and ecoregion of the mitigation wetland since there are different scoring ranges based on ecoregion, HGM class and/or plant community type. If the mitigation wetland area includes multiple HGM classes or plant communities, such that different scoring ranges would apply to these areas, separate data should have been collected from those areas. Note that Table 3 only includes ranges for Category 2 and Category 3 wetlands since Category 2 is the minimum level of quality that needs to be achieved in accordance with Ohio wetland regulations (OAC Rule 3745-1-54). Refer to Mack (2004b, 2004c) for expanded versions of Table 3 with scoring ranges below Category 2.

The VIBI score should be achieved by the end of the monitoring period unless the monitoring data demonstrates that the wetland is on a clear trajectory to achieve the appropriate score within 2 years of end of the monitoring period. Trajectory is determined by evaluating the trend of the data over time and by fitting a regression line to the Vegetation IBI scores calculated during the monitoring period. The shape and slope of the line can then compared to the slopes in Table 4 and the performance curves in Figures 8 to 15 of the appropriate wetland type. This approach is not available if the data necessary to calculate the Vegetation IBI is only collected, or is only required to be collected, at the end of the monitoring period (i.e. there is only one VIBI data point). In this situation, the minimum VIBI score must be achieved by end of the monitoring period.

Table 4 summarizes the key HGM classes, plant community types and ecoregions for determining the appropriate VIBI score for the mitigation wetland. A linear regression equation and slope is provided which was derived by fitting a regression to two points (0, minimum VIBI score for the type). For example in Figure 9, the minimum score for Category 2 wet meadows is

60. The equation and slope in Table 4 for wet meadows was derived from the line with points (0, 60). Obviously, the performance curve in Figure 9 is somewhat stylized and actual data collected over time may not be linear.[16] However, if the minimum slope of a regression line fitted to actual data is greater than 6.6, this provides evidence that the mitigation wetland will exceed the performance goal in less than 10 years.

There are some situations where two VIBI scores should be calculated and reported. This will typically occur when the mitigation requires the development of wetland forest communities. In this situation, the Vegetation IBI score for an intermediate community type, e.g. a shrub swamp, may be approved as the performance goal. When this happens, the VIBI for the *intermediate* community (e.g.VIBI-SHRUB) and the *final* community (VIBI-FOREST) should *both* be calculated, but the minimum score from the VIBI of the intermediate community is used to determine achievement of the minimum VIBI score as an intermediate successional step to wetland forest.

6.2.5 Woody spp. Establishment

A difficult issue in the mitigation for woody dominated communities, especially wetland forests, is the potential time lag between initial planting and full community development. Given the long term nature of forest succession (multi-decadal to centuries), it is understood that high quality forest will not be fully developed by the end of any reasonable monitoring period. Because of this the performance standards for wetland forest restoration require a demonstration that forest succession is occurring and increasing over the monitoring period by the collection of standard forest community data (frequency, density, basal area, importance values.

Given the fast-growing nature of shrub species and the ability to aggressively plant a mitigation site with wetland shrubs, establishment of wetland shrub communities (e.g. buttonbush swamps, alder swamps) can occur within the monitoring period (i.e. 5-10 years), although it is recognized natural shrub communities do have an important tree and forest component that will develop over time (e.g. Figure 17).[17]

For mitigation of wetland forest communities, the performance standard requires a demonstration that if current successional trends continue a forest community will develop based on an evaluation of standard forest community measures (stem counts, basal area, importance values, etc.) and simple predictive models (e.g. linear regression). Hypothetical performance curves for tree and shrub establishment were developed using shrub and forest community stand characteristics of reference wetlands as the "end points" of the curves (Figures 16 to 23).[18] Stand characteristics of natural wetlands are summarized in Table 17. The performance curves

[16] Obviously, quadratic or cubic regression equations can be fitted to curvilinear data and the results from the fitted regression line used to interpret trends at a mitigation wetland. In this situation, use of the performance curves in Figures 8 to 15 and slopes in Table 4 may have to be modified.

[17] Natural shrub swamps are often located within a matrix of upland or wetland forest such that wetland and upland trees are present in margins of the shrub swamp or on microtopographic features at the edge or within the shrub swamp. Data from the sampling of woody vegetation in shrub swamps clearly shows the presence and importance of these tree species. This presents an interesting design issue in that successful shrub swamp (and for that matter wetland forest) mitigation should also include reforestation of uplands around the actual mitigation wetland boundary.

[18] Thus, the numbers of stems per hectare at 100 years are average values of reference wetlands of that type of wetland. In this sense, although the performance curves are hypothetical (and straight lines) they are derived from the stand characteristics of real wetlands.

and summary table can be used as guidelines for planting intensities needed restore shrub swamps and to initiate forest succession. For example assuming a 10 year monitoring period, expected densities at the end of the monitoring period would be as follows: 170 stems ha^{-1} of 0-5 cm (0 - 2in) diameter trees (~70 stems per acre); 80 stems ha^{-1} of subcanopy (e.g. *Carpinus caroliniana*) trees (~30 stems per acre); 30 stems ha^{-1} of 5 - 15cm (2 - 6in) diameter trees (~12 stems per acre); and 690 stems ha^{-1} of shrub species (e.g. *Lindera benzoin, Ilex verticillata,* etc.) (~280 per acre) (Figure 16). Final densities for all tree size classes can be seen in the 30 and 100 year graphs of Figure 16.

Basically, the approach here is to use longitudinal stand data to demonstrate that secondary succession has begun and that at some time in the future a wetland forest will be fully developed. The practical question, given the pragmatic need for a relatively short monitoring period, is what level of woody species establishment and growth is sufficient to release a site from monitoring because the mitigation activities have initiated secondary succession? The 10 year performance curves in Figures 16 to 23 provide intermediate end points for answering this question. If stem densities at a forest mitigation increase over time (each monitoring event) and are similar to densities observed at the end of 10 years for a particular forest community performance curve, then there is some assurance that forest succession has commenced, and if current trends continue into the future, that a wetland forest will develop. In addition to the data provided in Figures 16-23 and Table 17, other forest succession data or models can be used to evaluate the woody stem collected at a mitigation project and to demonstrate that succession is occurring. Additional forestry data can be found in the community templates in the Appendices of this report. The approach outlined here is to demonstrate, using stand data from the mitigation wetland collected over time, that the site is on an ecological trajectory towards wetland forest by end of the monitoring period.

The above discussion assumes in large part the reforestation of a treeless location. Trends would be complicated when mitigation is occurring on areas that already are dominated by woody species or that are already forests. For example, mitigation may involve restoring wetland hydrology to an existing forest dominated by a mix of mesic upland and wetland trees. With the reestablishment of wetland hydrology, one would expect to see a decline in overall stem densities and a decline of upland species as these trees die. But, wetland species, especially if wetland trees are planted within the existing stand, would be expected to show an increase. In this situation, these shifts in stand characteristics should be clearly presented by graphs and tables of hydrophytic versus nonhydrophytic woody species.

At a minimum, trajectory is determined by fitting a regression line to stem counts per hectare for shrub species, subcanopy tree species, 0-5cm size class tree species, and 5-15cm size class tree species[19] as measured during the monitoring period and comparing the slope of that line to the slopes in Figures 16 to 23.

For mitigation of wetland shrub communities, the performance standard is to demonstrate that the wetland has stem densities of shrub and tree species equivalent to natural shrub swamp communities using longitudinal forestry statistics (stem counts, basal area, importance values, etc.) and simple predictive models showing that a shrub swamp has developed (or will develop within two years of the end of the

[19] This assumes secondary succession is occurring where no woody species are present. If larger diameter trees are present they should also be counted and compared to the performance curves in Figures 16 to 23.

monitoring period) and will continue to develop if current successional trends continue. As with wetland forests, hypothetical performance curves for tree and shrub establishment were developed using shrub community stand characteristics of reference wetlands as the "end points" of the curves (Figures 16 to 23), and these stand characteristics are summarized in Table 17. The performance curves and summary table can be used as guidelines for planting intensities. Additional shrub community woody stem data can be in found in the Appendices of this report. For example at 10 years in a depressional buttonbush swamp, there are ~1600 stems per hectare (~650 per acre)[20] with 120, 40, and 30 stems per hectare of 0-5 cm (0-2in), subcanopy, and 5-15cm (2-6in) trees, respectively (Figure 17).

6.2.6 Data presentation for vegetation data

The Vegetation IBI score and metric values and metric scores for each monitoring event should be summarized in tables like Tables 12 or 13. Data reductions and raw data should be included in paper and digital appendices of the monitoring report. A graph showing the VIBI score(s) over time with the performance standard indicated should be included (see e.g. Figure 44). Results from a regression analysis (equation, F statistic, R^2, p value) should be included in the graph or the legend of graph. The regression line should also be shown on the graph (Figure 44). In addition to the VIBI scores and metrics, percent cover of unvegetated open water, native perennial hydrophytes, and invasive species should also be graphed in the same manner and values included in a summary table.

Raw and reduced woody stem data should be included in paper and digital appendices to the monitoring report. A stand table (e.g. Table 17) should be included in the body of the report that reports species, frequency, relative frequency, density, relative density, basal area, relative basal area, and importance values for each monitoring event. Separate tables which summarize density (stems/ha) and importance values of each species over each monitoring event should also be included. Finally, depending on the predictive model used, a graph(s) of shrub, 0-5cm, 5-15cm and subcanopy tree species similar to those presented in Figures 16-23 should be presented with a performance goal, results from a regression analysis (equation, F statistic, R^2, p value), and the regression line indicated on the chart.

6.3 Amphibians - Ecologic Standards

Detailed procedures for calculating the AmphiIBI score can be found in *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 7: Amphibian Index of Biotic Integrity (AmphIBI) for Ohio Wetlands,* Ohio EPA Technical Report WET/2004-7 (Micacchion 2004). The performance standard requires that the mitigation wetland achieve the Amphibian IBI score by the end of the monitoring period monitoring, unless the data shows that the wetland is on a clear trajectory to achieve the AmphIBI score within 2 years of end of the monitoring period. Trajectory is determined by fitting a regression line to the Amphibian IBI scores calculated during the monitoring period and comparing the slope of that line to Table 4 and Figure 24. If data necessary to calculate the Amphibian IBI is only collected once at the end of the monitoring period, the score must be achieved by end of the monitoring period.

The AmphIBI score and metric values and metric scores for each monitoring event should be summarized in a table like Tables 12 or 13. Data reductions and raw data should be included in paper and digital appendices of the monitoring report. A graph showing the AmphIBI score(s) over time with the performance standard indicated

[20] This is estimate is derived from counts of shrub "clumps", i.e. multistemmed genets, and not of counts of each stem of each shrub plant. Actual "stem" counts would be much higher.

should be included (see e.g. Figure 44). Results from a regression analysis (equation, F statistic, R^2, p value) should be included in the graph or the legend of graph. The regression line should also be shown on the graph (Figure 44). A list of each species collected, the number of individuals collected, the number of individuals per trap hour, and the relative abundance of each species should be reported in a separate table for each monitoring event.

6.4 Other taxa groups - Ecologic Standards

Performance standards using other taxa groups, e.g. breeding bird use or macroinvertebrate communities, may be developed and used on a case by case basis depending on the particular goals of a mitigation project. Data presentation of data from other taxa group should follow the format outlined above for vegetation or amphibian data.

6.5 Biogeochemical Standards

The performance standard requires that the median values of the soil chemistry parameters listed in the Table 5 be substantially achieved at the time construction is completed or by the end of the monitoring period unless the data shows that the median values will be achieved within 2 years of end of the monitoring period. Soil and background water chemistry data should be summarized in tables like Tables 12 and 13. The table should include median, 25th and 75th percentiles, and N as follows:

	year1	year2
parameter	n = 5	n = 4
TOC	6.9(5.2-7.4)	6.3(5.8-7.0)

Raw data and data reductions should be included in paper and digital appendices.

Soil and water chemistry data should also be compared to median values from the appropriate natural wetland type. These values can be found in Fennessy et al. (2004, Tables 7, 10).

6.6 Ecological Services

If the mitigation involves the restoration, creation, or enhancement of specific wetland functions and values, e.g. the creation of endangered species habitat, increasing flood storage in a watershed, creating migratory waterfowl habitat, etc., specific goals for performance and success should be developed on a case-by-case basis to determine whether the specific function or value was created and to what extent. Data presentation of data from other taxa group should follow the format outlined above for vegetation or amphibian data.

7.0 STANDARD MITIGATION MONITORING REPORT FORMAT

Because mitigation monitoring is a type of scientific study, the format of mitigation monitoring should follow basic scientific paper format. Each monitoring report should include an executive summary, background section, methods, results, and discussion of the results, and an overall conclusion as to degree to which the mitigation wetland is or will be capable of meeting the performance standards by the end of the monitoring period. Summary tables and appropriate graphs of floral and faunal data, IBI scores, IBI metric values, chemistry data, hydrographs, etc. should be provided that include prior years sampling results. Appropriate graphs or tables which compare the data collected at the mitigation wetland to the performance standards should be provided and graphs showing the trend of the data over time shall be provided. Field data sheets, data summaries, and chain of custody forms should be included in appendices.

7.1. Executive Summary

Each report should include a brief summary similar to an abstract which describes the type and current state of development of the mitigation. The performance standards that have been met and not met should be listed and trends in performance based on the data should be described.

7.2 Background information

Each report should include a concise narrative discussion of the following information: 1) the size, type, quality, and location of the impacted wetland(s); 2) the overall goals of mitigation the project, i.e. the size, type, landscape position, quality, ecological services, etc.; 3) the construction practices and design of the mitigation wetland(s) with a focus on soil type, condition, and chemistry, water control structures, hydroperiod, maximum and minimum water depths, plant communities, faunal communities, etc. The background section should include a table with information listed in Table 18. The name, affiliation, address, phone number, and e-mail address of the following should be listed:

1. Applicant for Section 401 Certification or Isolated Wetland Permit or current holder of the permit if permit has been transferred including all permit numbers.

2. Owner of land, including fee simple owner and all easement holders on which mitigation wetland is located;

3. All persons responsible for performing monitoring and the activity(ies) they are (will) be performing;

4. All laboratories where samples will be submitted for analysis including a listing of the laboratories certifications and accreditations.

7.3 Methods - Monitoring Protocols and Performance Standards

Each report should include a concise description of the monitoring protocols and performance standards used. Any alternative or modified monitoring methods should be described in sufficient detail that they can be replicated by another investigator. Monitoring protocols should be summarized in tables similar to Tables 6 and 18-20. A map showing the location of each sample plot, transect, baseline, or other permanent sampling station should be provided. The latitude and longitude of sample locations should be listed in a separate table or included on the field data sheets in the appendices. Permanent sampling stations should be photo-documented from the same position and angle during summer of monitoring event years.

7.4 Results and Discussion

Results from monitoring should be presented concisely. Text should explain but not reiterate information presented in tables and figures. The tables, figures and text in the results section should clearly describe the trends observed in the data and relate these trends to the performance goals for the mitigation.

7.4.1 Size, Morphometry, Perimeter:Area Ratio

Data on size, morphometry, and perimeter:area ratio can be summarized in a table like Table 14. A plan view map generated from geographic positioning system data should be included. The map should show areas of open water, upland areas, dominant vegetation, berms, dikes and location of water control structures.

7.4.2 Hydrology

At a minimum the key hydrologic indicators should be presented in the text or tables. A hydrograph of the water levels should be presented for each well location. Staff gauge data can be included in a separate table or graphed with the water level data. Raw hydrology data should be included in electronic appendices. Where networks of piezometers or soil tensiometers are used potentiometric surface maps should be included by season, month, measurement date, etc. The hydrology results should explicitly and clearly compare the HGM class of the impacted wetland(s) (or the alternative approved HGM class goal) with the actual HGM class of the mitigation wetlands(s) as it has developed post-construction.

7.4.3 Vegetation Data

The Vegetation IBI score and metric values and metric scores for each monitoring event should be summarized in a table like Tables 12 or 13. Data reductions and raw data should be included in paper and digital appendices of the monitoring report. A graph showing the VIBI score(s) over time with the performance standard indicated should be included (see e.g. Figure 44). Results from a regression analysis (equation, F statistic, R^2, p value) should be included in the graph or the legend of graph. The regression line should also be shown on the graph (Figure 44). In addition to the VIBI scores and metrics, percent cover of unvegetated open water, native perennial hydrophytes, and invasive species should also be graphed in the same manner and values included in a summary table.

Raw and reduced woody stem data should be included in paper and digital appendices to the monitoring report. A stand table (e.g. Table 17) should be included in the body of the report that reports species, frequency, relative frequency, density, relative density, basal area, relative basal area, and importance values for each monitoring event. Separate tables which summarize density (stems/ha) and importance values of each species over each monitoring event should also be included. Finally, depending on the predictive model used, a graph(s) of shrub, 0-5cm, 5-15cm and subcanopy tree species similar to those presented in Figures 16-23 should be presented with a performance goal, results from a regression analysis (equation, F statistic, R^2, p value), and the regression line indicated on the chart.

7.4.4 Amphibian Data

Data reductions and raw data should be included in paper and digital appendices of the monitoring report. A graph showing the AmphIBI score(s) over time with the performance standard indicated should be included (see e.g. Figure 44). Results from a regression analysis (equation, F statistic, R^2, p value) should be included in the graph or the legend of graph. The regression line should also be shown on the graph (Figure 44). A list of each species collected, the number of individuals collected, the number of individuals per trap hour, and the relative abundance of each species should be reported in a separate table for each monitoring event.

7.4.5 Biogeochemistry Data

Soil and background water chemistry data should be summarized in tables like Tables 12 and 13. The table should include median, 25th and 75th percentiles, and N as follows:

parameter	year1 n = 5	year2 n = 4
TOC	6.9(5.2-7.4)	6.3(5.8-7.0)

Raw data and data reductions should be included in paper and digital appendices.

7.5 Conclusions

The report should conclude with a

discussion of each performance goal and whether it has been met or not met based on the data collected to date. Trends in the data (positive, negative, no change) should be explicitly addressed. The report should conclude with a statement of whether, based on the data, and any planned adaptive management activities at the mitigation, the author expects that all (or some) of the performance goals for the mitigation will be met by the end of the monitoring period.

7.6 Appendices - Paper

Photographs sampling plots
Field Data Sheets
Field Notebook Pages
Delineation Forms
3rd Reduction Quantitative Data in spreadsheet
Recorded copy of conservation easement, land transfer, etc.
ORAM score forms of impacted wetlands

7.7 Appendices - Electronic Submissions

Arcview shape files or other GIS format with metadata

Quantitative data in digital format (Excel)

Vegetation data - 1st and 3rd reductions (See Mack 2004c)

Woody stem data
Hydrologic data
Amphibian data
Other raw quantitative data

8.0 MITIGATION BANKS

Mitigation Banks are pre-built areas of wetland creation or restoration where permit applicant's needing to perform compensatory mitigation can be authorized to purchase mitigation credits from the banker in lieu of constructing an individual mitigation site themselves. Mitigation banks have been advocated as having several advantages over typical individual mitigation projects: 1) consolidation of mitigation into a single large parcel or parcels, *when ecologically appropriate*, may be advantageous for maintaining aquatic ecosystem integrity; 2) mitigation banks can bring together financial, planning, and scientific expertise not available to many project specific proposals and this consolidation of resources can (and should) increase the potential for successful mitigations and maximize opportunities for biodiversity and function; 3) temporal losses of function can be reduced because mitigation banks are established prior to the impact; and 4) permit review times may be reduced and the use of limited agency resources maximized by reviewing larger bank projects versus many smaller individual projects (60 Federal Register 58607). Thus, mitigation banks are expected to be much better in quality, function, value, etc. than individual mitigation sites because of their size, diversity of habitats, economies of scale, active adaptive management, single ownership, etc. In practice, however, mitigation banks can be prone to the same flaws as smaller individual mitigations: steep slopes, poor design, lack of adaptive management, unvegetated open water, predominance of invasive or tolerant species, lack of functional replacement, atypical hydrology from natural wetlands, atypical floral and faunal communities, failure to meet performance goals, etc (Ohio EPA unpublished data).

Because of the economies of scale and ability to consolidate financial, planning, and scientific resources present to mitigation bankers, and also because of the greater risk and loss to overall aquatic ecosystem integrity and no net loss goals if a large mitigation bank fails in whole or in part, performance standards and monitoring requirements for mitigation banks should equal or exceed that required for a smaller, individual mitigations. Most of the performance standards presented here can be used with little or no change. Some will require regular adaptation due to the size (often very large) of mitigation banks, or because of how compensatory mitigation at a bank is approved via the wetland permitting process. Because many mitigation banks are built in phases and have areas with different hydrologic and/or plant community targets, separate performance standards and monitoring protocols may need to be developed for each phase or even subareas of a phase depending on the particular bank design.

8.1 Performance Standards and Monitoring Protocols at Mitigation Banks

8.1.1 Acreage

Performance standards and monitoring for wetland size (§§2.1.1, 4.1.1) will generally be applicable with little or no change to mitigation banks. Although the outer boundaries of bank areas can be easily delineated using standard techniques, great attention should be paid to obtaining accurate estimates of wetland area within the boundaries of the bank. All banks are required to implement the random survey design (§4.2.6.2) to obtain estimates of wetland area within the outer delineated boundary. The random survey design at least equals, if not exceeds, the comprehensive determination approach in the 1987 Delineation Manual for obtaining estimates of wetland area at large mitigation banks.

8.1.2 Basin Morphometry

The basin morphometry standard and monitoring protocol (§§2.1.2, 4.2.2) can be applied as is for many typical bank designs or can be adapted or substituted with more detailed as built surveys. In banks with multiple basins or distinct subareas, data will need to be collected from each of the basins or subunits.

8.1.3 Perimeter:Area Ratio

At large consolidated mitigation banks the perimeter:area ratio standard will not be useful, except as a possible design goal. At small bank sites or at banks comprised of multiple, smaller, geographically separated areas, this standard may be useful.

8.1.4 Hydrology

Despite its critical importance to mitigation success, quantitative hydrologic data has been rarely collected at mitigation banks in Ohio. For the reasons noted above (e.g. consolidation of resources, risks from failure), hydrologic monitoring is required at every hydrologically distinct area and subarea of a mitigation bank (§§2.1.3, 4.1.3). The bank plan should specify the hydrogeomorphic class and hydroperiod for each hydrologically distinct area and subarea of the bank. Where managed water control structures are required to maintain this regime, a specific schedule for control of the structure (e.g. timing of adding or removing boards to water structures, controlling pumps or valves, etc.) should be included in the bank plan. Transfer of the bank property to an ultimate owner after the monitoring period has ended must include a property restriction requiring future adherence to this schedule and hydrologic regime. While it is understood that inter-year hydrologic variability is expected, bank plans can and should include a hydrogeomorphic class and a commitment to achieving the broad hydrologic regime goal (e.g. seasonally inundated, seasonally saturated, regularly inundated, etc.) as a performance standard.

8.2.1 Unvegetated Open Water

If mitigation banks in Ohio have had one consistent design and performance failure, it is the significant amount of “wetland” created that is little more than shallow, unvegetated open water. It is understood that a "hemi-marsh" approach to wetland creation or restoration that maximizes marsh habitat types especially for different bird species (diving ducks, dabbling ducks, wading birds, shorebirds, passerine birds, etc.), requires the creation of some areas of deeper water habitats, but in natural wetlands open water areas are usually densely vegetated with submersed and floating aquatic species. The 10% limit on unvegetated open water allows for creation of deep water habitats from borrow areas. Open water in excess of 10% of the wetland area of the bank should be specifically negotiated and approved in the mitigation bank plan and decisions made whether to allocate full or partial credit (or no credits) to such areas since they do not meet the definition of "wetland."

