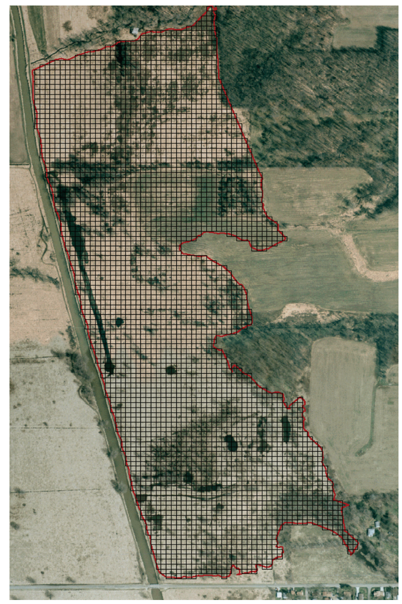
State of Ohio
Environmental Protection Agency

Wetland Ecology Group
Division of Surface Water

ECOLOGICAL ASSESSMENT OF OHIO MITIGATION BANKS:

Vegetation, Amphibians, Hydrology, Soils

Ohio EPA Technical Report WET/2006-1



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Photographs cover page (clockwise from top left): Trumbull Creek Berm 7 (J. Mack); 10m x 10m grid at Chippewa Central Mitigation Bank; sedge meadow Big Island Area A (D. Gill);. Bullfrog at Cherry Valley Bank (M. Micacchion); setting up random plot at Cherry Valley Area B-C (J. Mack); least bittern chicks at Little Scioto Area 3 (M. Micacchion).

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AN ECOLOGICAL ASSESSMENT OF OHIO MITIGATION BANKS VEGETATION, AMPHIBIANS, HYDROLOGY, SOIL

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ABSTRACT

Mitigation banks are often considered to have multiple advantages over individual mitigations including improved economies of scale; consolidation of economic, planning, and scientific resources; greater likelihood of success, etc. There are few assessments of multiple banks to determine whether these advantages are in fact producing a more successful or more consistently successful mitigation wetland. And no attention has been paid to the main risk of mitigation bank: failure of large banks represents a substantial net loss of wetland acreage or function whereas failure of individual small mitigations usually represents a nominal loss. Of the bank area assessed (nearly 400 ha), approximately 25% was not "wetland" but was primarily shallow unvegetated pond; of the remaining "wetland" acreage, approximately 25% was "poor" quality, 58% was "fair" quality, and 18% was "good" quality when vegetation data from mitigation banks was compared to ecoregionally calibrated scores from natural reference wetlands. Only one bank had areas where forest regeneration is occurring and no bank had restored common Ohio shrub swamp communities, e.g. buttonbush or alder swamps. When amphibian communities are compared, the amphibian community composition and quality was significantly lower at banks than natural forest, shrub, or emergent wetlands. Pond-breeding salamanders and forest dependent frog species were nearly absent and amphibian communities at banks were all dominated by one or more of four common tolerant frog species. Based on the data collected here, successful banks were defined as maximizing areas defined as "wetland," minimizing areas of open water, having hydroperiods which mimic hydroperiods of natural wetlands, maximizing cover of perennial native hydrophytes, minimizing cover of invasive plant species, and have mean VIBI scores of 40-60 (fair to good). Based on these criteria, of the 12 banks assessed in Ohio, 3 were mostly successful, 5 were successful in some areas but failed in other areas, and 4 were mostly failed. Unfortunately, this is not the proportion of success and failure that was at least implicitly promised in the Federal Bank Guidance. The economies of scale and consolidation of resources was to provide a consistently higher quality "product" of wetland restoration than was achievable by individual restorations. This "promise", although clearly achievable, has not been consistently attained in practice. But the basic practical fact remains, that a workable regulatory compensatory mitigation program needs a mitigation banking system that is successful acre for acre and also ecologically. What is needed is a re-appreciation that this is not easy work, that the "devil" is in the details at all levels (theory, planning, design, and management), and that "nature" does know "best" (or at least is our best referent for "success").

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INTRODUCTION

Mitigation banking is defined in the *Federal Guidance for the Establishment, Use and Operation of Mitigation Banks* (Federal Bank Guidance) (60 Federal Register 58605-58614) as "...wetland restoration, creation, enhancement, and in exceptional circumstances preservation undertaken expressly for the purpose of compensating for the unavoidable wetland losses in advance of development actions, when such compensation cannot be achieved at the development site or would not be environmentally beneficial. It typically involves the consolidation of small, fragmented wetland mitigation projects into one large contiguous site. Units of restored, created, enhanced or preserved wetlands are expressed as "credits" which may be subsequently withdrawn to offset "debits" incurred at a project development site."