8.2.2 Perennial Native Hydrophytes

This performance goal requires the basic establishment of perennial native wetland vegetation (OBL, FACW, and FAC). Relative cover of *just* OBL and FACW woody and perennial native species is 65.6%, 73.5% and 81.4% for Category 1, 2 and 3 wetlands, respectively based on Ohio EPA's reference wetland data set, so the goal of 75% cover of perennial OBL, FACW *and* FAC species can be considered a highly realistic minimum standard for basic vegetation establishment.

8.2.3 Invasive Species

The performance standard requires that invasive species occupy less than 5% of the wetland area. Good to high quality natural wetlands have low or dominance of invasive species; low to moderately-high quality wetlands may sometimes have higher percentages of invasive species (Mack 2004b). Wetlands, during initial years post-restoration or creation, are especially susceptible to colonization by invasive species. Active invasive species control is required to eliminate or reduce invasive species until native species have become established and natural competition becomes a factor in the wetland development. While there are no guarantees that invasive species will not become established in the future, at least until the end of the monitoring period, invasive species will be need to be kept at low levels of abundance through active management in order to meet this performance goal.

8.2.4 Ecologic Condition: Vegetation IBI

As an integrative measure of a mitigation bank's equivalence or deviation from natural reference wetland characteristics, the Vegetation IBI should be useful as a performance standard for nearly all mitigation banks. Because of there size, mitigation banks usually have multiple HGM and/or plant community classes as goal communities. Monitoring plans should be inclusive of the goal community types and their respective VIBI performance goals. Data from the random survey design should be aggregated by these community types in order to calculate VIBIs and other measures specific to that community.

8.2.5 Woody Species Establishment

Goals for demonstrating woody species establishment and/or the initiation of forest succession are and should be applicable for any mitigation bank where credits or sold for impacts to wetland forests or shrub swamps.

8.3 Ecologic Condition: Amphibian IBI

As an integrative measure of a mitigation bank's equivalence or deviation from natural reference wetland characteristics, the Amphibian IBI should be useful as a performance standard for mitigation banks where forest or shrub wetlands are developed with the specific goal of creating breeding habitat for forest dependent frogs and salamanders.

8.4 Biogeochemistry

Soil and water chemistry data should always be collected at mitigation banks both to evaluate design and performance as well as to provide diagnostic information in the case of performance failure.

8.5 Other Measures of Condition or Function

Banks may be created in whole or in part to develop habitat for specific plants or animals (e.g. birds) or to create or replace wetland ecological services that have been lost in that landscape. Where this is a goal of the bank, numeric goals with appropriate monitoring should be developed on a case by case basis.

8.6 In-Kind Replacement and Mitigation Banks

Obviously, strict in-kind replacement as outlined in Section 2.1.4 will often not possible for impacts authorized for compensatory mitigation at a mitigation bank, the exception being in-kind replacement of forest for forest and emergent for emergent as defined and required by OAC Rule 3745-1-50 and -54, respectively. Authorization of compensatory mitigation at a bank is made on a case by case basis in each certification or permit (OAC Rule 3745-1-54) based on a consideration of, at a minimum, the following factors: the regulatory category of the impacted wetland; the watershed of the impacted wetland; the service area of the bank; whether the impacted wetland was "forest" or "emergent" and whether the bank is developing these respective communities; the size of the impacted wetland; and whether mitigation at the bank otherwise makes sense from the larger perspective of functional replacement.

8.7 Performance-Driven Credit Release Schedules

With the exception of the initial pre-construction release, release of credits at mitigation banks is based on the ecological performance of the mitigation bank. Release schedules can be tailored to the particular characteristics and goals of the bank. With appropriate justifications, or lack thereof, release percentages can be increased or decreased. Table21 outlines a generic release schedule adaptable to most mitigation bank proposals.

9.0 STANDARD CONDITIONS FOR SECTION 401 CERTIFICATIONS AND ISOLATED WETLAND PERMITS

Summary tables for mitigation requirements are provided which can be attached to Section 401 Certifications and isolated wetland permits. These tables specify and summarize the key aspects of the proposed mitigation and avoid the need for lengthy written conditions by referencing applicable sections of this document for performance, monitoring and data analysis protocols. Alternative or modified performance standards and monitoring protocols are briefly summarized in these tables. Detailed descriptions of alternative, modified, or additional standards or protocols should be provided in the final approved mitigation plan and in the monitoring reports. Where necessary these tables can be supplemented with written conditions. Tables 6 and 18-20 provide a general format for the conditions. Note that these tables presume a final mitigation plan is part of the approved certification or permit. If a final mitigation plan will be submitted and approved later, the information in Tables 6 and 18-20 should be included in the final approved plan.]. Completed tables for a hypothetical large mitigation project are shown below.

Example of Standard Conditions for a Large, Multiple Phase Mitigation Project

Compensatory mitigation for the authorized impacts shall be performed in accordance with the requirements listed below in Sections A, B, C, and D. If the wetland mitigation site(s) is not performing as proposed by the monitoring period, the monitoring period may be extended by written notice of the Ohio EPA and the applicant may be required to undertake adaptive management activities at the site(s) to improve performance or to seek out new or additional wetland mitigation areas.

The long term goal is to develop and manage Phase 1 such that high quality forested wetlands are reestablished over at least 70% of the acreage with high quality shrub swamp over 30% of the acreage. For Phase 2, the goal is to reestablish high quality mixed emergent marsh and wet meadow communities. Given the long term nature of forest succession (multi-decadal), it is understood that high quality forest will not be fully developed by the end of the monitoring period. Because of this the performance standards for Phase 1 have two components 1) an interim plant community target by the end of the monitoring period (shrub swamp), and 2) a demonstration that forest succession is occurring and increasing over the monitoring period by the collection of standard forest community data (frequency, density, basal area, importance values).

Section A. Required wetland type, location, number, amount, and monitoring period for wetland mitigation. Insert information for each mitigation wetland required to be constructed.

	Site A	Site B
Name of project(s)	Phase 1	Phase 2
HGM class of mitigation(s). List HGM class goal for each mitigation area	Impoundment	Impoundment
Duration of inundation/saturation List hydroperiod goal (~%) of each mitigation area (e.g. seasonally inundated, permanently saturated, etc.)	~30% regularly inundated, ~70% seasonally inundated	~50% seasonally saturated, ~50% seasonally inundated
Dominant plant community(ies) List goal plant community (~%) (marsh, wet meadow, fen, bog, shrub swamp, swamp forest) for each mitigation area.	~30% shrub swamp, ~70% forested	~50% mixed emergent marsh, ~50% wet meadow
Watershed(s) (11 Digit HUC) where mitigation site(s) will be located	East branch of Cuyahoga River	East branch of Cuyahoga River
Ecological region where mitigation site(s) will be located	Erie-Ontario Drift and Lake Plains	Erie-Ontario Drift and Lake Plains
Length of monitoring period in years Specify number of years of monitoring required, e.g. 5, 10, 15 etc.	10 years	6 years
Monitoring Frequency Specify monitoring frequency, e.g. every year (annual), every other year (biennial), every third year (triennial), etc. (See Monitoring Activities Table for detailed list of activities.	biennial	biennial
The number of individual wetland areas that are expected to be constructed	1	1
Total acreage of mitigation wetland in hectares (acres) that is expected to be constructed	16ha (40a)	12ha (30a)

Section B. Required monitoring and reporting activities. All reports due by December 31st of year is performed. x = activity at both phases, x1 = activity at Phase 1 only, x2 = activity at phase 2 only. Some sampling in Phase 2 not begun until 2009 in order to sample Phases 1 and 2 in same field seasons.

Section refers to applicable sections in *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 6: Standardized Monitoring Protocols and Performance Standards for Wetland Creation, Enhancement and Restoration, v. 1.0* sections

Monitoring activity	section	06	07	08	09	10	11	12	13	14	15	16
Phase 1 will be constructed in 2006 and Phase 2 will be constructed in 2007												
Delineation	4.1.1			x				x				x1
Basin morphometry	4.1.2			x		x		x		x1		
Perimeter:Area ratio	4.1.3			x		x		x		x1		
Hydrologic monitoring	4.1.4		x1	x	x2							
Qualitative mitigation evaluation	4.1.5			x		x		x		x1		x1
Vegetation sampling (fixed, random)	4.2		x1		x		x		x		x1	
Amphibian sampling	4.3		x1		x1		x1		x1		x1	
Soil and water sampling	4.4		x1		x		x		x		x1	
Other taxa group sampling	4.5		na									
Ecological services	4.6		na									
As built and monitoring plans	8.1	x1	x2									
Annual monitoring report	8.2		x	x	x	x	x	x	x	x1	x1	x1
Performance certification and request to be released from monitoring	8.3								x2			x1

Section C. Applicable PERFORMANCE STANDARDS. The standards checked below apply to the mitigation wetland(s) required to be constructed. Section refers to applicable sections in *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 6: Standardized Monitoring Protocols and Performance Standards for Wetland Creation, Enhancement and Restoration, v. 1.0*

performance standard	performance standard sections	check all that apply to mitigation site	insert requested information and/or specify an alternative approved performance standard
Acreage	2.1.1	X	A total of 28ha (70a) is proposed to be created in two phases, Phase 1 = 16ha (40a), Phase 2 = 12ha (30a)
Basin morphometry	2.1.2	X	
Perimeter:Area ratio	2.1.3	X	

Section C. Applicable PERFORMANCE STANDARDS. The standards checked below apply to the mitigation wetland(s) required to be constructed. Section refers to applicable sections in *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 6: Standardized Monitoring Protocols and Performance Standards for Wetland Creation, Enhancement and Restoration, v. 1.0*

performance standard	performance standard sections	check all that apply to mitigation site	insert requested information and/or specify an alternative approved performance standard
Hydrologic regime	2.1.4	X	
Unvegetated open water	2.2.1	X modified	Up to 15% of the wetland area of Phase 2 may be unvegetated open water
Native perennial hydrophytes	2.2.2	X	
Invasive species	2.2.3	X	
Vegetation - Ecologic standards	2.2.4	X	Phase 1 VIBI-SH (intermediate goal for proposed forest areas; VIBI-F will also be calculated and reported) Minimum VIBI-SH score = 53 Phase 2 VIBI-E Minimum VIBI-E score = 53 (marsh), 60 (wet meadow)
Woody spp. establishment (Shrub Swamps)	2.2.5.1	X	
Woody spp. establishment (Swamp Forests)	2.2.5.2	X	
Amphibians - Ecologic standards	2.3	X	Phase 1 only Minimum AmphIBI score = 20
Other taxa groups - Ecologic standards	2.4	not applicable	
Biogeochemical standards	2.5	X	
Ecological services	2.6	not applicable	

Section D. Applicable monitoring and data analysis requirements. The monitoring and data analysis protocols checked below will be used to evaluate mitigation performance. Section refers to applicable sections in *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 6: Standardized Monitoring Protocols and Performance Standards for Wetland Creation, Enhancement and Restoration, v. 1.0*

performance standard	standard monitoring and data analysis protocol sections	check all that apply to mitigation site	Describe alternative monitoring and/or data analysis requirements
Acreage	4.1.1, 6.1.1	X	
Basin morphometry	4.1.2, 6.1.2	X	
Perimeter:Area ratio	4.1.3, 6.1.3	X	
Hydrologic regime	4.1.4, 6.1.4	X alternative	50 shallow, manually read (weekly) piezometers will be installed instead of automated level recorders and staff gauges

Section D. Applicable monitoring and data analysis requirements. The monitoring and data analysis protocols checked below will be used to evaluate mitigation performance. Section refers to applicable sections in *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 6: Standardized Monitoring Protocols and Performance Standards for Wetland Creation, Enhancement and Restoration, v. 1.0*

performance standard	standard monitoring and data analysis protocol sections	check all that apply to mitigation site	Describe alternative monitoring and/or data analysis requirements
Unvegetated open water	4.2.1, 6.2.1	X	
Native perennial hydrophytes	4.2.2, 6.2.2	X	
Invasive species	4.2.3, 6.2.3	X	
Vegetation sampling - fixed plots only	4.2.6.1, 6.2.4, 6.2.5, 6.2.6	X	
Vegetation sampling - fixed and random plots	4.2.6.2, 6.2.4, 6.2.5, 6.2.6	X	
Amphibians sampling	4.3, 6.3	X	
Other taxa groups - Ecologic standards	4.4, 6.4	not applicable	
Biogeochemical standards	4.5, 6.5	X	
Ecological services	4.6, 6.6	not applicable	

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Table 1a. Hydrogeomorphic classes for wetland classification system for Ohio wetlands.

	class	class modifiers
I	Depression (incl. areas that could be considered flats, e.g. “wet woods”	(A) Surface water (sheet flow, precipitation) (B) Ground water (seasonal to permanent input)
II	Impoundment	(A) Beaver (B) Human
III	Riverine	(A) Headwater depression (1^{st} or 2^{nd}) (B) Mainstem depression (3^{rd} order or >) (C) Channel
IV	Slope (incl. hillside fens, mound fens, lacustrine fens, and forest seeps)	(A) Headwater (1^{st} or 2^{nd} order) (B) Mainstem (3^{rd} order or larger) (C) Isolated (D) Fringing
V	Fringing (does not include lacustrine fens)	(A) Reservoir (B) Natural lake
VI	Coastal	(A) Open embayment (B) Closed embayment (C) Barrier-protected (D) River mouth (E) Diked - managed (F) Diked - unmanaged (G) Diked - failed
VII	Bog	(A) Strongly ombrotrophic (B) Moderately ombrotrophic (C) Weakly ombrotrophic
add code	Mitigation	Add appropriate pre-code to HGM class: mr - mitigation, restoration mc - mitigation, creation e.g. “mrII” = mitigation, restoration, impoundment

Table 1b. Plant community modifiers for Wetland classification system for Ohio wetlands.

(1) Forest	(2) Emergent	(3) Shrub
(a) Swamp forest	(a) Marsh	(a) Shrub Swamp
(I) oak-maple (ii) oak-maple-ash (iii) maple-ash (iv) pin oak (v) pumpkin ash (vi) mixed forest (vii) red maple (viii) white pine bog (ix) cottonwood (x) river birch (xi) other (specify)	(I) submergent marsh (ii) floating-leaved marsh (iii) mixed emergent marsh (iv) cattail marsh	(I) buttonbush swamp (ii) alder swamp (iii) mixed shrub swamp (iv) other (specify)
(b) Bog Forest	(b) Wet meadow	(b) Bog shrub swamp
(I) tamarack bog (ii) tamarack-hardwood bog	(I) wet prairie (ii) oak openings sand prairie (iii) prairie sedge meadow (iv) fen (v) reed canary grass meadow (vi) other (specify)	(I) tall shrub bog (ii) leatherleaf bog
(c) Forest seep (I) skunk cabbage seep (ii) sedge seep (iii) skunk cabbage-sedge seep (iv) other (specify)	(c) Sphagnum bog (incl. open kettle bogs with scattered shrubs, classic ringed bogs with open water centers and perimeters of shrubs and tamarack)	(c) Tall shrub fen

Table 2a. Mean hydrological indicators by HGM class.

HGM class	% time water in root zone (<-30cm)	mean depth (cm)	flashiness index
depression	47	-35.3	1.7
impoundment	53	-29.4	2.0
riverine headwater	97	-4.2	1.9
riverine mainstem	30	-49.3	2.0
slope	100	-6.1	1.9

Table 2b. Surface water levels (ft above sea level) for Lake Erie Coastal Marsh (drowned river mouth) (Old Woman Creek, Huron, Ohio). Data provided by David Klarer, Old Woman Creek National Estuarine Reserve.

year	mouth	mean	SD	minimum	maximum
1987	closed	575.37	0.42	574.43	576.14
	open	574.06	0.75	571.84	576.10
1988	closed	573.76	0.53	573.05	575.67
	open	572.95	0.42	571.92	573.96
1989	closed	574.79	0.62	573.14	576.11
	open	572.31	0.71	570.81	574.11
1990	closed	574.19	0.81	572.18	576.04
	open	572.68	0.59	571.08	573.95
1991	closed	573.31	0.53	572.74	575.23
	open	573.35	0.47	572.20	574.73
1992	closed	574.40	0.87	572.85	576.22
	open	573.14	0.50	571.77	575.02
1993	closed	573.74	0.56	573.20	574.83
	open	573.62	0.59	571.93	573.93
1994	closed	573.73	0.44	573.25	575.35
	open	573.49	0.85	571.85	575.54
1995	open	573.33	0.08	573.22	573.69
	closed	572.89	0.53	570.97	574.29

Table 3. Ranges for Vegetation IBI scores for Category 2 and 3 Wetlands by hydrogeomorphic (HGM) class, HGM subclass, plant community class, and ecoregion. Ranges are from Table 7 *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 9: Field Manual for the Vegetation Index of Biotic Integrity for Wetlands v. 1.3*, Ohio EPA Technical Report WET/2004-9. HGM classes and plant community classes defined in Tables 8A and 8B of *INTEGRATED WETLAND ASSESSMENT PROGRAM. Part 9: Field Manual for the Vegetation Index of Biotic Integrity for Wetlands v. 1.3*, Ohio EPA Technical Report WET/2004-9. EOLP = Erie-Ontario Drift and Lake Plains (glaciated Allegheny Plateau) (see Figure 1).

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

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

Table 4. Regression equations and minimum slopes for performance curves for Vegetation and Amphibian IBIs by wetland type and region. See Figures 8 to 15 and 24 for performance curves.

HGM	Plant Community	ecoregion	slope	equation	refer to Figure
VEGETATION IBI					
Depression	all except wet meadow	EOLP	>6.7	y = 6.7year - 6.7	Figure 8
		all other regions	>5.6	y = 5.6year - 5.6	Figure 8
All (depression, slope, impoundment, riverine)	Wet meadow	all	>6.6	y = 6.6year - 6.6	Figure 9
Impoundment	all except wet meadow	EOLP	>6.6	y = 6.6year - 6.6	Figure 13
		all other regions	>5.2	y = 5.2year - 5.2	Figure 13
Riverine Headwater	all except wet meadow	EOLP	>6.3	y = 6.3year - 6.3	Figure 11
		all other regions	>5.2	y = 5.2year - 5.2	Figure 11
Riverine Mainstem and Channel	all except wet meadow	EOLP	>6.3	y = 6.3year - 6.3	Figure 12
		all other regions	>4.7	y = 4.7year - 4.7	Figure 12
Slope	Forest seep	all regions	>6.6	y = 6.6year - 6.6	Figure 10
Coastal	all	all	>5.4	y = 5.4year - 5.4	Figure 15
Bog, weakly ombrotrophic	all	all	>7.2	y = 7.2year - 7.2	Figure 14
Bog, strong to moderately ombrotrophic	all	all	>2.6	y = 2.6year - 2.6	Figure 14
Fringing (not incl. lacustrine fens)[21]	---	---	---	---	---
AMPHIBIAN IBI					
Depression, Riverine, Impoundment	Swamp Forest, Shrub Swamp	all	>2.2	y = 2.2year -2.2	Figure 24

[21] For fringing wetlands other than lacustrine fens use slopes and equations for depressions or impoundments as appropriate.

Table 5. Performance standards for wetland soils. Standards for total N for non-marsh systems not proposed.

HGM class	Plant community	% solids	total Organic Carbon (TOC) (%)	total N (%)
Depression	Marshes	< 62.4	> 3.6	> 0.5
	Shrub swamps	< 41.9	> 10.1	---
	Forests (vernal pools)	< 58.1	> 5.4	---
	Forests (wet woods)	< 57.4	> 6.6	---
	Wet meadows (wet prairie, prairie sedge meadow, other, etc.)	< 55.9	> 3.1	> 0.5
	Wet meadows - Lake Plains Sand Prairies	< 61.0	> 9.5	---
Impoundment	Marshes	< 46.6	> 3.9	> 0.5
	Shrub swamps	< 62.1	> 3.7	---
Riverine mainstem	Marshes	< 46.6	> 3.9	> 0.5
	Shrub swamps	< 62.1	> 3.7	---
	Swamp forests	< 66.1	> 2.9	---
Riverine headwater	Marshes, shrub swamps	< 46.6	> 4.1	> 0.5
Slope	Fen (calcareous)	< 30.0	> 24.5	---
	Fen (other)	< 48.0	> 9.0	---
	Forest seeps	< 38.0	> 9.3	---
Coastal	all	< 54.9	> 4.1	> 0.5
Bog	all	< 18.9	> 41.7	---

Table 6a. Conceptual 5 year schedule for required monitoring and reporting activities. All reports due by December 31st of year activity is performed.

Monitoring activity	section	0	1	2	3	4	5
Site was (will be) constructed in _________ (insert year)							
Delineation	4.1.1			x		x	
Basin morphometry	4.1.2		x				x
Perimeter:Area ratio	4.1.3		x				x
Hydrologic monitoring	4.1.4		x	x			
Qualitative mitigation evaluation	4.1.5			x		x	
Vegetation sampling (fixed, random)	4.2		x		x		x
Amphibian sampling	4.3		x		x		x
Soil and water sampling	4.4		x		x		x
Other taxa group sampling	4.5		x		x		x
Ecological services	4.6		x		x		x
As built plans and monitoring plan	8.1	x					
Annual monitoring report	8.2		x	x	x	x	x
Performance certification and request to be released from monitoring	8.3						x

Table 6b. Conceptual 10 year schedule for required monitoring and reporting activities. All reports due by December 31^{st} of year is performed.

Monitoring activity	section	0	1	2	3	4	5	6	7	8	9	10
Site was (will be) constructed in _________ (insert year)												
Delineation	4.1.1			x				x				x
Basin morphometry	4.1.2		x				x				x	
Perimeter:Area ratio	4.1.3		x				x				x	
Hydrologic monitoring	4.1.4		x	x								
Qualitative mitigation evaluation	4.1.5			x		x		x		x		x
Vegetation sampling (fixed, random)	4.2		x		x		x		x		x	
Amphibian sampling	4.3		x		x		x		x		x	
Soil and water sampling	4.4		x		x		x		x		x	
Other taxa group sampling	4.5		x		x		x		x		x	
Ecological services	4.6		x		x		x		x		x	
As built and monitoring plans	8.1	x										
Annual monitoring report	8.2		x	x	x	x	x	x	x	x	x	x
Performance certification and request to be released from monitoring	8.3											x

Table 7. Conceptual schedule of activities during monitoring event.

year	month	activity
year prior to monitoring event	November	Install water level monitoring well
	December	Prepare, repair, calibrate equipment as needed Purchase needed equipment and supplies Prepare sampling schedule
monitoring event year	February	Quarterly check and download of monitoring well
	late March to April	Perform 1st sampling pass for amphibians (actual date depends on local weather)
	May	Perform 2nd sampling pass for amphibians (actual date depends on local weather) GPS wetland boundaries Measure basin morphometry Perform water sampling
	June	Quarterly check and download of monitoring well Perform 3rd sampling pass for amphibians (actual date depends on local weather)
	June 15 to August 30	Perform vegetation sampling Perform soil sampling Harvest vegetation for standing biomass
	September to December	Quarterly check and download of monitoring well Analyze data Prepare monitoring report
	December	Remove monitoring well (leave for 2nd year) Submit monitoring report

Table 8. Summary of performance standards and the monitoring data used to determine conformance with the standard.

performance section	performance standard	monitoring section	monitoring data that may be used to determine conformance with standard	data analysis section
2.1.1	Acreage	4.1.1	GPS perimeter; GPS of larger areas of upland or unvegetated open water; estimates of wetland from random plot data (if required); estimates of wetland from fixed plots	6.1.1
2.1.2	Basin morphometry	4.1.2	As built plans; post construction survey of morphometry	6.1.2
2.1.3	Perimeter:Area ratio	4.2.3	Comparison of GPS perimeter of impact wetland(s) versus mitigation wetland(s)	6.1.3
2.1.4	Hydrologic regime	4.1.4	Quantitative data of hydroperiod and water depth from regular staff gauge measurements and/or automated ground or surface water level recorders and comparison to hydrographs	6.1.4
2.2.1	Unvegetated open water	4.2.1	Quantitative estimates of %unvegetated open water from fixed and random plots and visual estimate of %unvegetated open water; GPS area of %unvegetated open water.	6.2.1
2.2.2	Perennial native hydrophytes	4.2.2	Quantitative estimates of % cover of native, perennial hydrophytes from fixed and random (if required) plots; overall visual estimate of % cover for site.	6.2.2
2.2.3	Invasive species	4.2.3	Quantitative estimates of % cover of invasive species from fixed and random (if required) plots; overall visual estimate of % cover for site.	6.2.3
2.2.4	Vegetation - Ecologic standards	4.2.4	Vegetation IBI score calculated from fixed plots and random plots (if required) compared to Table 3 and slopes and performance curves in Table 4 and Figures 8-15.	6.2.4
2.2.5.1	Woody spp. establishment (Shrub Swamps)	4.2.5	Quantitative estimates of stem density of shrub species compared to slopes and performance curves in Figures 16-23.	6.2.5.1

Table 8. Summary of performance standards and the monitoring data used to determine conformance with the standard.

performance section	performance standard	monitoring section	monitoring data that may be used to determine conformance with standard	data analysis section
2.2.5.2	Woody spp. establishment (Swamp Forests)	4.2.5	Quantitative estimates of stem density of shrub species, subcanopy tree species, 0-5cm tree species, 5-15cm tree species compared to slopes and performance curves in Figures 16-23.	6.2.5.2
2.3	Amphibians - Ecologic standards	4.3	Amphibian IBI score calculated compared to slopes and performance curves in Table 3 and Figure 24.	6.3
2.4	Other taxa groups - Ecologic standards	4.4	Quantitative measurements compared to numeric goals for taxa group using appropriate sampling methodology	6.4
2.5	Biogeochemical standards	4.5	Quantitative measurements of Total Organic Carbon (%), total solids (%), and total Nitrogen (%). Comparison to median values and 25th and 75th percentiles of appropriate Restoration Template in Table 5.	6.5
2.6	Ecological services	4.6	Quantitative measurements compared to numeric goals for specific (ecological service (function or value) using appropriate sampling methodology	6.6

Table 9. Minimum hydrologic monitoring requirements.

size	hydrologic regime	monitoring
relatively small, single "basin" individual mitigations	seasonally inundated with water depth >30 cm (12 in)	weekly staff gauge readings OR at least 1 automated ground water level recorder (readings twice per day) and staff gauge readings during data logger downloads OR manually monitored network of shallow piezometers OR other equivalent method(s)
	seasonally to permanently saturated (or possible short periods of shallow inundation <30cm)	at least 1 automated ground water level recorder (readings twice per day) OR manually monitored network of shallow piezometers or soil tensiometers OR other equivalent method(s)
mitigation banks and large individual mitigation sites	seasonally inundated with water depth >30 cm (12 in)	at least 1 automated ground water level recorder per subarea of site (readings twice per day) and staff gauge readings during data logger downloads OR manually monitored network of shallow piezometers OR other equivalent method(s)
	seasonally to permanently saturated (or possible short periods of shallow inundation <30cm)	at least 1 automated ground water level recorder per subarea of site (readings twice per day) OR manually monitored network of shallow piezometers or soil tensiometers OR other equivalent method(s)

Table 10. Summary of vegetation survey data types, descriptions, and quality assurance procedures for plot based vegetation sampling method specified.

data type	description	data quality procedures
presence	Presence/absence. Determining that a particular plant species is present in the survey plot	1. use of nested quadrats which require close examination of small area followed by examination of larger and larger quadrats 2. collection of voucher specimens of difficult genera or families or plants unable to be identified in the field for later identification in the lab 3. properly and completely filling out the data form and reviewing the data form for completeness immediately after the survey is completed 4. collection of data by trained field botanists
% cover	estimate of percent cover of plant species, litter co ver, and open water cover determined to be present in the survey plot	1. use of "doubling" cover classes which enable reproducible cove class assignments by different users 2. properly and completely filling out the data form and reviewing the data form for completeness immediately after the survey is completed 3. collection of data by trained field botanists
diameter at breast height (dbh)	measuring the dbh of a tree or shrub at "breast height" using a dbh tape measure.	1. using professional dbh tape and taking measurements at same height 2. training users on proper method for using and reading tape 3. properly and completely filling out the data form and reviewing the data form for completeness immediately after the survey is completed
stem counts	counting every woody plant above 1m high in the entire survey plot	1. training users on sampling method procedures. 2. properly and completely filling out the data form and reviewing the data form for completeness immediately after the survey is completed
water depth	measuring the depth of water in the centers of the intensive modules in the survey plot using a meter stick	see above
litter depth	measuring the depth of litter in the centers of the intensive modules in the survey plot by digging a small test hole and measuring the depth with a ruler	see above
depth to saturated soil	measuring the depth until saturated soils are reached in the centers of the intensive modules in the survey plot by digging a small test hole and measuring the depth with a ruler	see above
woody debris counts	counting every piece of course woody debris in the intensive modules greater than 10cm in diameter	see above
standing biomass	harvesting to ground level all plant material rooted in a $0.1m^2$ quadrat of the 8 (typical) nested quadrats, drying the material and weighing it.	1 and 2 above and use properly calibrated scale
tussock/hummock counts	counting the number of tussocks and hummocks in the intensive modules	see above
microhabitat interspersion	estimating the overall amount of microhabitat using a qualitative microhabitat interspersion scale	see above

Table 11. Analytical parameters and suggested methods for soil analysis.

parameter	method
pH	SW846-9045C (soil)
P, Bray 1 (weak)	NRC-13
P, Bray 2 (strong)	NRC-13 (acid concentration 4X weak Bray)
Cation Exchange Capacity	NRC-13
Exchangeable Ca, Mg, K	NRC -13
Total Organic Carbon	USEPA 415.1, LECO2000 Analyzer, CE Instruments CHN-Analyzer (Model nc-2100), or equivalent method
Total Nitrogen	USEPA 415.1, LECO2000 Analyzer, CE Instruments CHN-Analyzer (Model nc-2100), or equivalent method
Total solids	USEPA 160.3

Table 12. Example of summary table for VIBI scores, metric values, and chemistry data.

parameter	year 1	year 3	year 5	year 7	year 9
VIBI - E score					
Metric 1 Carex richness					
Metric 2 Dicot richness					
Metric 3 Shrub richness					
Metric 4 Hydrophyte Richness					
etc. cont. with other metrics					
Total organic carbon					
%Nitrogen					
etc. cont. with other chemistry					
Coarse woody debris					
Depth to saturated soil					
etc. continue other parameters					

Table 13. Example of summary table for VIBI scores, metric values, and chemistry data for multiple sites.

parameter	parameter	year 1	year 3	year 5	year 7	year 9
Site A (or Plot 1)	VIBI - E score					
	Metric 1 Carex richness					
	Metric 2 Dicot richness etc.					
	Total organic carbon					
	%Nitrogen etc.					
Site B (or Plot 2)	VIBI - E score					
	Metric 1 Carex richness					
	Metric 2 Dicot richness etc.					
	Total organic carbon					
	%Nitrogen etc.					
Site C (or Plot 3)	VIBI - E score					
	Metric 1 Carex richness					
	Metric 2 Dicot richness etc.					
	Total organic carbon					
	%Nitrogen etc.					

Table 14. Summary table for acreage, morphometry, and perimeter:area ratio performance standards assuming a 10 year monitoring period and data collection in years 2, 6, and 10.

parameter	year 2	year 6	year 10
Acreage			
(1) Delineated acreage (maximum wetland acres)			
(2) Upland acreage			
(3) Acreage of %unvegetated open >10%			
Actual wetland acreage [deduct (2) and (3) from (1)]			
Basin morphometry			
Number of transects slopes <15:1			
Percent of perimeter with slopes <15:1			
Perimeter:Area Ratio			
Perimeter length of impacted wetland times 0.75			
Perimeter length of mitigation wetland			
ratio of perimeter length mitigation:impacted			

Table 15. Description of HGM classes

HGM Class/Subclass	Soils	Landscape position	Hydrology
Depression (A) Surface water, (B) Ground water	Mineral to organic (muck) soils	not associated with river or streams; not located on floodplains although sometimes on terraces above floodplains. Includes areas that could be considered "flats," e.g. "wet woods"	Dominant pathway is vertical (precipitation and evapotranspiration) sometimes with shallow ground water recharge or discharge Permanence can range from seasonally saturated to shallowly inundated, seasonally inundated to regularly to permanently inundated or saturated
Impoundment (Beaver, Human)	Mineral to organic (muck) soils	usually located on floodplains or in headwaters of streams and rivers; sometimes on terraces above floodplains or in other landscape contexts more typical of depressions	Sources can be precipitation only to more commonly impounded catchments of streams; losses from evapotranspiration, through-flow from beaver dams or culverts. Often regularly to permanently inundated or saturated
Riverine headwater depression (1st or 2nd)	mineral or often organic (muck) soils	associated with headwater streams 1st and 2nd order and often perennially connected with braided channels; beaver activity can make these difficult to distinguish from beaver impoundments	Ground water, sheet flow from uplands, and perennial connection with headwater streams. Often regularly to permanently inundated or saturated
Riverine mainstem depression (3rd order or greater)	usually mineral soils	associated with 3rd order or greater streams and often abandoned oxbows or depressions on floodplain subject to seasonal flooding	Dominant source overbank (usually spring) flood events from river and precipitation and possible shallow groundwater. After spring flooding most mainstem depressions shift to a vertical hydrologic pathway (precipitation, evapotranspiration) similar to depressions
Riverine channel (3rd order or greater)	mineral or often organic (muck) soils	sometimes referred to as "wetland" streams where stream channel is "wetland"	Perennial or nearly perennial surface water connection with river with no alluvial dikes or separations of floodway and floodplain
Slope (Headwater, Mainstem , Isolated, Fringing	peat (with or without marl) or muck	located at breaks in slope or the locations where artesian ground water expresses at surface. Includes "mound" fens, "lacustrine" fens, and forest seeps	Dominant source is ground water; losses from evapotranspiration and discharge of flowing ground water to streams or other wetlands. For "fens" ground water is circumneutral to alkaline and with moderate to high Ca or Mg concentrations. For forest seeps, water is often neutral to slightly acidic.
Fringing (A) Reservoir, (B) Natural lake (does not include lacustrine fens)	Mineral to organic (muck) soils	located around margins of natural lakes (does not include lacustrine fens) and larger reservoirs (smaller reservoirs can be treated as human impoundments)	Perennial or nearly perennial surface water connection with water from lake or reservoir. Note that lacustrine fens (fens on margins of natural kettle lakes) are classified as a type of slope. Some natural kettle lakes are better classified as "bogs" or have bogs around their margins.
Coastal (Open embayment, Closed embayment, Barrier-protected, River mouth, Diked - managed, Diked - unmanaged, Diked - failed)	Mineral to organic (muck) soils	located below or adjacent to 575' and subject to hydrological influence of Lake Erie	Hydrology wholly or partly due to natural fluctuations in Lake Erie water levels, or in the case of diked wetlands, formerly due to natural fluctuations in Lake Erie water levels.
Bog (Strongly ombrotrophic, Moderately ombrotrophic, Weakly ombrotrophic)	strongly (peat), moderately (peat or muck), weakly (muck)	Strongly depressional landscape positions not associated with streams or rivers dominated by Sphagnous mosses	Dominant source of hydrology is precipitation with water chemistry altered by predominance of sphagnous mosses

Table 16. Example hydrologic data from automated shallow ground water level recorder (Remote Data Systems Ecotone™ Well with 20" well screen). Inter-day difference calculated by taking the absolute value of the difference between two readings. Note large change in depth on August 27th.

date	time	level (cm)	staff gauge (cm)	inter-day difference	code
17-Aug	20:00	-36.8	*	*	below root zone
18-Aug	8:00	-30.7	*	6.1	below root zone
18-Aug	20:00	-25.1	*	5.6	root zone
19-Aug	8:00	-25.4	*	0.3	root zone
19-Aug	20:00	-29.5	*	4.1	root zone
20-Aug	8:00	-33.8	*	4.3	below root zone
20-Aug	20:00	-41.1	*	7.4	below root zone
21-Aug	8:00	-46.2	*	5.1	below root zone
21-Aug	20:00	-47.8	*	1.5	below root zone
22-Aug	8:00	-47.8	*	0	below root zone
22-Aug	20:00	-47.5	*	0.3	below root zone
23-Aug	8:00	-34.8	*	12.7	below root zone
23-Aug	20:00	-27.9	*	6.9	root zone
24-Aug	8:00	-25.9	*	2	root zone
24-Aug	20:00	-29	*	3	root zone
25-Aug	8:00	-33.3	*	4.3	below root zone
25-Aug	20:00	-37.6	*	4.3	below root zone
26-Aug	8:00	-41.4	*	3.8	below root zone
26-Aug	20:00	-46	*	4.6	below root zone
27-Aug	8:00	-47.5	*	1.5	below root zone
27-Aug	20:00	6.4	*	53.8	inundated
28-Aug	8:00	6.6	*	0.3	inundated
28-Aug	20:00	3.8	*	2.8	inundated
29-Aug	8:00	2.3	*	1.5	inundated
29-Aug	20:00	1.3	*	1	inundated
30-Aug	8:00	0	*	1.3	root zone
30-Aug	20:00	-0.8	*	0.8	root zone
31-Aug	8:00	-3.3	*	2.5	root zone
31-Aug	20:00	-3.6	*	0.3	root zone
1-Sep	8:00	-3.6	*	0	root zone
1-Sep	20:00	-5.1	*	1.5	root zone
2-Sep	8:00	-8.9	*	3.8	root zone
2-Sep	20:00	-11.7	*	2.8	root zone
		mean depth	-22.8		
		flashiness	4.7		
		%time in root zone	42.4%		

Table 17. Average forestry statistics by species for forest and shrub wetlands. Frequency refers to size class frequency (Mack 2004c). Species lists are aggregated and some species have geographically restricted distributions in Ohio wetlands.

Community	Species	frequency	relative frequency	density stems ha^{-1}	relative density	dominance $m^2\ ha^{-1}$	relative dominance	importance value
Tall Shrub Bog	Acer rubrum	6	0.472	307	0.040	4.596	0.277	0.263
	Acer saccharinum	2	0.167	40	0.005	0.379	0.015	0.062
	Aronia melanocarpa	1	0.083	910	0.118	0.042	0.002	0.068
	Betula alleghaniensis	6	0.500	350	0.045	0.941	0.108	0.218
	Carpinus caroliniana	1	0.083	10	0.001	0.002	0.000	0.028
	Cephalanthus occidentalis	1	0.083	1459	0.189	0.029	0.002	0.092
	Fagus grandifolia	3	0.250	30	0.004	1.082	0.043	0.099
	Fraxinus pennsylvanica	4	0.333	60	0.008	1.278	0.051	0.131
	Ilex verticillata	2	0.166	1396	0.180	0.160	0.017	0.121
	Nyssa sylvatica	8	0.625	520	0.068	7.388	0.481	0.392
	Pinus strobus	1	0.083	10	0.001	0.594	0.068	0.051
	Populus heterophylla	6	0.500	180	0.024	3.520	0.140	0.221
	Quercus bicolor	4	0.333	80	0.011	3.535	0.141	0.162
	Quercus palustris	1	0.083	10	0.001	0.398	0.016	0.034
	Rosa palustris	1	0.083	1027	0.133	0.020	0.001	0.073
	Salix bebbiana	1	0.083	139	0.018	0.003	0.000	0.034
	Salix discolor	1	0.083	10	0.001	0.011	0.001	0.029
	Salix sericea	2	0.167	330	0.042	0.330	0.038	0.082
	Sambucus canadensis	1	0.083	67	0.009	0.001	0.000	0.031
	Toxicodendron vernix	4	0.333	368	0.047	2.070	0.131	0.171
	Ulmus americana	1	0.083	10	0.001	0.123	0.005	0.030
	Ulmus rubra	3	0.250	50	0.007	0.351	0.014	0.090
	Vaccinium corymbosum	1	0.111	1574	0.205	0.147	0.007	0.108
	Viburnum recognitum	1	0.083	607	0.079	0.012	0.001	0.054
Tamarack-Hardwood Bog	Acer rubrum	11	0.917	340	0.060	11.222	0.613	0.530
	Fagus grandifolia	1	0.083	30	0.005	0.001	0.000	0.030
	Fraxinus nigra	4	0.333	240	0.042	0.305	0.017	0.131
	Ilex verticillata	3	0.250	1520	0.268	0.061	0.003	0.174
	Larix laricina	5	0.417	170	0.030	4.364	0.238	0.228
	Nyssa sylvatica	1	0.083	20	0.004	0.245	0.013	0.033
	Quercus bicolor	1	0.083	20	0.004	0.005	0.000	0.029
	Quercus rubra	3	0.250	180	0.032	0.096	0.005	0.096
	Toxicodendron vernix	2	0.167	100	0.018	0.002	0.000	0.062
	Ulmus americana	1	0.083	40	0.007	0.001	0.000	0.030
	Vaccinium corymbosum	3	0.250	1880	0.332	0.183	0.010	0.197

Table 17. Average forestry statistics by species for forest and shrub wetlands. Frequency refers to size class frequency (Mack 2004c). Species lists are aggregated and some species have geographically restricted distributions in Ohio wetlands.

Community	Species	frequency	relative frequency	density stems ha^{-1}	relative density	dominance m^2 ha^{-1}	relative dominance	importance value
Leatherleaf Bog	Acer rubrum	5	0.417	180	0.020	1.490	0.245	0.227
	Aronia melanocarpa	1	0.083	880	0.098	0.017	0.003	0.062
	Betula populifolia	6	0.500	440	0.049	2.459	0.405	0.318
	Chamaedaphne calyculata	1	0.083	5260	0.587	0.103	0.017	0.229
	Larix laricina	6	0.500	880	0.098	1.974	0.325	0.308
	Vaccinium corymbosum	1	0.083	1300	0.145	0.026	0.004	0.078
Tamarack Bog	Acer rubrum	4	0.333	250	0.053	1.061	0.133	0.173
	Aronia melanocarpa	1	0.083	350	0.074	0.007	0.001	0.053
	Betula populifolia	1	0.083	25	0.005	0.307	0.039	0.042
	Larix laricina	5	0.417	1600	0.337	6.518	0.818	0.524
	Nemopanthus mucronatus	1	0.083	75	0.016	0.002	0.0002	0.033
	Vaccinium corymbosum	1	0.083	2350	0.495	0.046	0.006	0.195
Forest Seep	Acer rubrum	7	0.556	267	0.095	8.756	0.243	0.298
	Acer saccharinum	11	0.917	430	0.417	21.860	0.723	0.686
	Acer saccharum	4	0.292	85	0.027	0.659	0.019	0.113
	Alnus incana	3	0.250	225	0.119	0.466	0.017	0.129
	Alnus serrulata	2	0.167	30	0.029	0.066	0.002	0.066
	Betula alleghaniensis	5	0.375	80	0.028	3.146	0.069	0.157
	Betula nigra	7	0.583	500	0.400	13.285	0.946	0.643
	Carpinus caroliniana	3	0.209	85	0.063	0.109	0.007	0.093
	Carya ovata	1	0.083	10	0.005	0.398	0.015	0.034
	Carya tomentosa	1	0.083	10	0.005	0.011	0.0004	
	Cephalanthus occidentalis	1	0.083	168	0.135	0.009	0.000	0.073
	Cornus amomum	1	0.083	60	0.050	0.012	0.001	0.045
	Cornus racemosa	3	0.250	100	0.052	0.082	0.003	0.102
	Fagus grandifolia	5	0.417	610	0.223	1.766	0.036	0.225
	Fraxinus nigra	5	0.375	80	0.040	3.665	0.132	0.182
	Fraxinus pennsylvanica	7	0.563	120	0.057	3.279	0.107	0.242
	Ilex verticillata	3	0.250	710	0.370	0.177	0.007	0.209
	Juglans nigra	1	0.083	10	0.010	0.594	0.020	0.038
	Lindera benzoin	4	0.334	945	0.308	0.129	0.003	0.215
	Liriodendron tulipifera	9	0.750	290	0.092	22.494	0.645	0.496
	Nemopanthus mucronatus	1	0.083	70	0.026	0.077	0.002	0.037
	Nyssa sylvatica	2	0.167	40	0.015	0.051	0.001	0.061
	Pinus strobus	6	0.500	150	0.055	19.901	0.406	0.320
	Quercus bicolor	2	0.167	20	0.010	1.750	0.065	0.081

Table 17. Average forestry statistics by species for forest and shrub wetlands. Frequency refers to size class frequency (Mack 2004c). Species lists are aggregated and some species have geographically restricted distributions in Ohio wetlands.

Community	Species	frequency	relative frequency	density stems ha^{-1}	relative density	dominance m^2 ha^{-1}	relative dominance	importance value
	Quercus palustris	1	0.083	10	0.005	0.241	0.009	0.033
	Rosa palustris	1	0.083	35	0.020	0.001	0.00003	0.035
	Sambucus canadensis	2	0.125	20	0.010	0.002	0.00004	0.045
	Spiraea alba	1	0.083	10	0.010	0.000	0.00001	0.031
	Ulmus rubra	3	0.250	91	0.039	1.081	0.028	0.106
	Vaccinium corymbosum	2	0.167	200	0.073	0.011	0.0002	0.080
	Viburnum recognitum	2	0.167	203	0.143	0.005	0.0001	0.103
Depression-Forest-Vernal Pool	Acer rubrum	8	0.667	506	0.212	17.688	0.455	0.445
	Acer saccharinum	9	0.722	258	0.168	22.648	0.744	0.545
	Acer saccharum	1	0.083	8	0.003	0.036	0.001	0.029
	Asimina triloba	2	0.167	100	0.070	0.013	0.0003	0.079
	Betula alleghaniensis	5	0.417	1025	0.423	1.525	0.034	0.291
	Betula lenta	3	0.250	37	0.038	0.170	0.012	0.100
	Carpinus caroliniana	2	0.190	51	0.033	0.058	0.003	0.075
	Carya ovata	1	0.083	6	0.003	0.002	0.00003	0.029
	Cephalanthus occidentalis	1	0.095	488	0.197	0.010	0.001	0.098
	Cornus amomum	1	0.083	33	0.007	0.005	0.0003	0.030
	Fagus grandifolia	1	0.117	18	0.013	1.440	0.074	0.068
	Fraxinus nigra	3	0.208	72	0.032	1.055	0.023	0.088
	Fraxinus pennsylvanica	5	0.401	296	0.103	4.561	0.189	0.231
	Hamamelis virginiana	2	0.167	30	0.018	0.005	0.0001	0.062
	Ilex verticillata	1	0.083	77	0.052	0.016	0.001	0.045
	Lindera benzoin	1	0.083	479	0.260	0.021	0.001	0.115
	Liriodendron tulipifera	2	0.167	63	0.035	2.019	0.046	0.083
	Nyssa sylvatica	4	0.306	315	0.162	1.332	0.031	0.166
	Ostrya virginiana	1	0.083	10	0.005	0.044	0.002	0.030
	Populus deltoides	2	0.166	146	0.026	5.534	0.111	0.101
	Quercus bicolor	2	0.148	27	0.013	2.221	0.087	0.083
	Quercus palustris	3	0.209	129	0.041	0.331	0.049	0.099
	Quercus rubra	1	0.104	18	0.009	0.082	0.002	0.039
	Rosa palustris	1	0.083	197	0.037	0.004	0.0002	0.040
	Salix nigra	2	0.167	27	0.006	0.018	0.001	0.058
	Salix sericea	1	0.083	25	0.008	0.001	0.0009	0.030
	Sambucus canadensis	1	0.083	275	0.083	0.005	0.001	0.056
	Tilia americana	2	0.146	20	0.010	0.183	0.004	0.053
	Ulmus americana	5	0.445	253	0.113	1.973	0.105	0.221

Table 17. Average forestry statistics by species for forest and shrub wetlands. Frequency refers to size class frequency (Mack 2004c). Species lists are aggregated and some species have geographically restricted distributions in Ohio wetlands.