According to the Federal Bank Guidance, mitigation banks can have several advantages over individual mitigation projects. First, the overall goal of maintaining "aquatic ecosystem integrity" may be improved by consolidating individual mitigation projects "when ecologically appropriate." When consolidation is *not* ecologically appropriate is not addressed but presumably would be when the small size of the impacted wetland is important to its ecosystem processes. An example might be small forested vernal pools with seasonal hydroperiods where consolidation into larger wetlands with permanent inundation might make it impossible for pond-breeding salamanders and wood frogs to utilize the site for breeding.

The second advantage is that mitigation banks have greater economies of scale over an individual mitigation project. This consolidation of financial, planning, scientific and regulatory review resources should result in wetland creation or restoration at mitigation banks that is more successful (ecologically or acre for acre), or at least more *consistently* successful than individual mitigation projects.

Third, mitigation banking should improve the overall efficiency of the wetland permit program by removing a time consuming step from the permit process: review and approval of individual mitigation plans. Again, unaddressed in the Federal Bank Guidance is the significant review time needed for large complex bank plans, credit releases, annual monitoring reports, and other bank management needs.

Finally, construction of banks should reduce temporal losses of wetland function, i.e. the lag between the wetland impact and obtaining a fully functional mitigation wetland. If a reduction in temporal loss is occurring at mitigation banks, it is only a partial reduction. For example, in Ohio most banks typically receive authorization to sell up to 30% of their credits prior to construction. For most banks constructed prior to 2004, additional credit releases (often up to 100%) were authorized upon the establishment of "adequate hydrology" even if other performance goals or wetland criteria (e.g. hydrophytic vegetation) were not being met. Completely unaddressed by the Federal Bank Guidance are the risks of mitigation banking. While consolidation of resources and individual impacts into a single large restoration site is perhaps the greatest advantage of mitigation banks, it is also the greatest disadvantage. When an individual mitigation project of 1ha fails, the net loss to the overall aquatic resource is relatively nominal; when a 100ha mitigation bank fails, the loss to the aquatic resource is substantial.

Given the 1) many claimed but largely untested advantages of mitigation banks, 2) the importance they have in the smooth, day-to-day functioning of the State of Ohio's regulatory program, and 3) the significant losses of wetland resource that could occur if banks are failing, Ohio EPA undertook a comprehensive assessment of all mitigation banks that had been constructed for sufficient time that evaluation of them was warranted using biological, biogeochemical, and hydrologic monitoring techniques developed in earlier studies and part of the State of Ohio's wetland assessment program (e.g. Fennessy et al. 2004; Mack et al. 2004; Mack 2004a, b, c; Micacchion 2004; Knapp 2004). To the authors' knowledge, this represents the most comprehensive, detailed effort to evaluate the success of mitigation banking undertaken to date. Mitigation banks should represent the best that is attainable in the restoration, creation, and enhancement of wetlands by providing a consistently high quality mitigation and substantially improved economic and regulatory efficiencies. The goal of this study was to evaluate whether banks in Ohio were in fact providing this consistently high quality wetland "product."

METHODS

Site selection

As of 2003, there were 18 mitigation banks constructed or approved for construction in Ohio (Several more have been proposed or come on-line since then). Of these 18 banks, 12 were constructed for a sufficient period of time to be included in this study (Table 1). Each bank was visited at least once (and usually several times) prior to sampling and a detailed site reconnaissance was performed to become familiar with the bank layout, subareas of the bank, and the dominant plant communities. Additionally, members of the study team were familiar with and had visited most of the banks multiple times while performing Mitigation Bank Review Team duties. Most of the 12 banks sampled had several discrete subareas (usually separated by berms). Logistical constraints (time, field staff, etc.) precluded sampling every subarea at every bank, but one or more subareas representative of the wetland habitats at the each bank were sampled (Table 2). The 12 banks were located in 3 Ohio ecoregions (lake plains of northwest Ohio, till plains of central Ohio, and glaciated Allegheny plateau of northeast Ohio) and 8 counties (Ashtabula (3), Licking (1), Lorain (1) Marion (2), Medina (1), Pickaway (1), Sandusky (2), Summit (1)) (Figure 1). Refer to Appendix C for maps of the individual bank sites.