Community	Species	frequency	relative frequency	density stems ha^{-1}	relative density	dominance m^2 ha^{-1}	relative dominance	importance value
	Ulmus rubra	4	0.350	132	0.058	0.747	0.029	0.146
	Vaccinium corymbosum	2	0.125	106	0.052	0.005	0.0001	0.059
	Viburnum prunifolium	2	0.167	17	0.017	0.004	0.0003	0.061
	Viburnum recognitum	2	0.125	215	0.104	0.005	0.0002	0.076
Depression-Shrub-Vernal Pool	Acer rubrum	6	0.458	356	0.132	8.168	0.268	0.286
	Acer saccharinum	6	0.492	262	0.107	10.678	0.354	0.318
	Acer saccharum	4	0.292	68	0.033	0.216	0.019	0.115
	Alnus serrulata	5	0.417	520	0.146	0.246	0.010	0.191
	Betula alleghaniensis	6	0.500	1183	0.219	1.683	0.267	0.329
	Betula nigra	7	0.583	200	0.056	4.017	0.167	0.269
	Carpinus caroliniana	2	0.200	37	0.031	0.105	0.007	0.079
	Carya laciniosa	1	0.083	3	0.002	0.001	0.002	0.028
	Carya ovalis	1	0.083	33	0.010	0.147	0.002	0.032
	Carya ovata	1	0.083	17	0.003	0.004	0.001	0.029
	Celtis occidentalis	4	0.333	17	0.009	0.298	0.011	0.118
	Cephalanthus occidentalis	1	0.099	1581	0.500	0.041	0.016	0.205
	Cornus amomum	1	0.116	67	0.025	0.003	0.003	0.048
	Cornus racemosa	5	0.417	360	0.101	0.108	0.004	0.174
	Cornus sericea	1	0.083	125	0.043	0.003	0.0002	0.042
	Fagus grandifolia	1	0.083	25	0.005	0.006	0.001	0.030
	Fraxinus nigra	4	0.300	145	0.223	4.170	0.226	0.250
	Fraxinus pennsylvanica	6	0.507	204	0.090	2.985	0.254	0.284
	Ilex verticillata	1	0.116	200	0.031	0.064	0.035	0.061
	Lindera benzoin	1	0.083	153	0.067	0.024	0.003	0.051
	Nyssa sylvatica	4	0.333	159	0.030	0.572	0.086	0.150
	Populus heterophylla	4	0.333	250	0.070	3.197	0.345	0.250
	Quercus bicolor	3	0.227	40	0.016	4.075	0.116	0.120
	Quercus palustris	3	0.260	57	0.018	1.549	0.175	0.151
	Ribes americanum	1	0.083	14	0.005	0.0003	0.00003	0.030
	Rosa palustris	1	0.083	208	0.072	0.005	0.002	0.052
	Salix amygdaloides	2	0.167	10	0.005	0.033	0.001	0.058
	Salix discolor	3	0.250	2500	0.243	0.344	0.256	0.250
	Salix exigua	2	0.125	12	0.003	0.002	0.0001	0.043
	Salix lucida	2	0.167	925	0.090	0.140	0.104	0.120
	Salix sericea	1	0.083	688	0.110	0.014	0.005	0.066
	Sambucus canadensis	1	0.083	3	0.002	0.0001	0.00001	0.028

Table 17. Average forestry statistics by species for forest and shrub wetlands. Frequency refers to size class frequency (Mack 2004c). Species lists are aggregated and some species have geographically restricted distributions in Ohio wetlands.

Community	Species	frequency	relative frequency	density stems ha^{-1}	relative density	dominance m^2 ha^{-1}	relative dominance	importance value
	Toxicodendron vernix	4	0.333	300	0.029	0.171	0.127	0.163
	Ulmus americana	3	0.262	44	0.027	1.054	0.132	0.140
	Ulmus rubra	3	0.264	120	0.040	1.434	0.072	0.125
	Vaccinium corymbosum	10	0.083	213	0.043	0.004	0.002	0.043
	Viburnum prunifolium	1	0.083	17	0.006	0.000	0.00002	0.030
	Viburnum recognitum	1	0.117	320	0.059	0.008	0.002	0.059
Depression-Forest-Wet Woods	Acer rubrum	6	0.459	160	0.062	6.983	0.173	0.231
	Acer saccharinum	7	0.583	223	0.145	23.787	0.620	0.450
	Acer saccharum	5	0.417	110	0.059	1.494	0.055	0.177
	Aronia melanocarpa	2	0.167	380	0.051	0.034	0.001	0.073
	Betula alleghaniensis	4	0.333	80	0.054	0.047	0.001	0.130
	Carpinus caroliniana	2	0.125	20	0.014	0.034	0.001	0.047
	Carya cordiformis	3	0.250	60	0.032	0.027	0.001	0.094
	Carya ovata	4	0.333	130	0.077	3.223	0.127	0.179
	Cornus racemosa	1	0.083	120	0.071	0.002	0.0001	0.052
	Fagus grandifolia	5	0.417	200	0.136	0.953	0.022	0.192
	Fraxinus nigra	7	0.583	170	0.101	1.844	0.073	0.252
	Fraxinus pennsylvanica	5	0.375	250	0.138	0.367	0.014	0.176
	Fraxinus profunda	7	0.583	130	0.099	8.837	0.186	0.290
	Ilex verticillata	6	0.500	4080	0.547	3.506	0.092	0.380
	Lindera benzoin	1	0.083	503	0.297	0.010	0.0003	0.127
	Liriodendron tulipifera	1	0.083	10	0.007	0.830	0.019	0.036
	Populus heterophylla	1	0.083	20	0.015	0.022	0.0005	0.033
	Quercus bicolor	4	0.306	60	0.039	3.604	0.130	0.158
	Quercus palustris	5	0.417	140	0.083	4.152	0.164	0.221
	Quercus rubra	2	0.125	20	0.013	0.025	0.001	0.046
	Ulmus americana	5	0.444	267	0.160	2.658	0.070	0.225
	Ulmus rubra	4	0.292	330	0.196	1.425	0.056	0.181
	Vaccinium corymbosum	1	0.083	80	0.011	0.088	0.002	0.032
	Viburnum recognitum	3	0.250	1175	0.166	1.537	0.040	0.152
Riverine-Forest	Acer rubrum	7	0.555	187	0.184	7.850	0.239	0.326
	Acer saccharinum	8	0.667	375	0.211	19.479	0.492	0.456
	Betula nigra	1	0.083	10	0.009	0.830	0.030	0.041
	Carpinus caroliniana	3	0.209	50	0.033	0.036	0.001	0.081
	Carya cordiformis	1	0.083	20	0.022	0.000	0.00001	0.035
	Carya ovalis	1	0.083	10	0.005	0.002	0.0001	0.030

Table 17. Average forestry statistics by species for forest and shrub wetlands. Frequency refers to size class frequency (Mack 2004c). Species lists are aggregated and some species have geographically restricted distributions in Ohio wetlands.

Community	Species	frequency	relative frequency	density stems ha^{-1}	relative density	dominance $m^2\ ha^{-1}$	relative dominance	importance value
	Carya ovata	2	0.167	20	0.015	0.989	0.026	0.069
	Cephalanthus occidentalis	1	0.104	463	0.323	0.040	0.001	0.143
	Cornus sp.	1	0.083	90	0.101	0.002	0.00004	0.062
	Fraxinus pennsylvanica	8	0.625	325	0.192	6.440	0.161	0.326
	Ilex verticillata	2	0.125	225	0.294	0.009	0.0003	0.140
	Lindera benzoin	1	0.111	213	0.163	0.005	0.0001	0.091
	Populus deltoides	1	0.083	50	0.026	20.402	0.480	0.197
	Populus heterophylla	2	0.167	40	0.021	0.766	0.018	0.069
	Quercus bicolor	3	0.208	50	0.067	11.235	0.325	0.200
	Quercus palustris	3	0.229	68	0.082	12.748	0.329	0.213
	Ulmus americana	8	0.667	130	0.069	3.255	0.077	0.271
	Ulmus rubra	3	0.250	63	0.045	0.775	0.021	0.105
Riverine-Shrub	Acer rubrum	6	0.500	305	0.122	5.792	0.294	0.305
	Acer saccharinum	6	0.479	200	0.115	4.970	0.231	0.275
	Alnus serrulata	3	0.208	658	0.379	0.046	0.007	0.198
	Betula nigra	4	0.292	211	0.080	2.047	0.165	0.179
	Celtis occidentalis	1	0.083	10	0.008	0.123	0.004	0.032
	Cephalanthus occidentalis	1	0.083	1644	0.567	0.032	0.007	0.219
	Fraxinus pennsylvanica	6	0.472	308	0.186	12.168	0.437	0.365
	Ilex verticillata	1	0.083	350	0.127	0.007	0.0003	0.070
	Juglans nigra	1	0.083	10	0.008	0.123	0.004	0.032
	Quercus palustris	2	0.167	25	0.018	3.087	0.332	0.172
	Salix nigra	2	0.167	60	0.041	0.839	0.042	0.083
	Spiraea tomentosa	1	0.083	70	0.033	0.001	0.001	0.039
	Ulmus americana	4	0.292	85	0.064	1.457	0.049	0.135
	Ulmus rubra	1	0.083	13	0.003	0.301	0.014	0.033

Table 18. Background information on wetland type, location, number, amount, and monitoring period for wetland mitigation. Insert information for each mitigation wetland required to be constructed.

	Impacted Wetland(s)	Mitigation Wetland(s)	(add columns as needed)
a. Name of project(s)			
b. County where project(s) located			
c. Latitude and Longitude of project(s) (DD.DDDDD)			
d. Name of watershed(s) where wetland(s) are located			
e. 11 and 14 Digit HUC code(s) where wetland(s) located			
f. HGM class of the site(s) (Table 1A, 15)[22].			
g. Duration of inundation/saturation[23] List hydroperiod (~%) of each site (e.g. ~30 %seasonally inundated, ~70% regularly inundated, etc.)			
h. Dominant plant community(ies) (Table 1B)[24] List plant community (~%), e.g. ~20% marsh, ~80% wet meadow -fen			
I. Ecological region where site(s) will be located (ECBP, EOLP, WAP, IP, MIDP, HELP) (Figure 1)			
j. Length of monitoring period in years Specify number of years of monitoring required, e.g. 5, 10, 15 etc.			
k. Monitoring Frequency Specify monitoring frequency, e.g. every year (annual), every other year (biennial), every third year (triennial), etc.			
l. The number of individual wetland areas that were impacted or number of individual mitigation wetlands that are to be constructed			
m. Total acreage of wetlands in hectares (acres)			

[22] The following HGM classes should be used: depression, impoundment-human, impoundment-beaver, riverine-headwater, riverine-mainstem, riverine-channel, slope, fringing, coastal, bog (weakly ombrotrophic), bog (moderately-strongly ombrotrophic).

[23] The following duration classes should be used: permanently inundated, regularly inundated, seasonally inundated, permanently saturated, regularly saturated, seasonally saturated.

[24] The following plant community classes should be used: swamp forest, bog forest, forest seep, marsh, wet meadow-fen, wet meadow-other, sphagnum bog, shrub swamp, tall shrub bog, tall shrub fen.

Table 19. Summary of applicable performance standards.

performance standard	performance standard sections	check all that apply to mitigation site	insert requested information and/or specify an alternative approved performance standard
Acreage	2.1.1		specify acreage of mitigation wetland(s)
Basin morphometry	2.1.2		If applicable list alternative standard, e.g. more or less than 50% of perimeter with side slopes <15:1
Perimeter:Area ratio	2.1.3		If applicable list alternative standard, e.g. approved p:a ratio <75% of impacted wetland(s)
Hydrologic regime	2.1.4		If applicable specify alternative goals
Unvegetated open water	2.2.1		If applicable list alternative standard, e.g. more than 10% wetland area can be unvegetated open water
Native perennial hydrophytes	2.2.2		If applicable list alternative standard, e.g. less than 75% of wetland area covered perennial, native hydrophytes
Invasive species	2.2.3		If applicable list alternative standard, e.g. more than 5% of wetland area covered by invasive species
Vegetation - Ecologic standards	2.2.4		List VIBI(s) (-E, -F, -SH) to be used[25] List minimum score at end of monitoring period
Woody spp. establishment (Shrub Swamps)	2.2.5.1		If applicable specify alternative goals
Woody spp. establishment (Swamp Forests)	2.2.5.2		If applicable specify alternative goals
Amphibians - Ecologic standards	2.3		List ecoregion of mitigation List minimum score at end of monitoring period
Other taxa groups - Ecologic standards	2.4		Include description of performance standard, monitoring requirements, and data analysis and presentation
Biogeochemical standards	2.5		If applicable specify alternative goals or parameters
Ecological services	2.6		Include description of standard, monitoring and data analysis requirements

[25] Note: where an intermediate community is standard, score from final community should be calculated and reported even though conformance with performance standard is determined by intermediate community score, e.g. for mitigation of a wetland forest, a shrub community may be an intermediate community step and score from VIBI-SHRUB is used to determine conformance; but the score from the VIBI-F should also be calculated and reported.

Table 20. Summary of applicable monitoring and data analysis requirements.

performance standard	standard protocol	check all that apply	Describe alternative monitoring and/or data analysis requirements
Acreage	4.1.1, 6.1.1		
Basin morphometry	4.1.2, 6.1.2		
Perimeter:Area ratio	4.1.3, 6.1.3		
Hydrologic regime	4.1.4, 6.1.4		
Unvegetated open water	4.2.1, 6.2.1		
Native perennial hydrophytes	4.2.2, 6.2.2		
Invasive species	4.2.3, 6.2.3		
Vegetation sampling - fixed plots only	4.2.6.1, 6.2.4, 6.2.5, 6.2.6		
Vegetation sampling - fixed and random plots	4.2.6.2, 6.2.4, 6.2.5, 6.2.6		
Amphibians sampling	4.3, 6.3		
Other taxa groups - Ecologic standards	4.4, 6.4		
Biogeochemical standards	4.5, 6.5		
Ecological services	4.6, 6.6		

Table 21. Generic Credit Release Schedule.

Release of initial 20% of credits	Release of next 10% of credits	Release of next 20% of credits	Release of next 20% of credits.	Release of last 20%
Construction completed within 6 months of release.	at least 30% of the area of the mitigation bank meets wetland criteria goal HGM class and hydroperiod achieved	at least 90% of the area of the mitigation bank meets wetland criteria greater than 75% of area of mitigation bank vegetated by perennial native hydrophytes less than 5% of area of mitigation bank vegetated by invasive species data shows that mitigation bank on a trajectory to meet performance standards by the end of the monitoring period	80% of area of mitigation bank has met all performance standards or data shows that mitigation bank on a trajectory to meet performance standards by the end of the monitoring period	last 20% of credits will be held until all performance criteria are met for entire bank

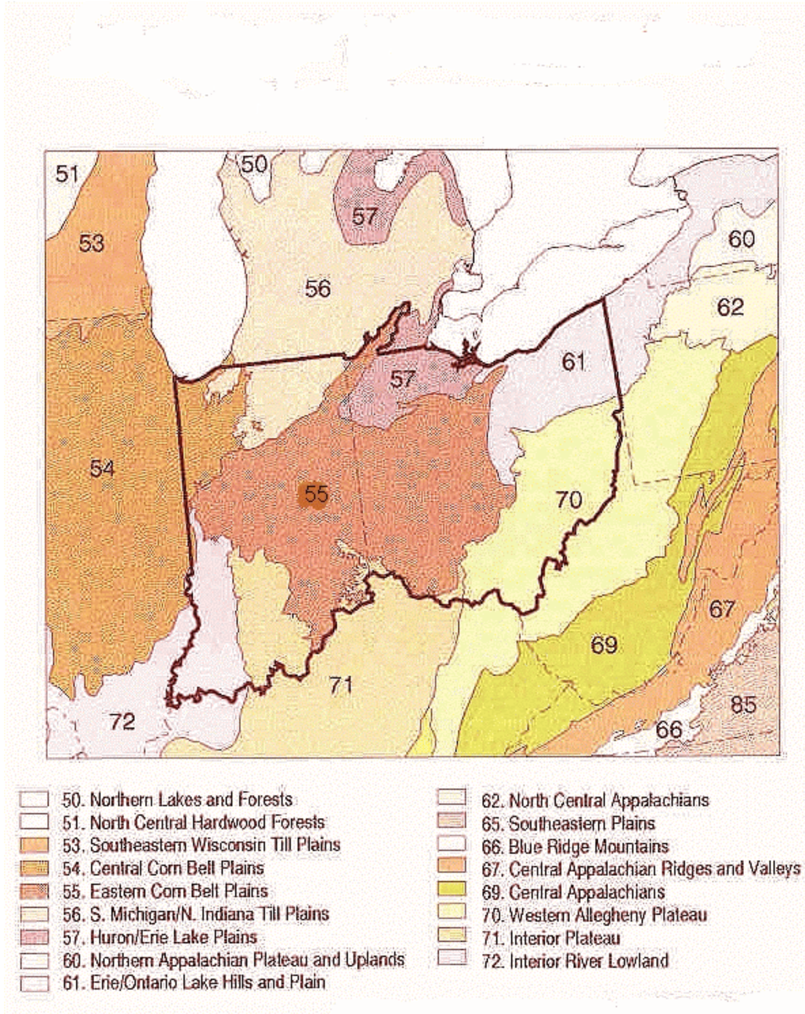


Figure 1. Ecoregions of Ohio, Indiana, and neighboring states. The Eastern Corn Belt Plains (ECBP) is Region 55, the Huron-Erie Lakes Plains (HELP) is Region 57, the Erie-Ontario Drift and Lakes Plains (EOLP) is Region 61, and the Western Allegheny Plateau (WAP) is Region 70. There are also small areas of Region 56 (Michigan-Indiana Till Plains) and Region 71 (Interior Plateau) in far northwest and southwest Ohio, respectively.

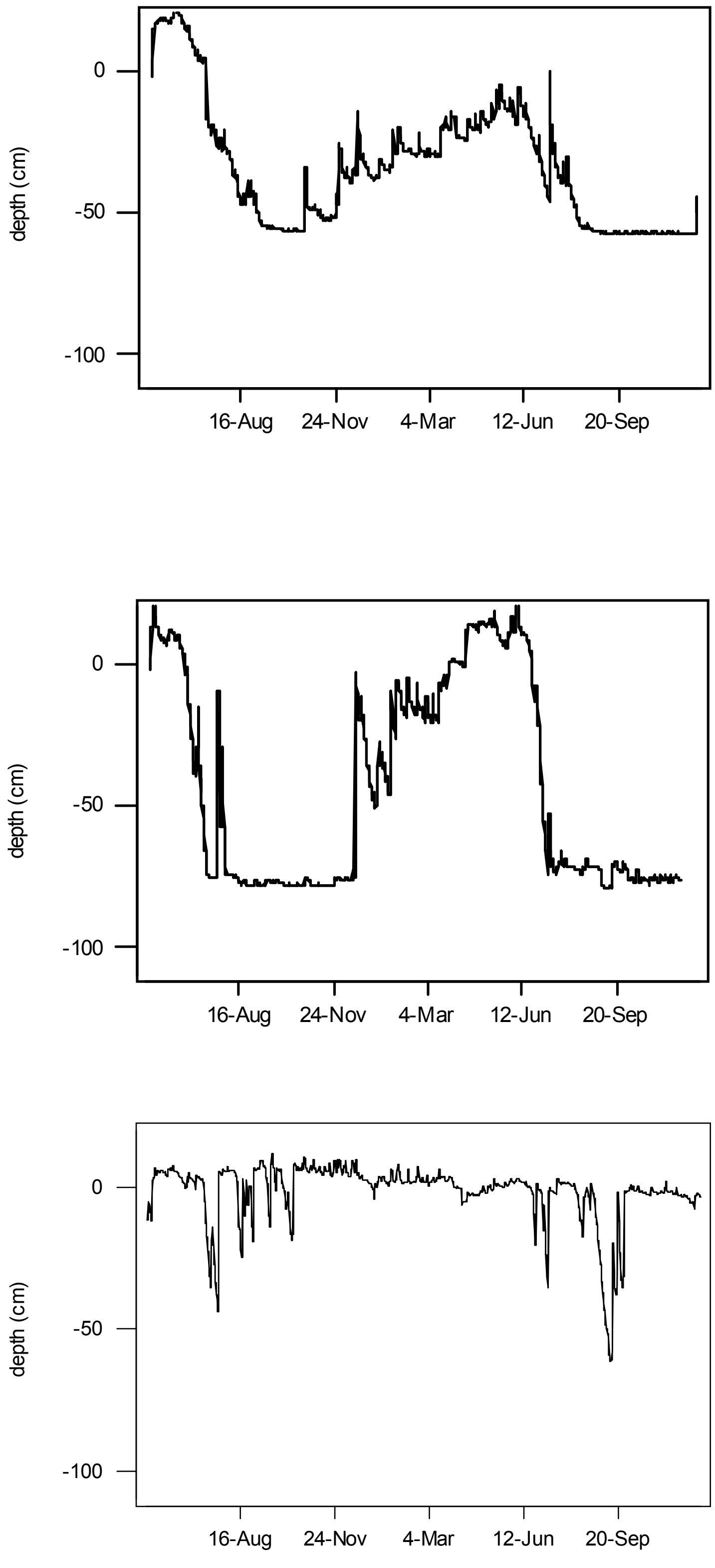


Figure 2. Typical hydrological signatures for depressions: A) depression with seasonal hydroperiod with regular to semipermanent inundation in some areas of wetland; B) depression with strong seasonal hydroperiod (wetland dries down completely in most years); C) permanently inundated depression with small seasonal signature during late summer.

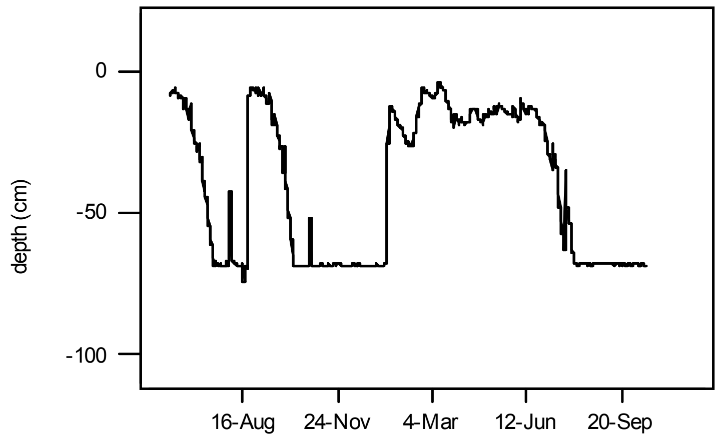


Figure 3. Hydrologic signature of an impoundment. Natural beaver pond on floodplain of Eagle Creek. Strong seasonal hydrology with occasional abrupt refilling of wetland.