Sampling methods - Vegetation, Soil, Water

To ensure maximum comparability with Ohio Environmental Protection Agency's (Ohio EPA) existing wetland reference data set, data was collected using Ohio EPA's standardized sampling methods (Mack 2004c; Mack et al. 2004). The vegetation survey was designed to collect data sufficient to determine conformance with the bank's existing performance standards, to calculate the Vegetation Index of Biotic Integrity (VIBI) (Mack 2004b) to obtain estimates of wetland versus non-wetland areas, per cent cover of invasive species, etc., to collect soil and water chemistry data, and other physical variables.

A combination of "focused" and random plots was used. The focused plots employed a set of 10 modules in a 20m x 50m layout (Figure 1). This is a modification of the "Whittaker" plot (Schmida 1984) and 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).

The location of the focused plots was subjectively determined in the field using the plot location rules in Mack (2004c). Plots were located in areas that were most representative of the conditions at that area of the bank being sampled. At least one 20m x 50m plot was established at each bank or subarea of a bank that was sampled.

Within the plot, presence and areal cover was recorded for herb and shrub stratums. Percent cover was estimated using cover classes of Peet et al. (1998) (solitary/few, 0-1%, 1-2.5%, 2.5-5%, 5-10%, 10-25%, 25-50%, 50-75%, 75-90%, 90-95%, 95-99%). The midpoints of the cover classes were used in all analyses. All woody species in the plot >1m tall were counted and assigned to diameter at breast height (dbh) classes as recommended by Peet et al. (1998) (0-1cm, 1-2cm, 2-5cm, 5-10cm, 10-15cm, 15-20cm, 20-25cm 25-30cm, 30-35cm, 35-40cm). Trees with dbh >40cm were individually measured. Midpoints of the diameter classes were used in all analyses. Standing biomass (g/m^2) was collected from $0.1m^2$ clip plots located in the eight nested quadrat corners of the intensive modules or from a single corner of each random module (Figure 2). Various physical variables (e.g. % open water, depth of standing water, litter depth, depth to saturated soils, number of tussocks and hummocks, and amount of coarse woody debris) were measured and a soil pit was dug in the center of every plot and soil color, texture, and depth to saturation recorded. A soil sample was collected from the top 12 cm of soil using a 8.25x25cm stainless steel bucket auger (AMS Soil Recovery Sampler) with a butyrate plastic liner by insert the auger to half its depth. The soil sample was analyzed for Total Organic Carbon (TOC), particle size, percent solids, pH, P, NH_4-N, NO_3-N, and metals (Al, Ba, Ca, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sr, Zn) at the Ohio EPA laboratory. If standing water was present, a grab sample of water was collected and analyzed for various water quality parameters (P, NH_4-N, NO_3-N, TOC, Ca, K, conductivity, DO, pH, Cl, Al, Ba, Ca, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sr, Zn).

In addition to the focused plots, a random survey design was also implemented because of the size of the bank sites, as check on the representativeness of the focused plots, and to obtain estimates of wetland versus non-wetland areas, per cent cover of invasive species, etc. Basically, the random survey took a standard plot comprised of ten 10m x 10m modules and randomly located the modules across the area sampled. A geospatially referenced 10m x10m grid was created on a map of each site (Figure 3). Depending on the information available for each bank, the grid was created on existing digital maps of a site, the areas of the bank sampled were mapped in the field using geographic positioning system instruments, or the bank areas were delineated on aerial photography of the bank site in Arcview™. Each grid square was sequentially numbered and associated with the latitude and longitude at the center of the square and a simple random sample was selected of at least twice the number of points needed using Minitab v. 12.0. A map showing the selected points was produced (Figure 4). Maps of the all 12 banks can be found in Appendix C.

The randomly selected points were evaluated in order. If a point was rejected, the next available point was evaluated. For example, if 10 random points were to be sampled and point No. 5 is found to be located on the berm of the bank, point 5 is rejected. The next point evaluated as a substitute is point No. 11. Points were rejected in the office and in the field. A point was rejected based on an office review of the maps if

1) it was located partly on a berm or dike, 2) located within a preexisting wetland area that was included in the perimeter of the bank unit, 3) it was located immediately adjacent to another random point. A point was rejected in the field if was located outside of the bank or on a dike or other engineered structure. If the point was located in a deep water area that was not wadable, i.e. greater than about 1.5m, it was recorded as "non-wetland, deep open water" with 100% open water cover, and water depth >1.5m, unless the area of deeper water was very small (e.g. a ditch). In that case the sample point was moved 10m in a randomly selected cardinal compass direction