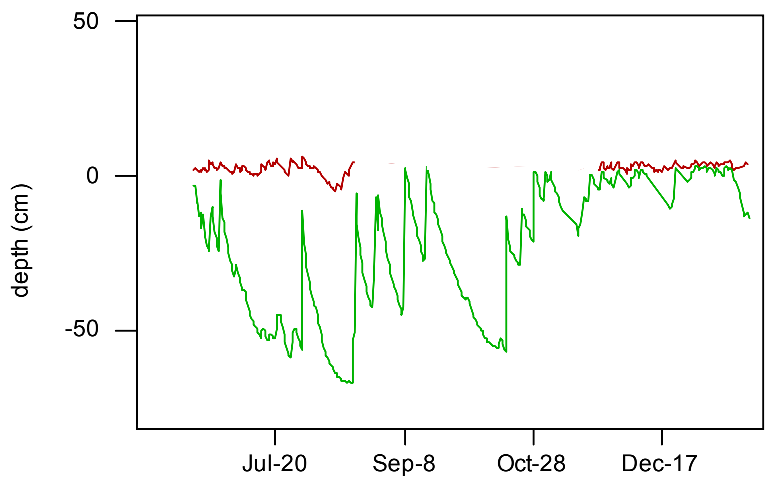


Figure 4. Hydrologic signature of a two slope wetlands. Upper line is slope wetland with hydrologic head (water is pushed up the well screen above ground level) and permanently saturated conditions (gap in hydrograph is due to data logger damage from deer). Lower line is slope wetland with a more seasonally saturated hydrology. Note summer decline in ground water inputs with multiple recharge events .

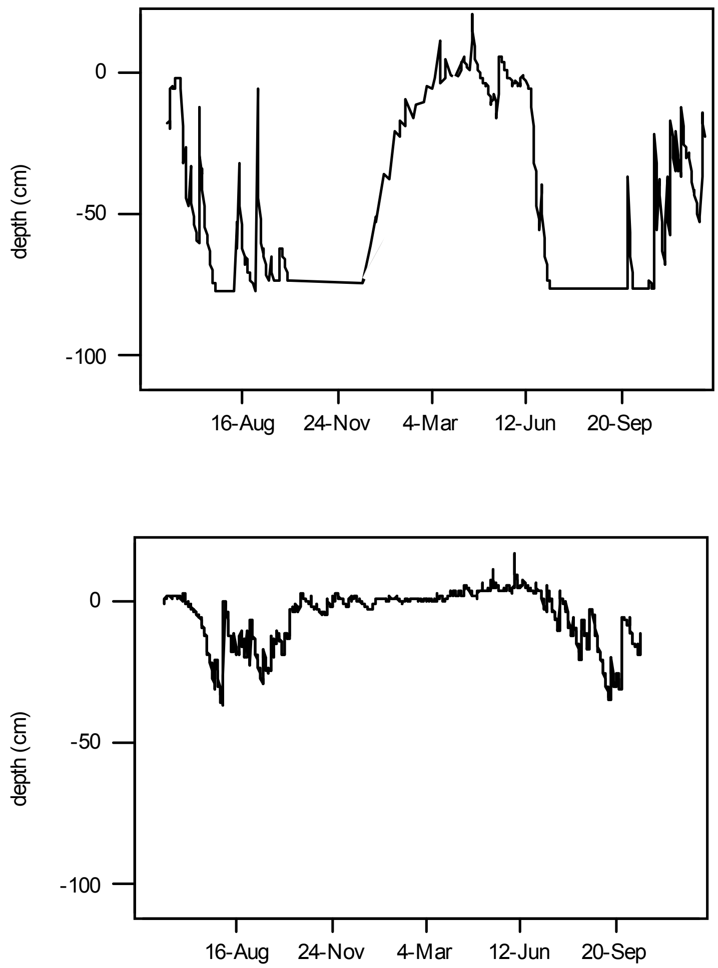


Figure 5. Hydrologic signature of riverine wetlands: A) Hydrologic signature of riverine mainstem wetland. Seasonally inundated with occasional flood events during the growing season which partially refill the wetland; B) Hydrologic signature of riverine headwater wetland. Permanently saturated and regularly inundated with ground water input moderating seasonal signature.

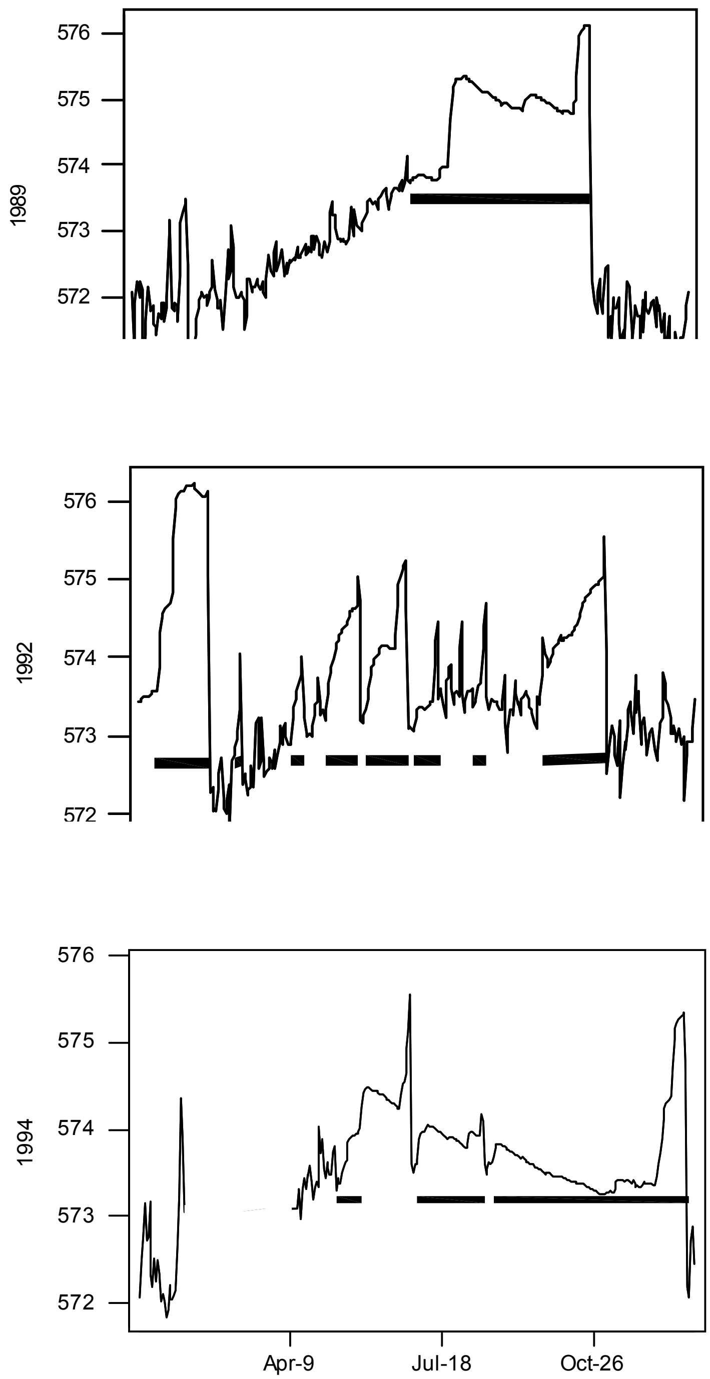
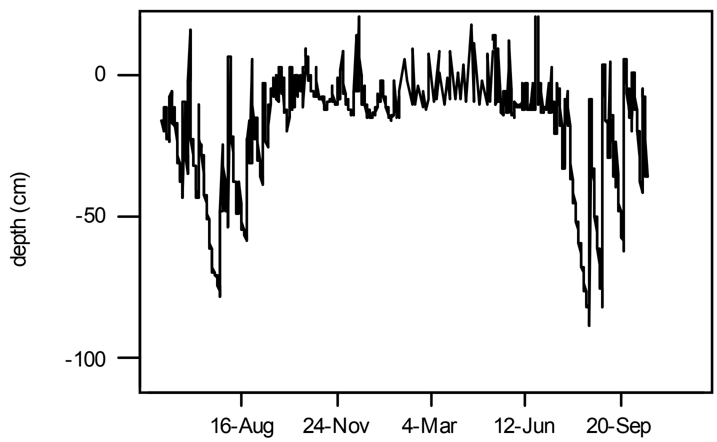


Figure 6. Hydrographs for Lake Erie Coastal Marsh (Drowned River Mouth) (Old Woman Creek, Huron, Ohio). Dark horizontal bars represent periods when mouth of river closed by sand bar. Y-axis is in feet above see level.



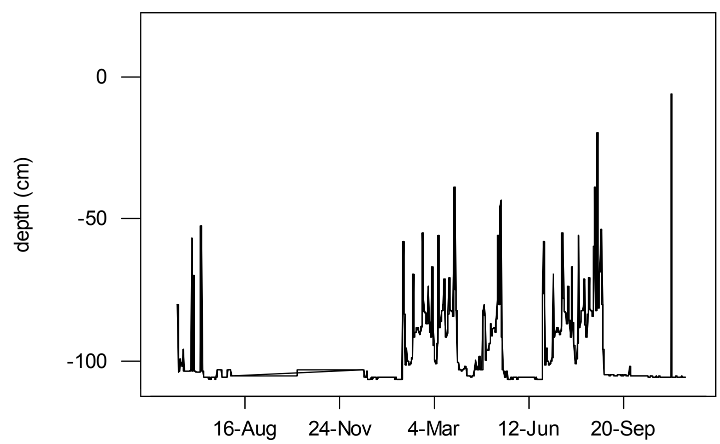
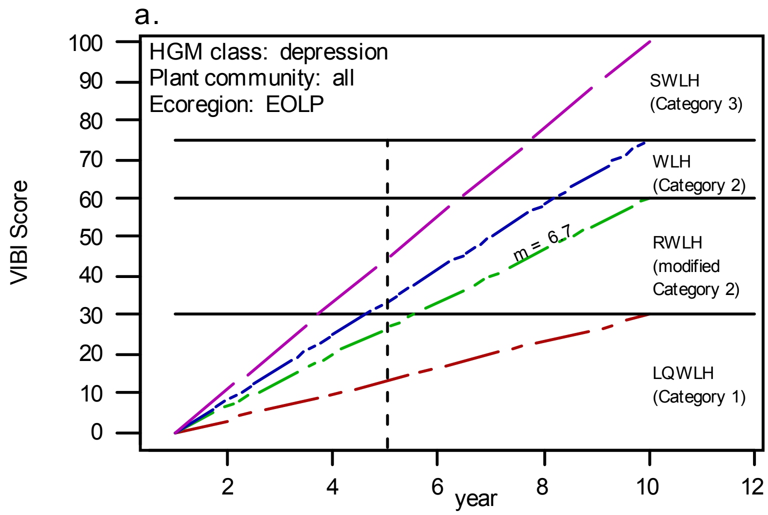


Figure 7. Hydrologic signature of stormwater influenced wetlands: A) permanently inundated riverine headwater wetland with strong stormwater influence from surrounding suburbanization; B) permanently inundated mitigation wetland with frequent storm water events from surrounding development. Well is basically dry except during large storm events. Note disconnection between surface and subsurface hydrology.



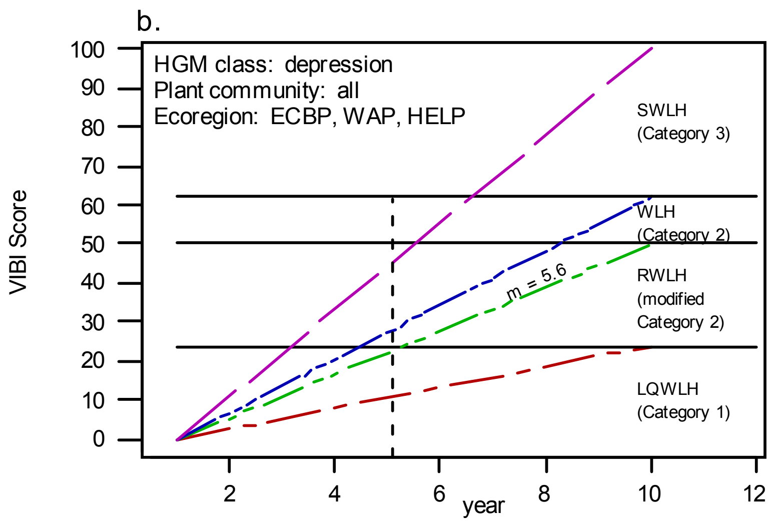


Figure 8. Performance curves for Vegetation IBI score for DEPRESSIONAL wetlands in the a) EOLP and b) all other ecoregions in Ohio. SWLH = Superior Wetland Habitat, WLH = Wetland Habitat, RWLH = Restorable Wetland Habitat, LQWLH = Limited Quality Wetland Habitat. Categories refer to wetland antidegradation categories in OAC Rule 3745-1-54. “m” = minimum slope of VIBI performance curve to achieve WLH (Category 2) VIBI score within 10 years.

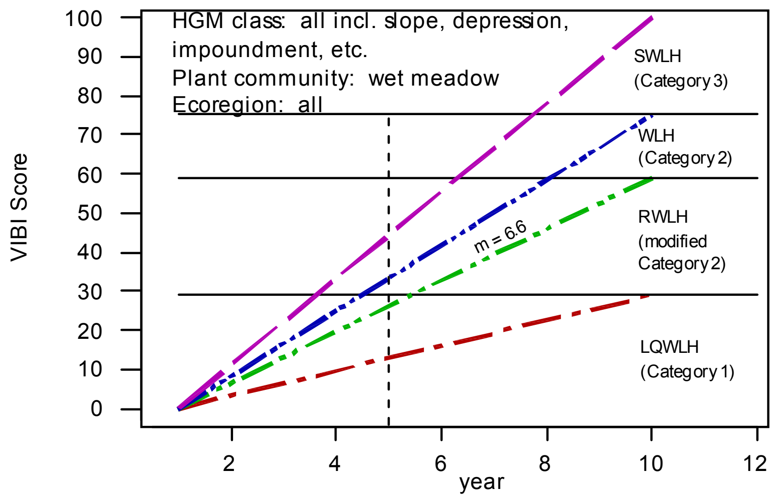


Figure 9. Performance curves for Vegetation IBI score for WET MEADOW wetlands for all HGM classes and ecoregions. SWLH = Superior Wetland Habitat, WLH = Wetland Habitat, RWLH = Restorable Wetland Habitat, LQWLH = Limited Quality Wetland Habitat. Categories refer to wetland antidegradation categories in OAC Rule 3745-1-54. “m” = minimum slope of VIBI performance to achieve WLH (Category 2) VIBI score within 10 years.

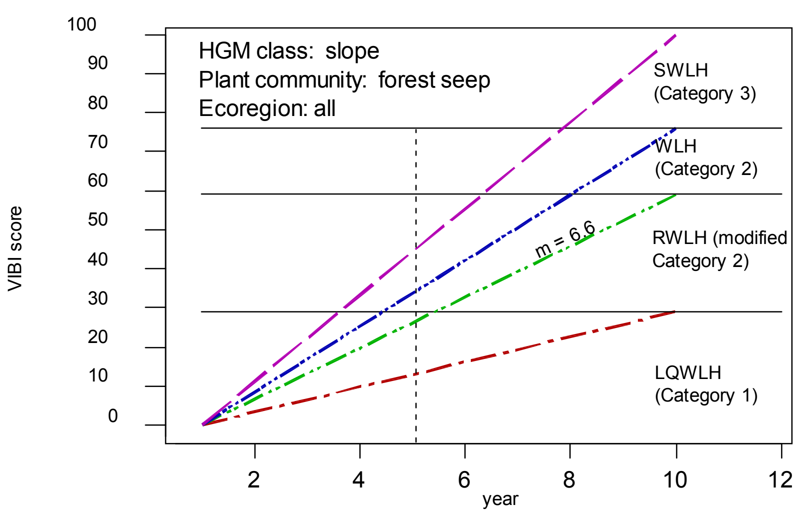


Figure 10. Performance curves for Vegetation IBI score for FOREST SEEP wetlands (HGM class = SLOPE) in all ecoregions. SWLH = Superior Wetland Habitat, WLH = Wetland Habitat, RWLH = Restorable Wetland Habitat, LQWLH = Limited Quality Wetland Habitat. Categories refer to wetland antidegradation categories in OAC Rule 3745-1-54. “m” = minimum slope of VIBI performance curve to achieve WLH (Category 2) VIBI score within 10 years.

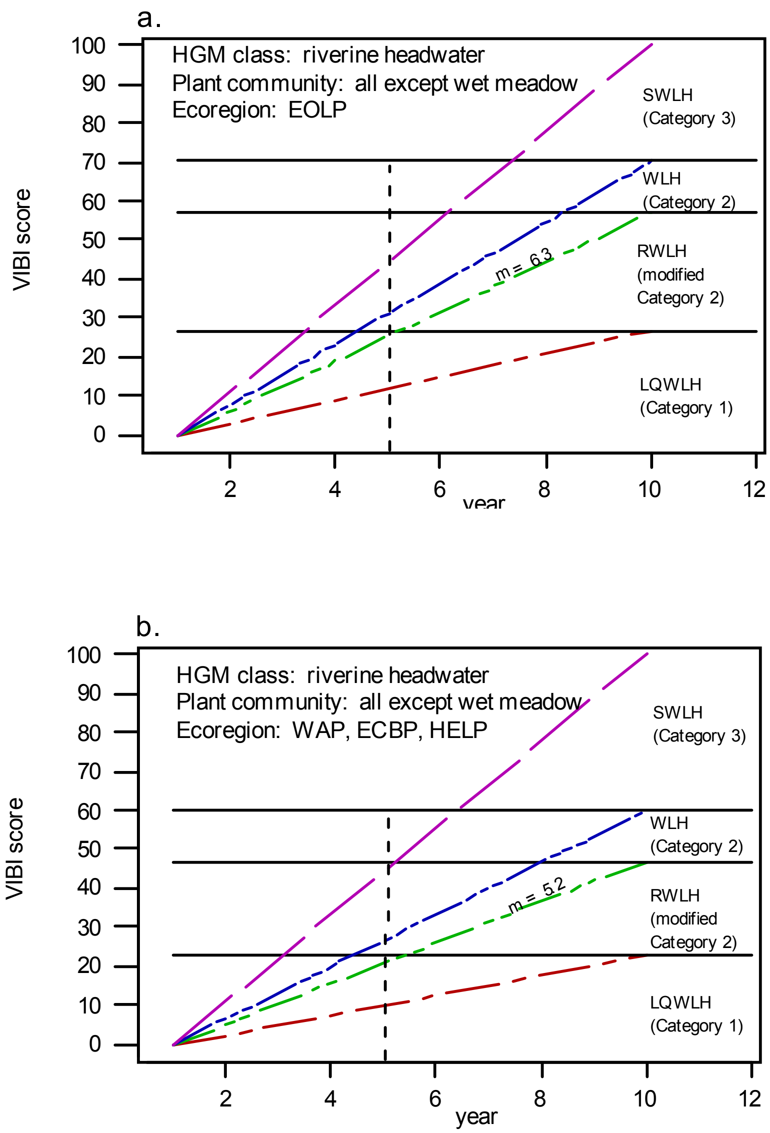


Figure 11. Performance curves for Vegetation IBI score for RIVERINE HEADWATER wetlands in the a) EOLP and b) all other ecoregions in Ohio. SWLH = Superior Wetland Habitat, WLH = Wetland Habitat, RWLH = Restorable Wetland Habitat, LQWLH = Limited Quality Wetland Habitat. Categories refer to wetland antidegradation categories in OAC Rule 3745-1-54. “m” = minimum slope of VIBI performance curve to achieve WLH (Category 2) VIBI score within 10 years.

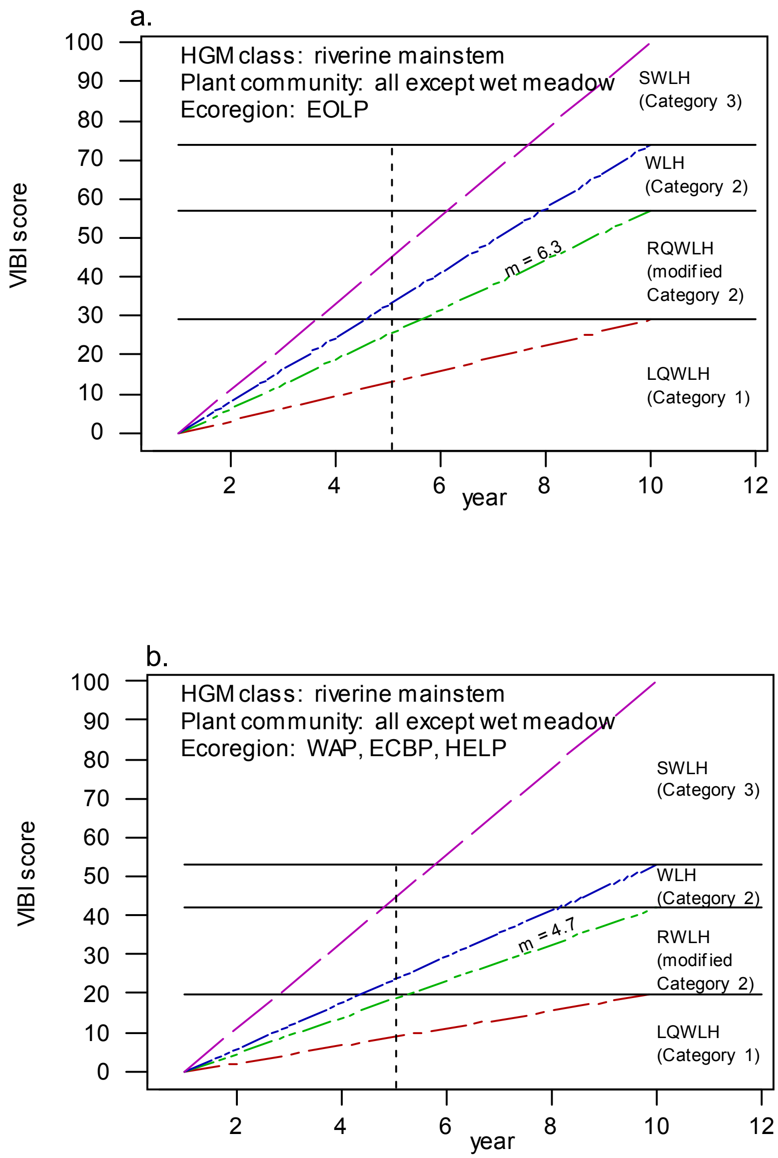
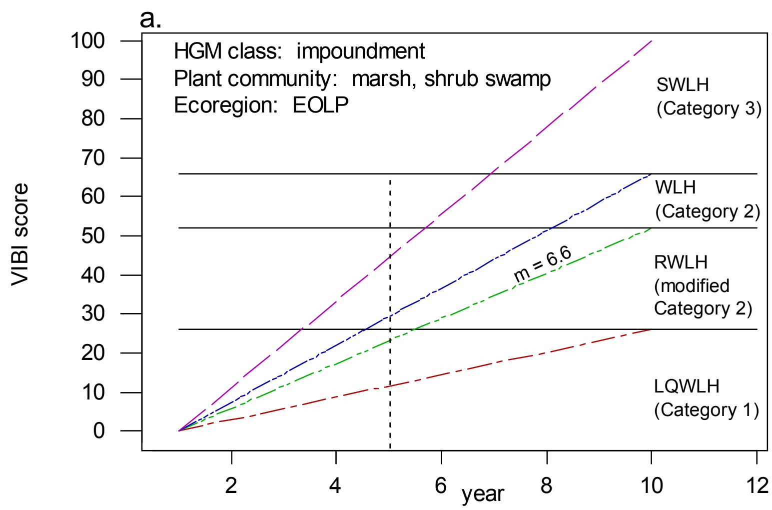


Figure 12. Performance curves for Vegetation IBI score for RIVERINE MAINSTEM wetlands in the a) EOLP and b) all other ecoregions in Ohio. SWLH = Superior Wetland Habitat, WLH = Wetland Habitat, RWLH = Restorable Wetland Habitat, LQWLH = Limited Quality Wetland Habitat. Categories refer to wetland antidegradation categories in OAC Rule 3745-1-54. "m" = minimum slope of VIBI performance curve to achieve WLH (Category 2) VIBI score within 10 years.



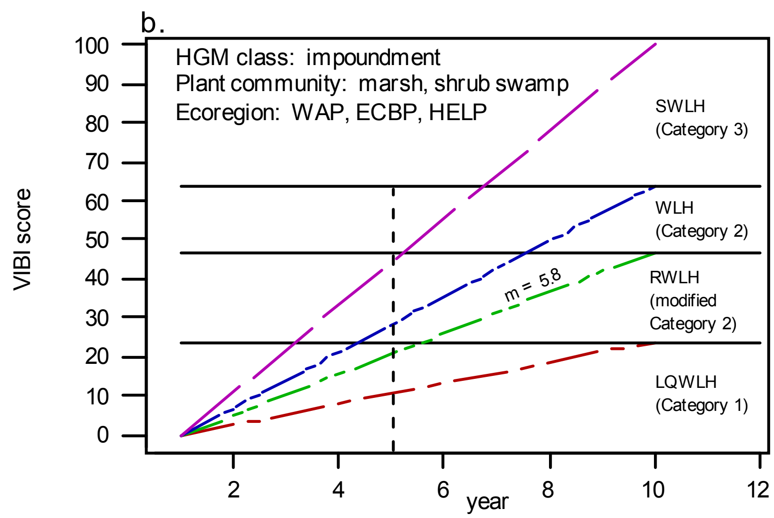


Figure 13. Performance curves for Vegetation IBI score for IMPOUNDMENT wetlands in the a) EOLP and b) all other ecoregions in Ohio. SWLH = Superior Wetland Habitat, WLH = Wetland Habitat, RWLH = Restorable Wetland Habitat, LQWLH = Limited Quality Wetland Habitat. Categories refer to wetland antidegradation categories in OAC Rule 3745-1-54. “m” = minimum slope of VIBI performance curve to achieve WLH (Category 2) VIBI score within 10 years.

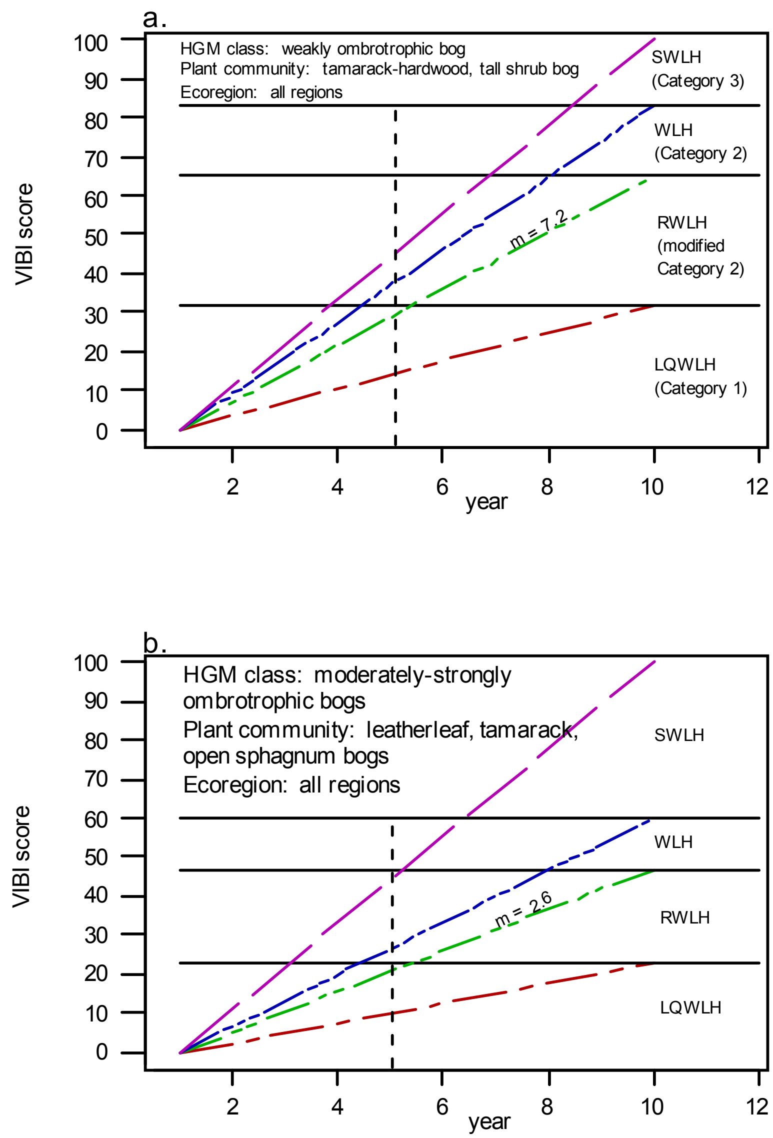


Figure 14. Performance curves for Vegetation IBI score for BOG wetlands in the a) WEAKLY OMBROTROPHIC BOGS b) MODERATELY TO STRONGLY OMBROTROPHIC bogs in all regions. SWLH = Superior Wetland Habitat, WLH = Wetland Habitat, RWLH = Restorable Wetland Habitat, LQWLH = Limited Quality Wetland Habitat. Most bogs are regulated as Category 3 wetlands regardless of their condition (OAC Rule 3745-1-54). “m” = minimum slope of VIBI performance curve to achieve WLH VIBI score within 10 years.

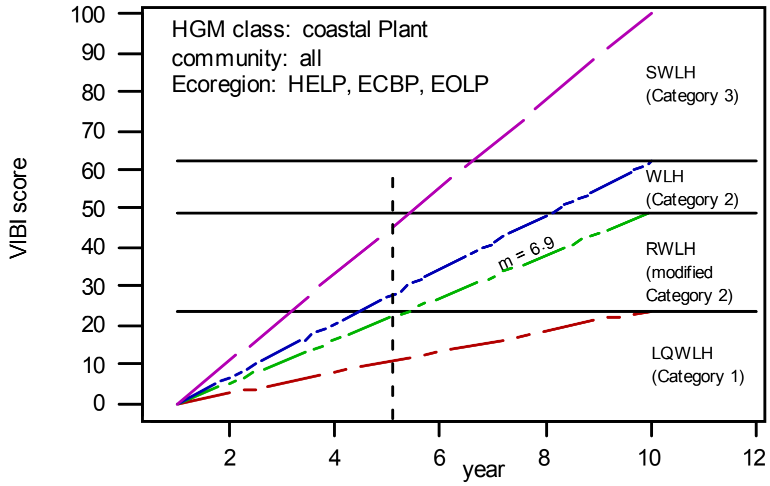


Figure 15. Performance curves for Vegetation IBI score for Lake Erie COASTAL wetlands in all ecoregions. SWLH = Superior Wetland Habitat, WLH = Wetland Habitat, RWLH = Restorable Wetland Habitat, LQWLH = Limited Quality Wetland Habitat. Categories refer to wetland antidegradation categories in OAC Rule 3745-1-54. Note: many coastal wetlands are regulated as Category 3 wetlands regardless of condition. "m" = minimum slope of VIBI performance curve to achieve WLH (Category 2) VIBI score within 10 years.

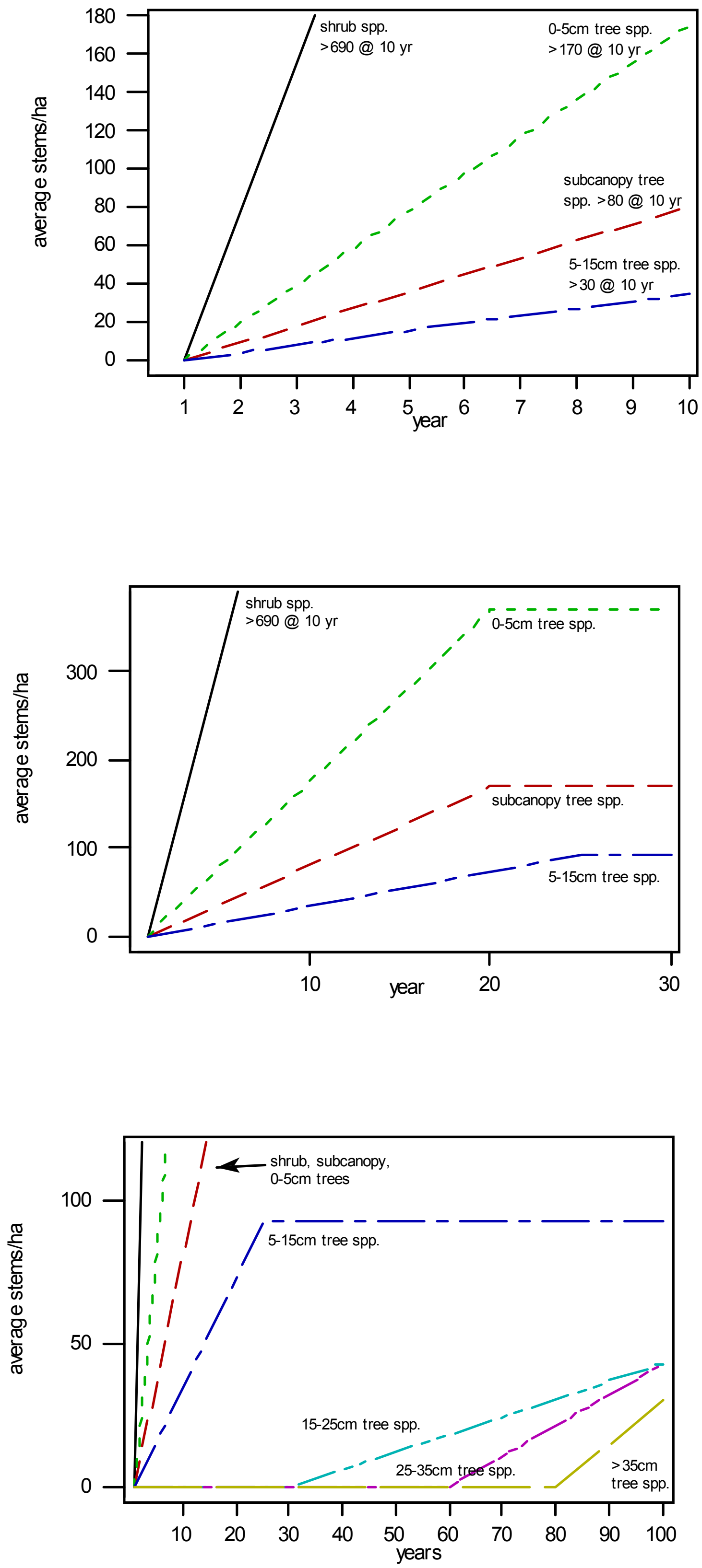


Figure 16. Hypothetical performance curves for tree and shrub establishment at 10, 30, and 100 years derived from reference wetland data for DEPRESSIONAL wetland FORESTS ("vernal pools").

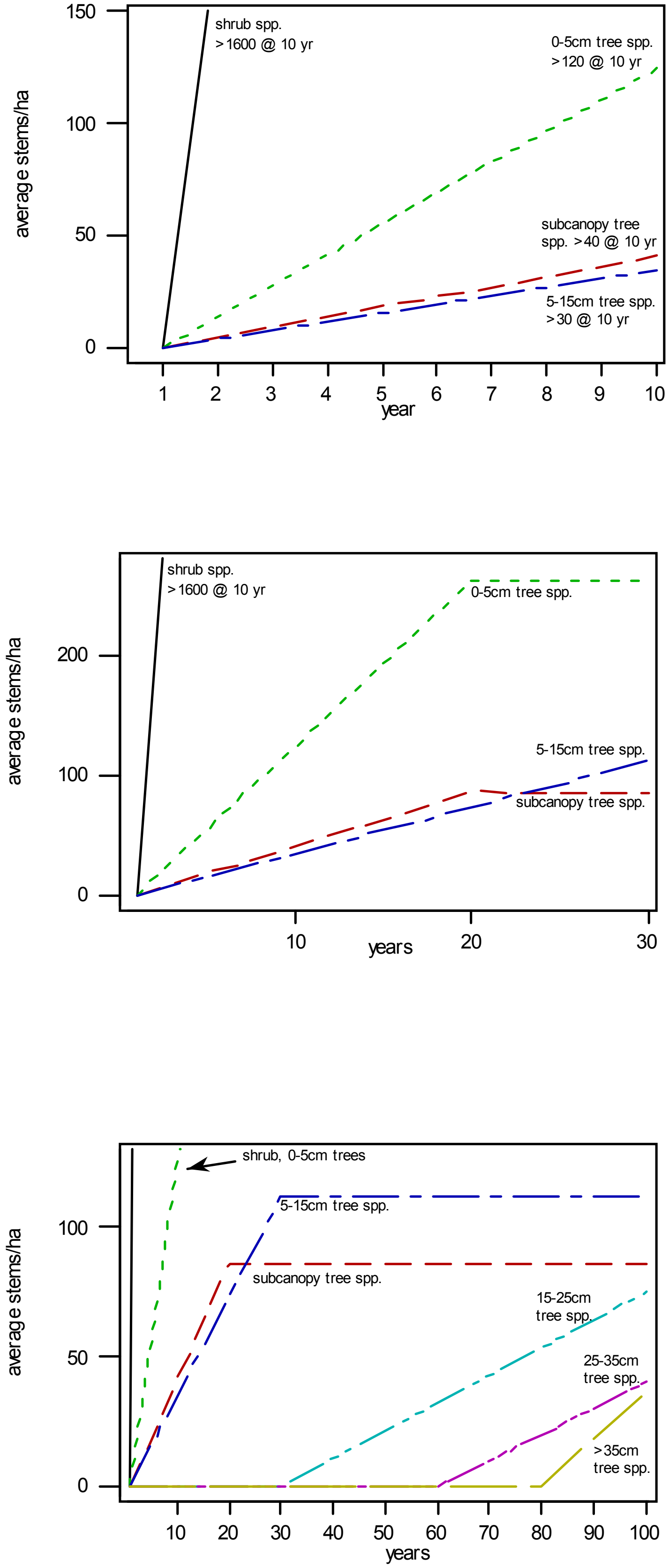


Figure 17. Hypothetical performance curves for tree and shrub establishment at 10, 30, and 100 years derived from reference wetland data for DEPRESSIONAL wetland SHRUB SWAMPS ("vernal pools").

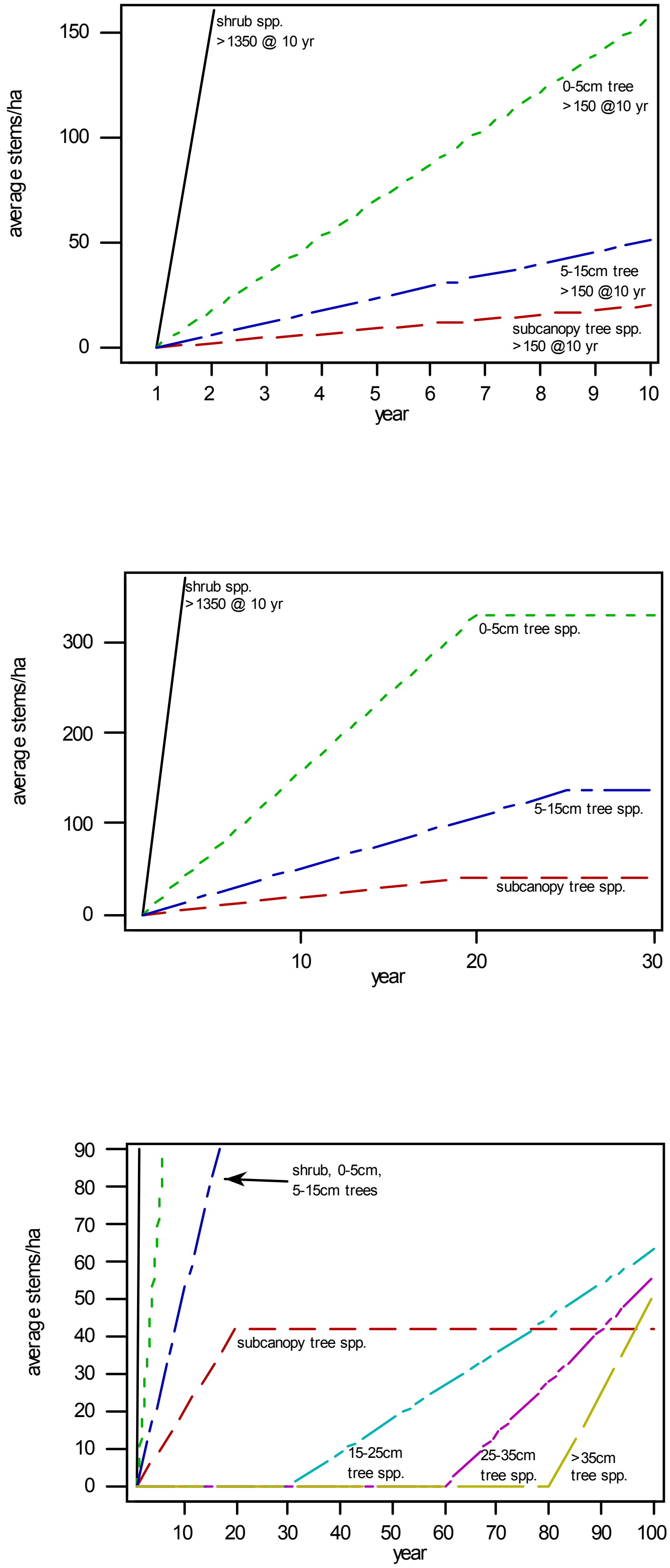


Figure 18. Hypothetical performance curves for tree and shrub establishment at 10, 30, and 100 years derived from reference wetland data for DEPRESSIONAL (flats) wetland FORESTS ("wet woods").

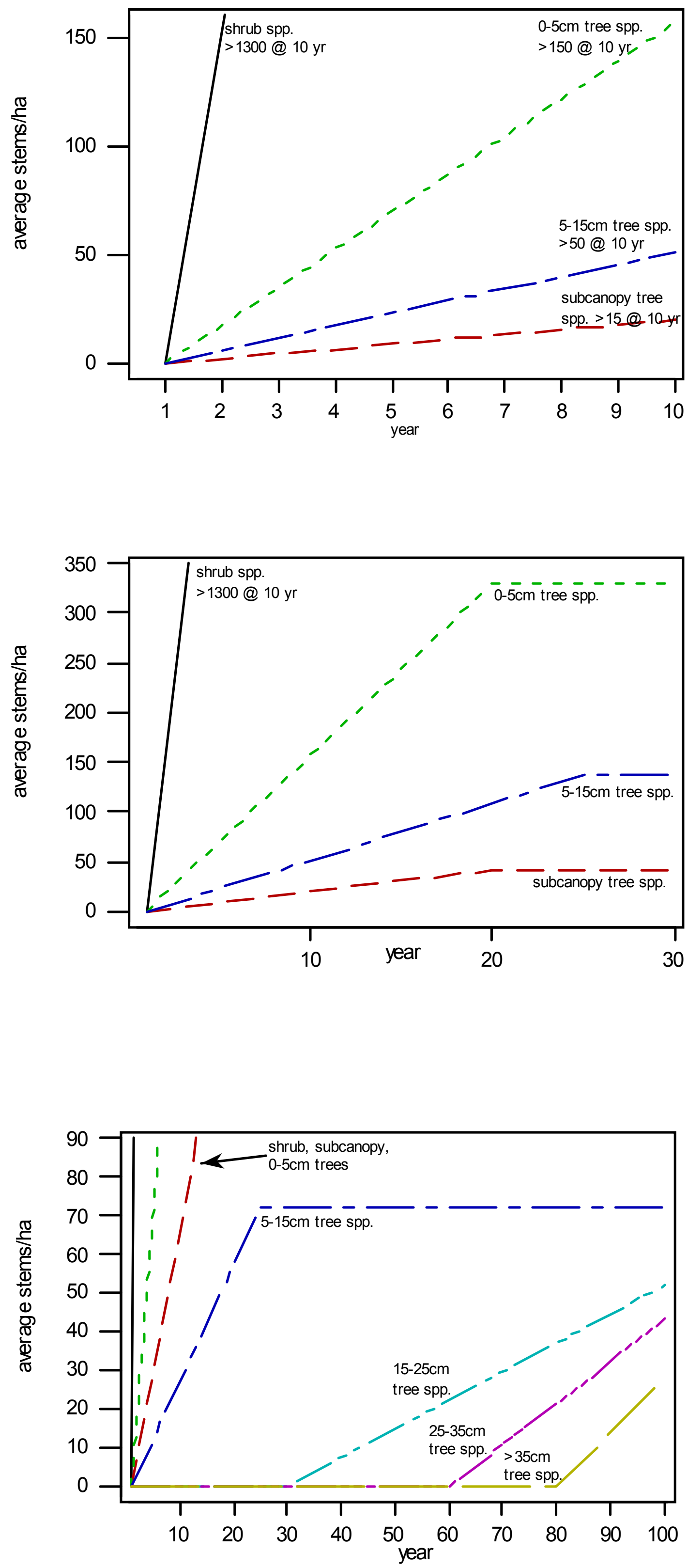


Figure 19. Hypothetical performance curves for tree and shrub establishment at 10, 30, and 100 years derived from reference wetland data for RIVERINE MAINSTEM wetland FORESTS.

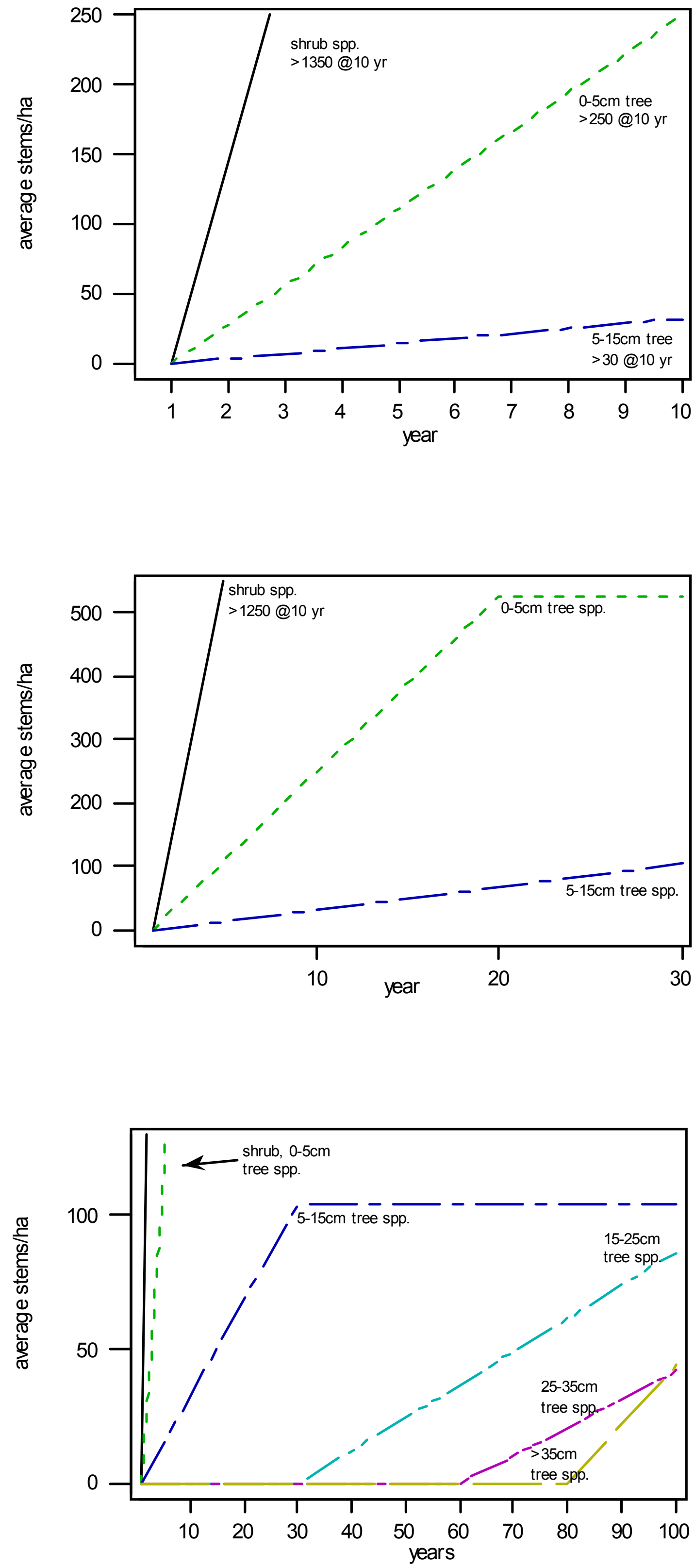


Figure 20. Hypothetical performance curves for tree and shrub establishment at 10, 30, and 100 years derived from reference wetland data for RIVERINE MAINSTEM wetland SHRUB SWAMPS.

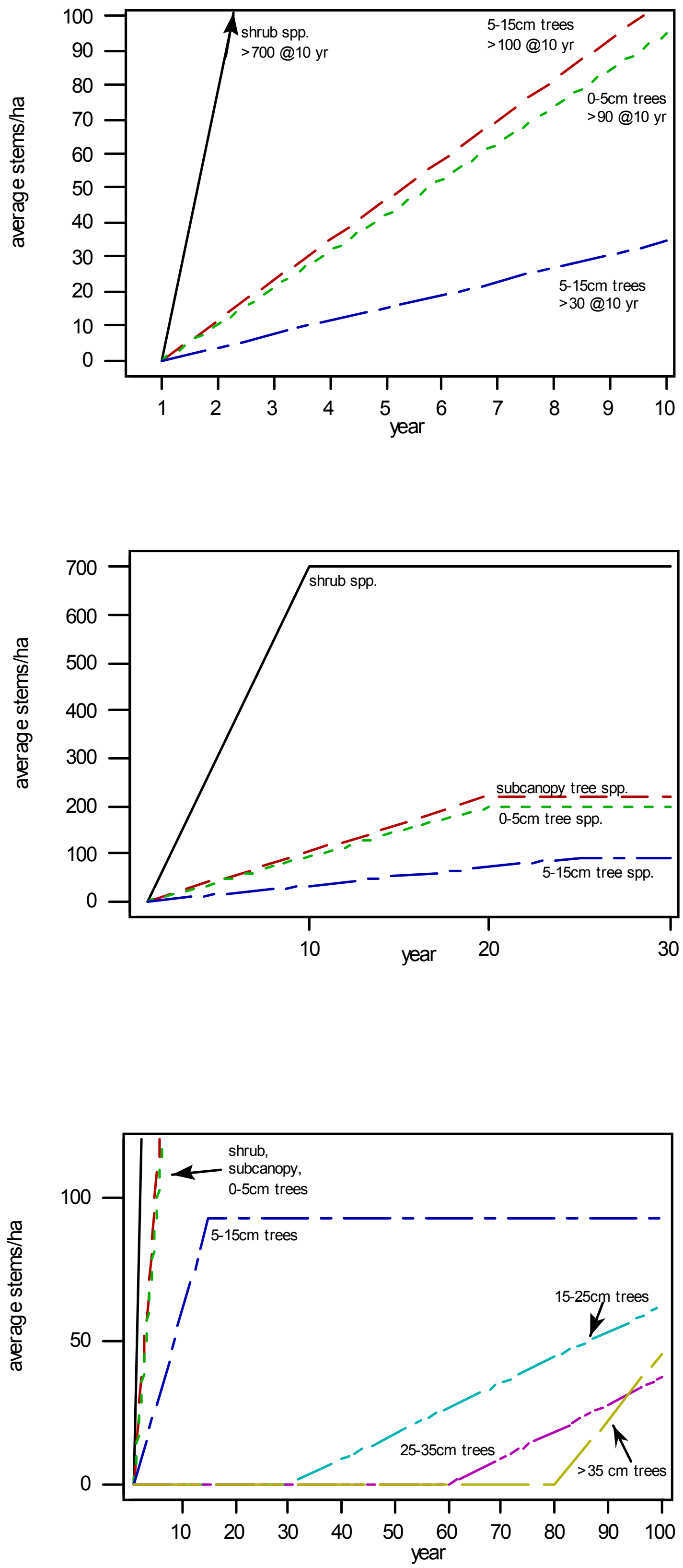


Figure 21. Hypothetical performance curves for tree and shrub establishment at 10, 30, and 100 years derived from reference wetland data for FOREST SEEPS (slope, swamp forests).

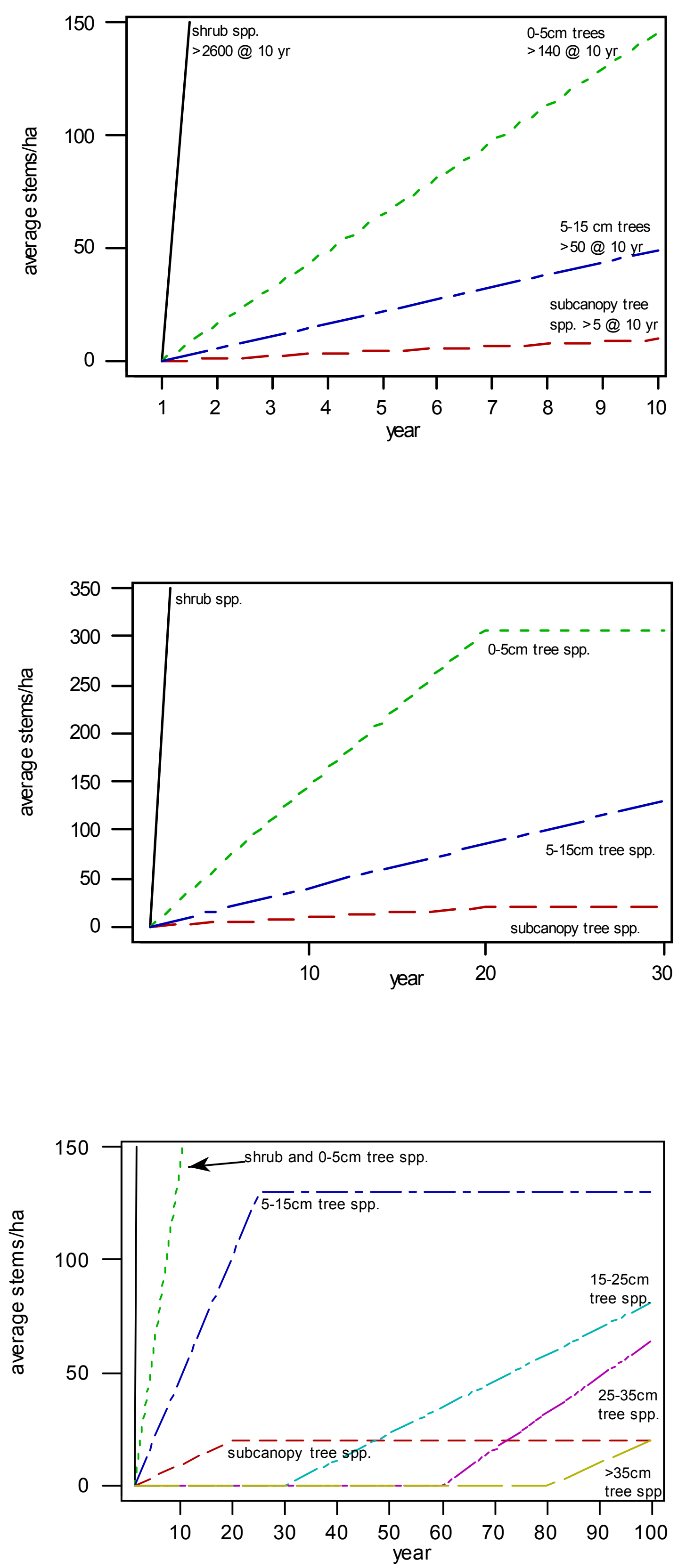


Figure 22. Hypothetical performance curves for tree and shrub establishment at 10, 30, and 100 years derived from reference wetland data for WEAKLY OMBROTROPHIC BOGS (TALL SHRUB BOG, TAMARACK-HARDWOOD BOG).

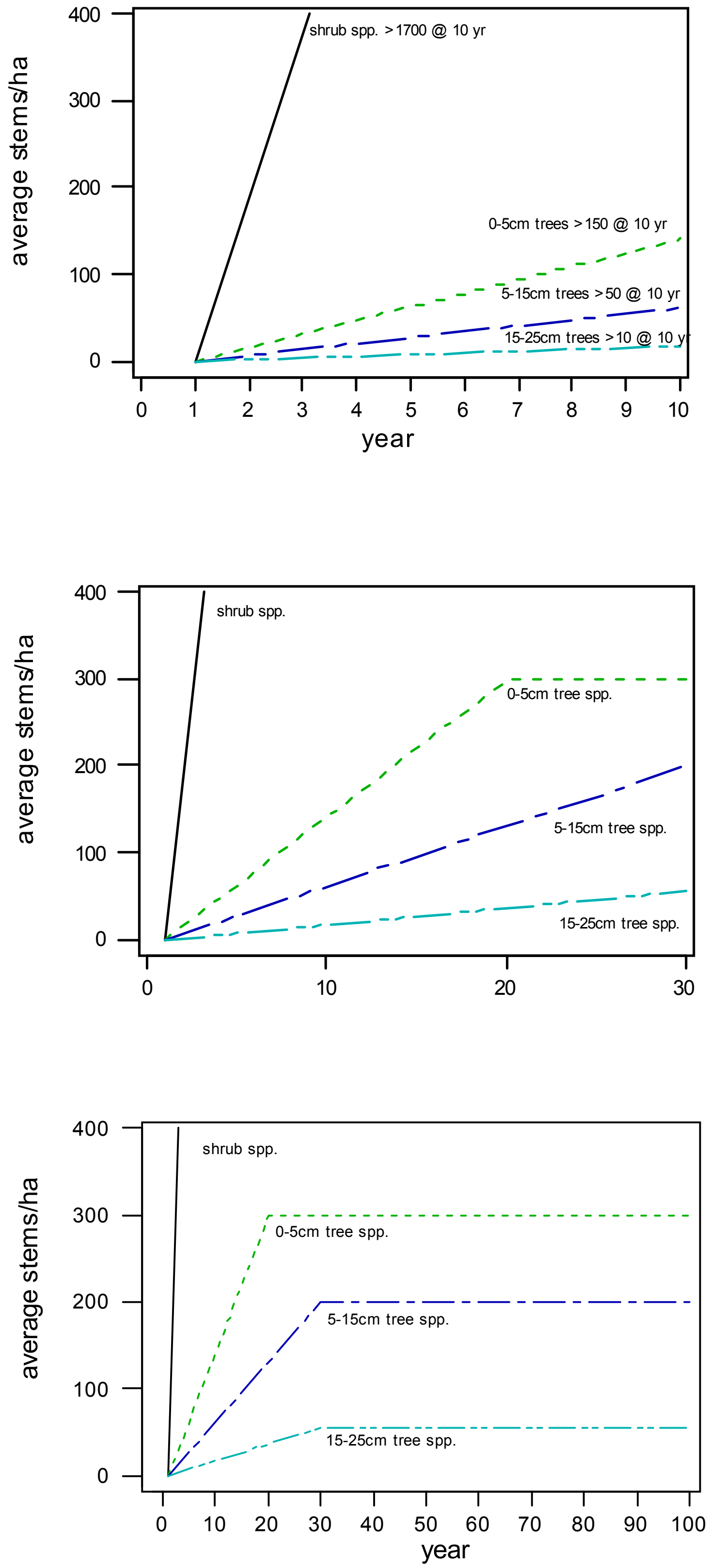


Figure 23. Hypothetical performance curves for tree and shrub establishment at 10, 30, and 100 years derived from reference wetland data for MODERATELY TO STRONGLY OMBROTROPHIC BOGS (LEATHERLEAF BOG, TAMARACK BOG).

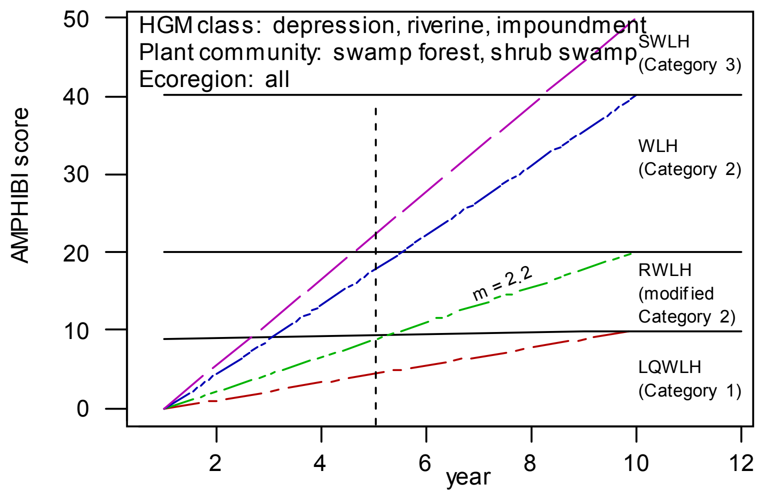


Figure 24. Performance curves for AMPHIBIAN IBI score. SWLH = Superior Wetland Habitat, WLH = Wetland Habitat, RWLH = Restorable Wetland Habitat, LQWLH = Limited Quality Wetland Habitat. Categories refer to wetland antidegradation categories in OAC Rule 3745-1-54. “m” = minimum slope of AMPHIBI performance curve to achieve WLH (Category 2) AMPHIBI score within 10 years.

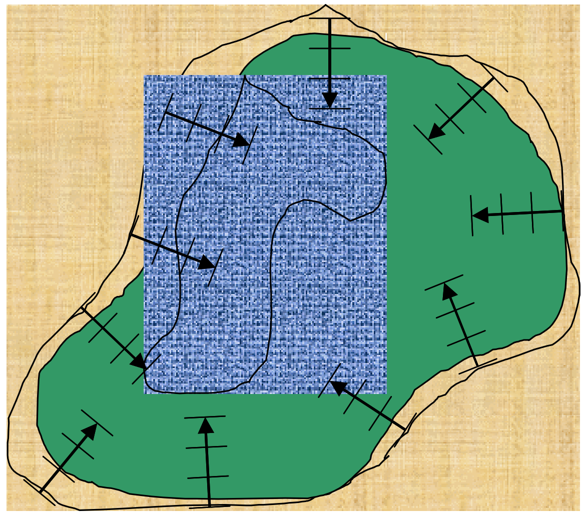


Figure 25. Typical placement of evenly spaced 15m transects to determine percentage of perimeter with side slopes less than 15:1. In this example, the 3 transects entering the area deeper water have side slopes greater than 15:1. Therefore, 70% of the wetland perimeter (7/10) is determined to have side slopes that are greater than 15:1.

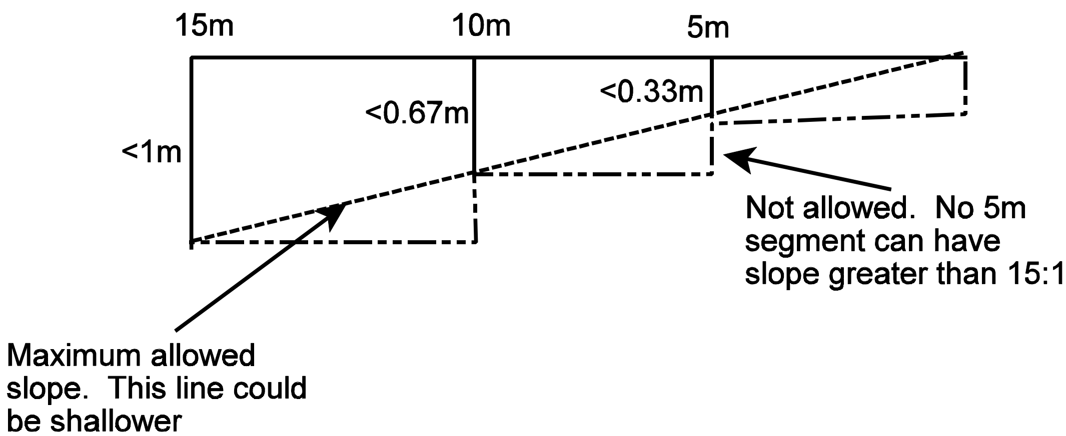


Figure 26. Maximum allowable slopes in order to meet 15:1 side slope requirement.

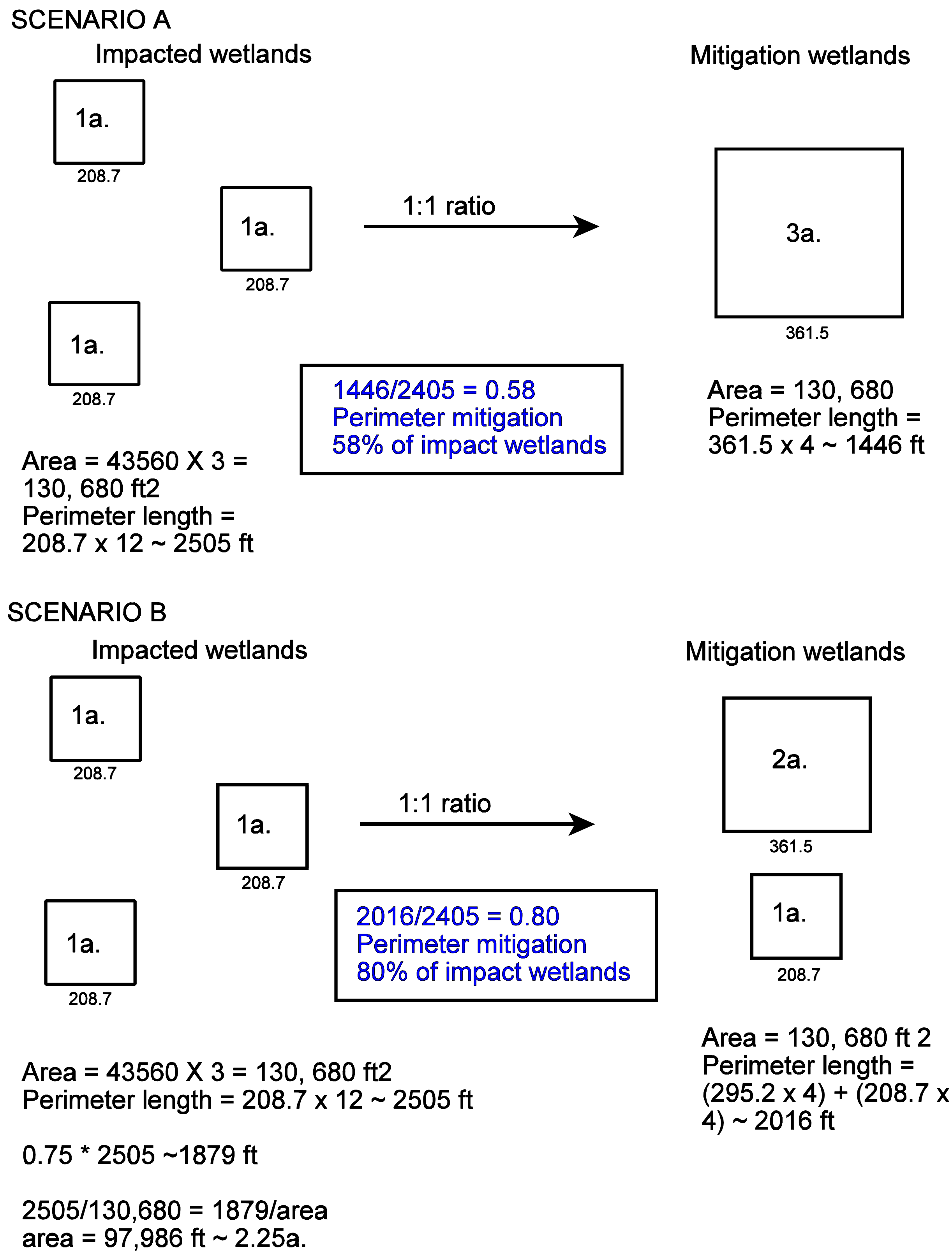


Figure 27. Scenarios for determining perimeter:area ratio performance standard.

Figure 28. Mitigation wetland with a predominance of open water and little emergent vegetation. The intensive modules of a sample plot should focus on the open water with perhaps one end of the plot at the edge of the wetland.

Figure 29. Mitigation wetland with a some open water and a predominance of emergent vegetation. The intensive modules of a sample plot should focus emergent vegetation with one end of the plot positioned near the upland edge and the other in an area of deeper water.

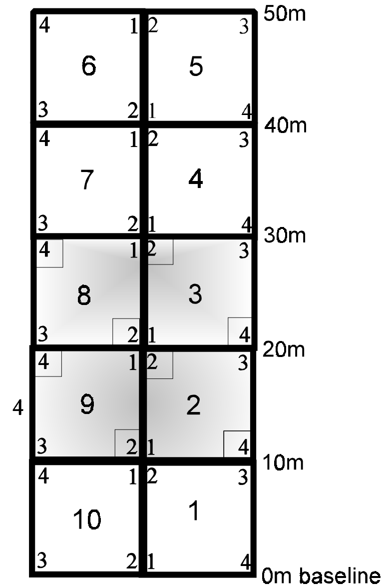


Figure 30. Standard (fixed or focused) 20m x 50m (2 x 5) vegetation sample plot. Standard intensive modules (2, 3, 8, 9) are shaded. Standard corners for nested quadrats (2, 4) are indicated by small squares. Modules are number in the direction of movement (down 1-5, back 6-10) along the center line; module corners are numbered clockwise in direction of movement down the centerline.

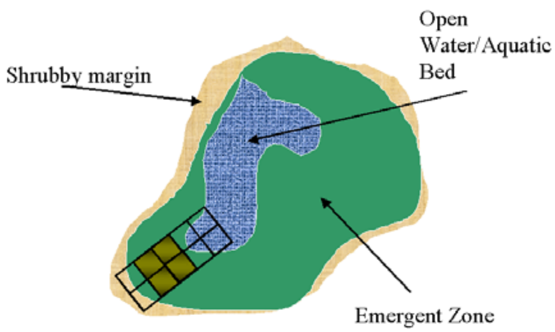


Figure 31. A typical mixed emergent marsh with shrubby margin and zones of emergent vegetation and deeper water habitat. A good plot location would have the intensive modules focused in the emergent zone and the "tales" of the plot anchored in the shrub and deeper water habitats.

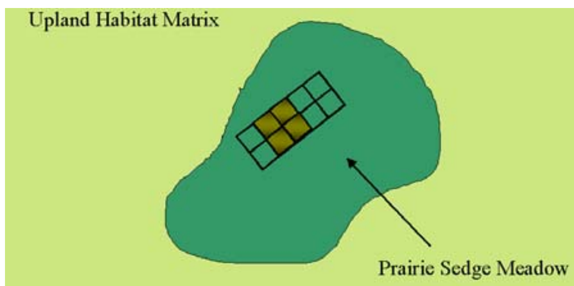


Figure 32. A wet meadow community located within a matrix of upland prairie and savannah. Because there is usually not strong zonation in this situation, a good plot location would be in an area representative of the wet meadow but not necessarily with the plot located along or near the edge of the wetland.

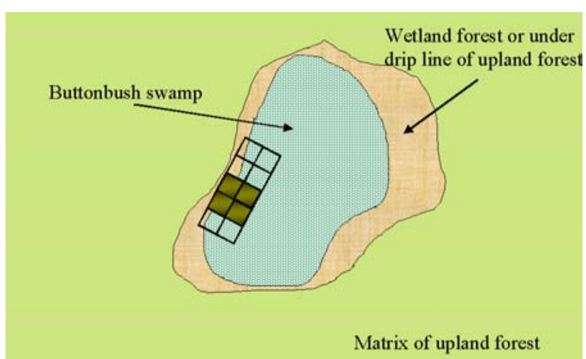


Figure 33. A buttonbush swamp located within an upland forest matrix. Typically, margins of swamp are shaded by wetland trees or under the drip line of upland forest. Because difficulty in running the long axis through 50m of buttonbush, it is easier to lay out the 20m short axes from the edge. A good plot location would have shade areas included but the intensive modules mostly including the buttonbush area.

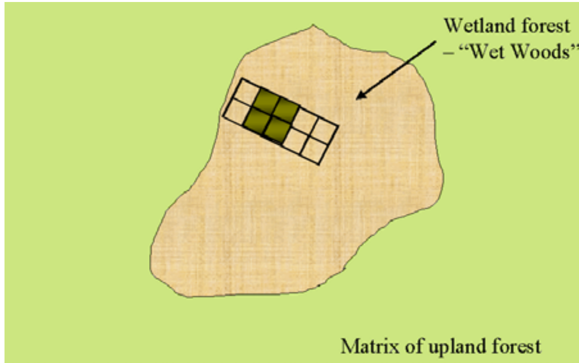


Figure 34. A swamp forest ("wet woods") located within an upland forest matrix. Similar to wet meadow communities there is usually not strong zonation in this situation. A good plot location would be in an area representative of the wetland forest but not necessarily with the plot located along or near the edge of the wetland.

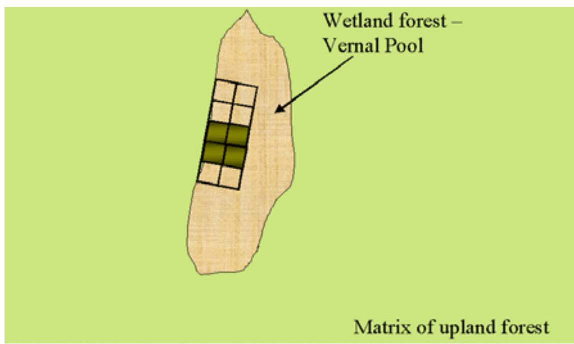


Figure 35. A swamp forest ("vernal pool") located within an upland forest matrix. Because of the often small size, irregular shape, and abrupt transition from upland to wetland, a good plot location will often need to include areas of the edge of the wetland in order to be representative of the community.

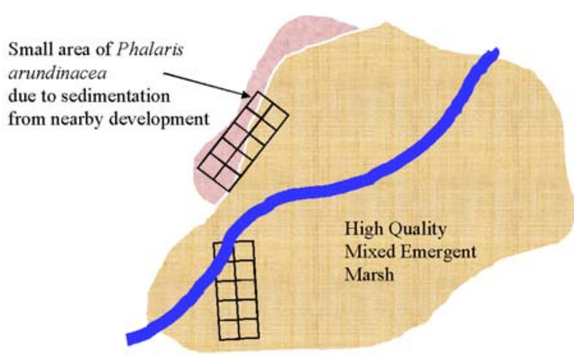


Figure 36. A high quality mixed emergent marsh with a localized area (arrow) of *Phalaris arundinacea*. To obtain an accurate VIBI score for the site, a plot should be located within the high quality area of the wetland. Percent cover of invasive species can be visually estimated, mapped with GPS instruments, or estimated with data from a second plot.

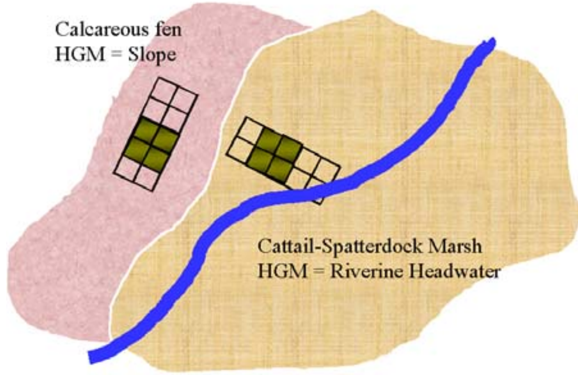


Figure 37. Where a “wetland” is comprised of two HGM classes, separate plots should be established within each HGM class.

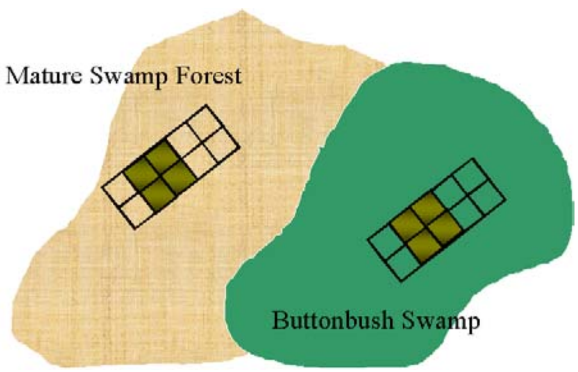


Figure 38. Where a wetland is comprised of two co-dominant plant communities, separate sample plots should be established in each community.

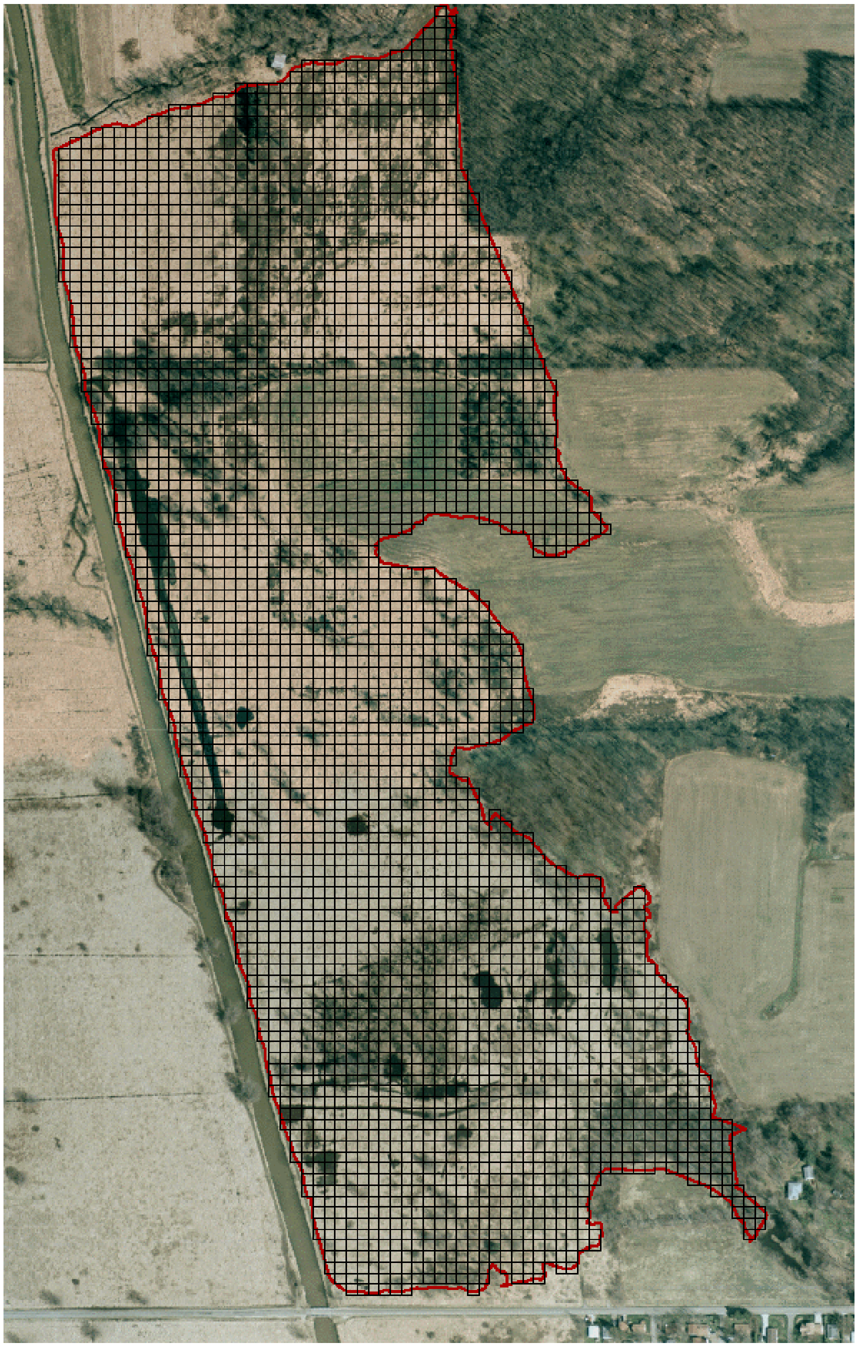


Figure 39. 10m x 10m geospatially referenced grid at Chippewa Central Mitigation Bank.

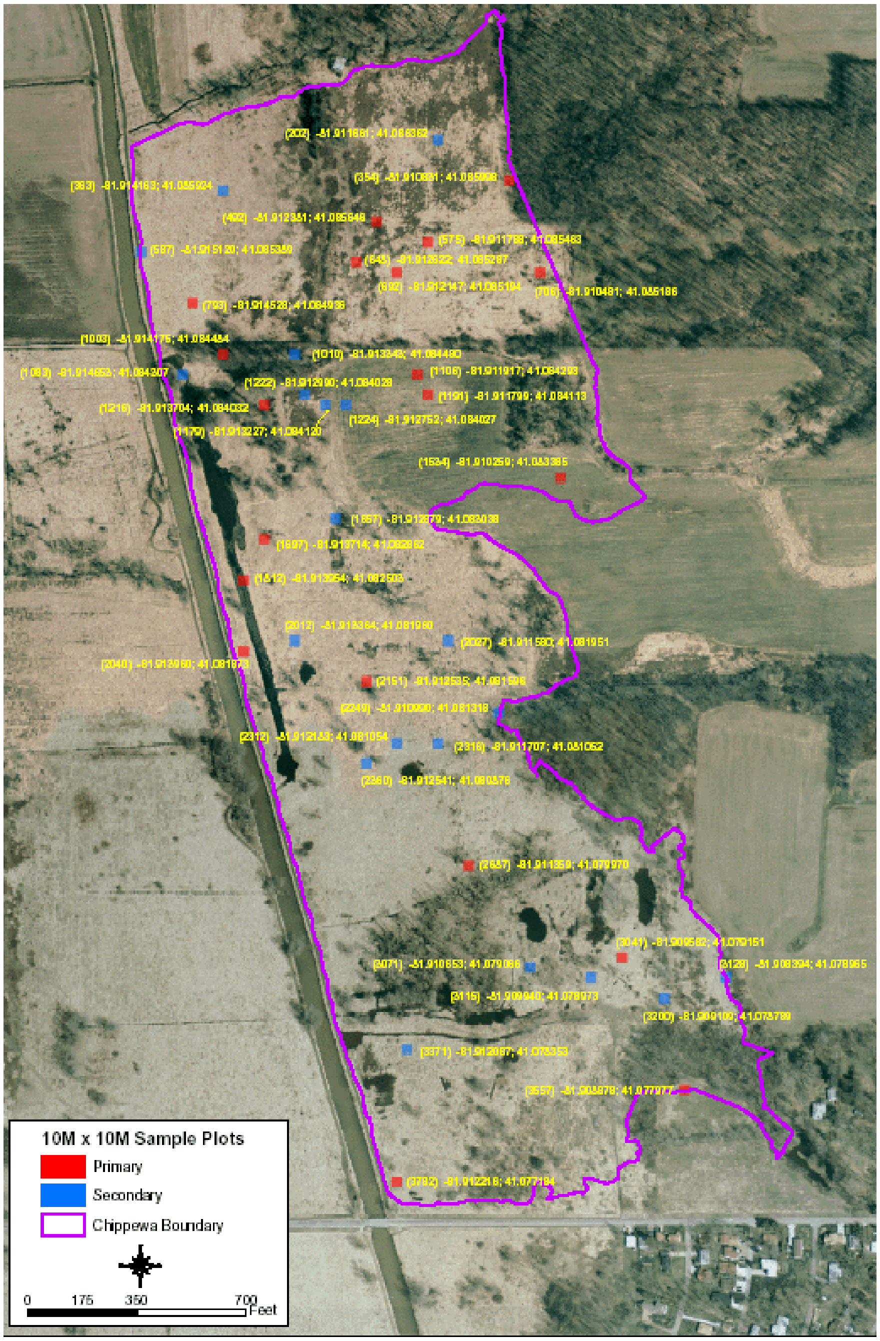


Figure 40. Map of random plots at Chippew Central Mitigation Bank. Primary plots are first 20 random plots which are used first (red); additional 20 plots used (secondary, blue) used if a primary plot is not usable.

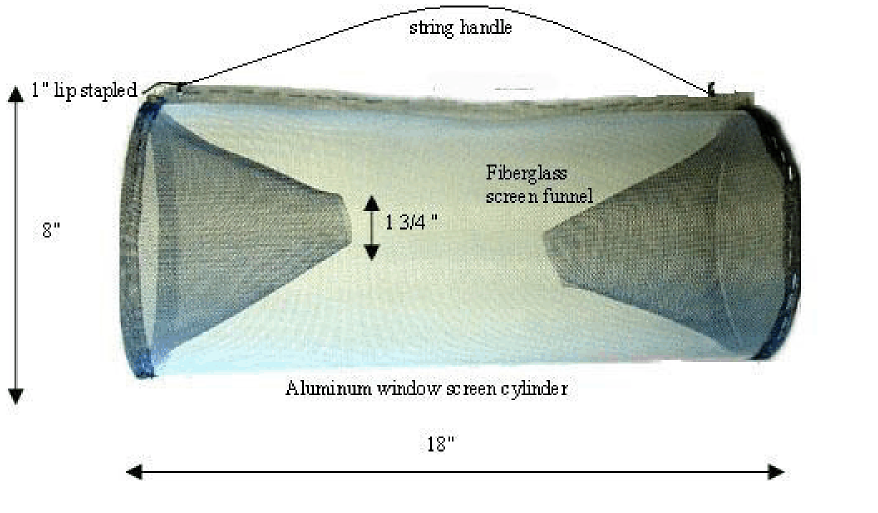


Figure 41. Funnel (activity) trap for amphibian and macroinvertebrate sampling. Aluminum window screening 28" x 18" is rolled into a cylinder 18" long and stapled through 1" lip to form a tube 8" in diameter. Fiberglass screening is cut out and stapled to form a funnel with an opening of 9" on the wide end and 1.75" on the narrow end. The narrow end of the funnel is placed inside the cylinder as indicated in the figure. The wide end of the funnel is rolled over the outside edge of the cylinder and stapled every 0.5". A string handle is attached to the lip. The trap is emptied by everting the fiberglass funnel at one end and dumping the contents into a white tray.

Figure 42. Typical funnel trap placement. Note how funnel openings are submersed but top of trap is left above water to reduce mortality in trap from low oxygen.

```
x4          x5     Samples 4 and 5: taken half way between the center and the far edge,
  \        /       at a 45 degree angle from initial line (i.e., line made by samples 1 - 3).
   \      /
     x3            Sample 3: taken and the approximate center of the wetland
     |
     x2            Sample 2:  taken half way between 1 and the approximate center of the wetland
     |
     x1            Sample 1: taken approximately 10 m from wetland boundary, near well
```

Figure 43. Sampling scheme used to collect soil samples at all wetlands.

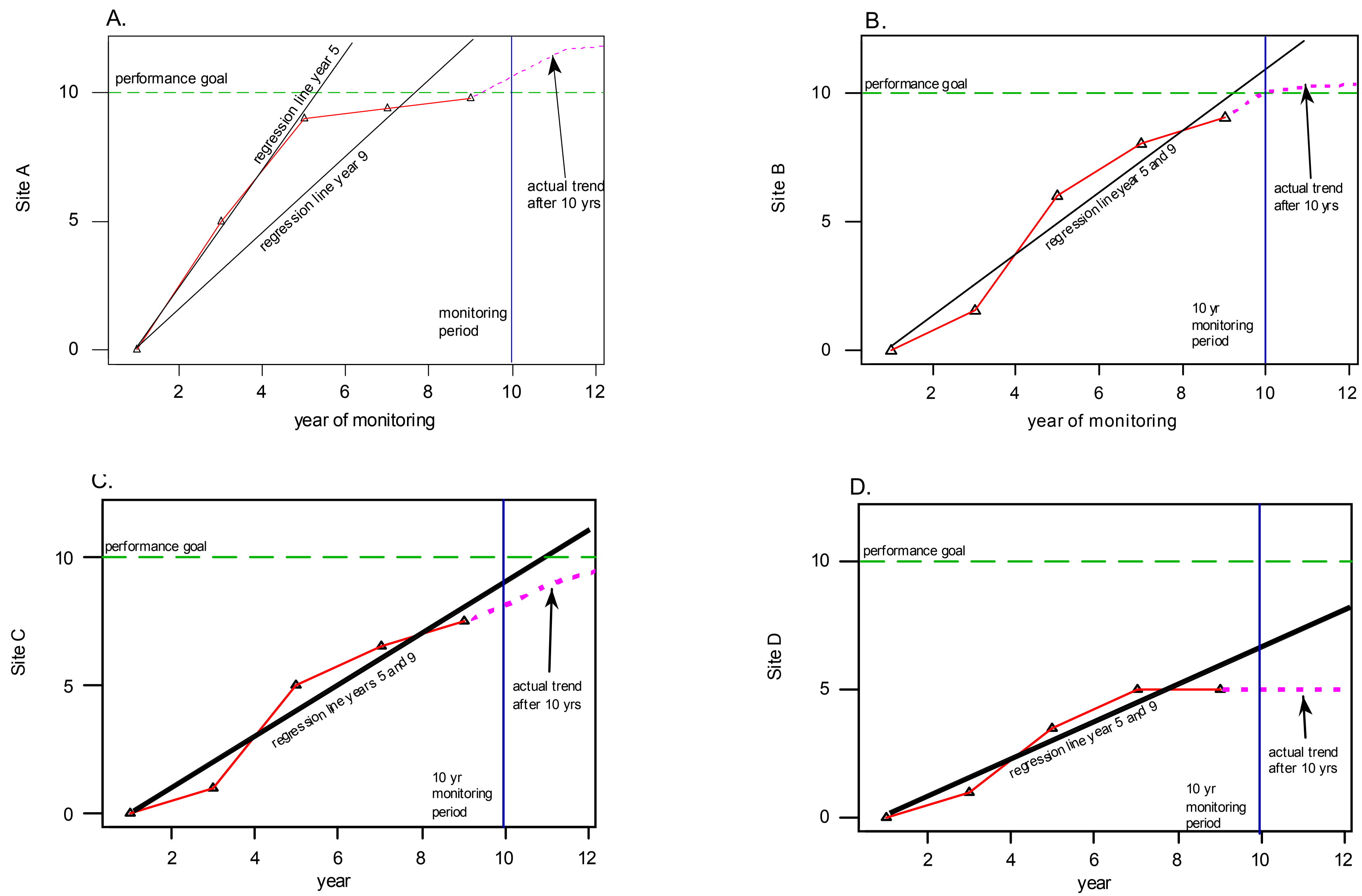


Figure 44. Performance curve scenarios (10 year monitoring period, data collected years 1, 3, 5, 7 9): A) Regression shows site exceeding goal before end of monitoring period; B) Site meets goal at 10 yrs; C) Regression shows site meeting goal by year 11 (site could be released from monitoring); D) Regression shows site not meeting goal by year 12, site performance plateaus after year 7, monitoring period should be extended and corrective action taken.

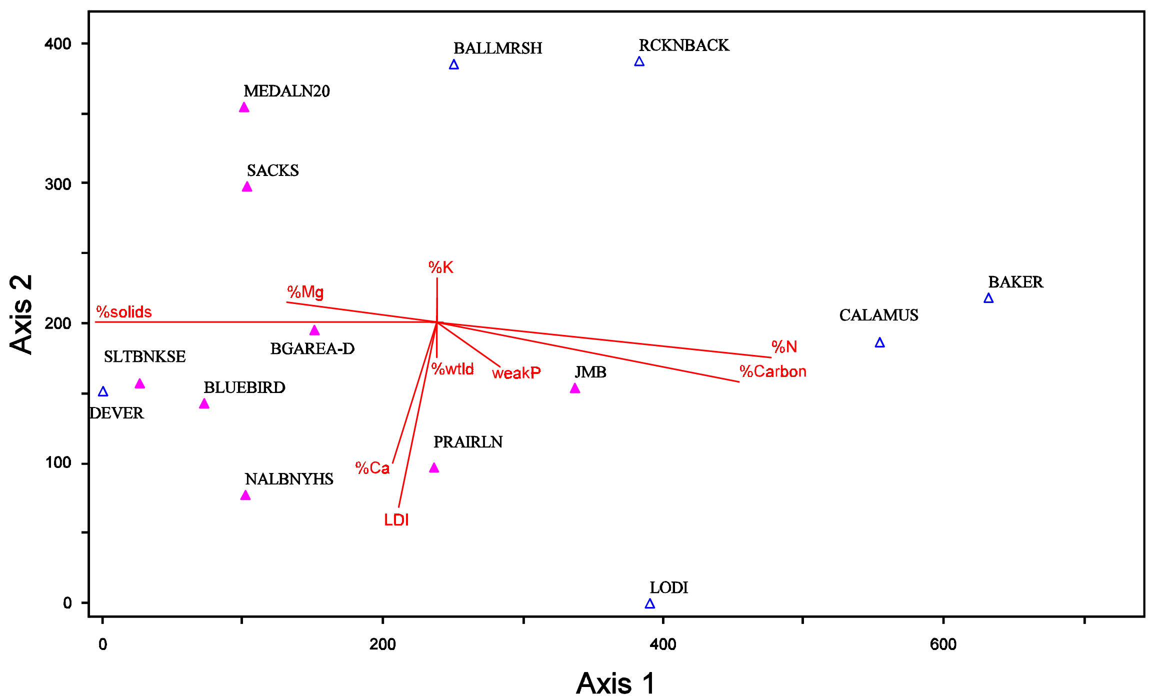


Figure 45. Example of detrended correspondence analysis of natural and mitigation wetlands with environmental joint plots.