At each selected point, a 10m x10m plot was established with the plot centered on the point. The same data was collected in the plot as in an intensive module of a focused plot except 1) a soil sample was collected in the center of the plot with a soil probe from the top 12 cm and analyzed for standard agronomic soil parameters (%organic matter (Walkley-Black), available P (Bray 1 and 2), exchangeable ions (K, Mg, Ca, H), pH, Cation Exchange Capacity, total C and N) at Midwest Laboratories, Inc., Omaha Nebraska (NCR 1998), and 2) additional water chemistry information was collected using a handheld YSI sonde (pH, DO, conductivity, temperature). The number of random plots varied depending on the size of the bank: less than 500 grid squares (<5 ha) approximately 5 random plots; 500-2000 grid squares (5 to 20 ha) approximately 10 random plots; >2000 squares (>20 ha) approximately 20 random plots.

Amphibian and macroinvertebrate sampling

Funnel traps were used to sample macroinvertebrates (results found in Knapp 2006) and amphibians using previously developed sampling protocols (Micacchion 2004, Knapp 2004). Other organisms, e.g. fish, that were found in the traps were also identified. A qualitative sample was also collected using a triangular ring frame dip net and by hand picking the substrates. The funnel traps were 46cm long and 20cm in diameter. The narrow end of each funnel was directed into the funnel trap body and had a 4.5cm opening. Traps were made from aluminum (funnel trap body) and fiberglass (cone-shape funnels at each end of the body) and assembled with staples (see photo on cover page).

At most sites, 10 funnel traps were placed evenly around the perimeter of the bank subarea. At a few very large subareas, or where the placement around the entire perimeter was not feasible (slopes too steep, water too deep, etc), transects along the sides of the subarea were used. Care was taken to assure that all habitat types within the wetland subareas were represented proportionally within each transect. Each area was sampled three times between March and early July with trapping runs about 5 to 6 weeks apart. In all cases, the traps were left in the wetland approximately 24 hours to ensure unbiased sampling for species with diurnal and nocturnal activity patterns and to limit mortality since individuals were not in traps for extended periods.

Traps were emptied by everting one funnel end and shaking the contents into a white collection and sorting pan. Organisms that could be readily identified in the field (especially adult amphibians and larger and easily recognized fish species) were identified and released. The remaining organisms were transferred to wide-mouth one liter plastic bottles and preserved with 95% ethanol. The contents of each trap were kept in separately marked bottles for individual analysis in the laboratory. Laboratory analysis of the funnel trap and qualitative macroinvertebrate and fish samples followed the standardized Ohio

EPA procedures (Ohio EPA 1989). Salamanders and their larvae were identified using keys in Pfingsten and Downs (1989) and Petranka (1998). Frogs, toads and tadpoles were identified using keys in Walker (1946).

Hydrology

Surface water depth and depth to saturated soils (if no standing water was present) was measured at each random plot. Shallow ground water wells were installed at each bank area sampled (Remote Data Systems, Inc. Model WL-40 or Ecotone Wells). Readings were collected two times per day (8am, 8pm) for at least one year. A total of 36 wells were deployed at the 33 bank subareas sampled. Wells were located just upslope of the area of maximum inundation at sites with substantial inundation and in representative locations for areas with saturated soils. Well installation was done in accordance with the procedures outlined in *Installing Monitoring Wells/Piezometers in Wetlands* (WRP 2000). Well screens were installed 50-100 cm deep depending on the soil profile. When a subsoil or impermeable layer was encountered, excavation of the hole for the well screen was halted. A staff gauge was installed near each well and water levels recorded whenever the wells were downloaded (approximately every 2-3 months). Annual hydrographs were constructed using the data from the ground water wells and various hydrologic attributes calculated.

Data analysis

Vegetation data from plots at the mitigation banks was reduced and analyzed using standard procedures found in Mack (2004c). Scores for the VIBI-E, -SH, and -F and there component metrics were calculated for each bank using the metrics and scoring ranges from Mack (2004b) (Tables 3 and 4) as well as other attributes of interest, e.g. areal cover of perennial native hydrophytes. Average values from mitigation bank plots were then compared to Ohio EPA's reference wetland data set using box and whisker plots, ANOVA and Tukey's multiple comparison test. All calculations were performed using Minitab v. 12.0. Simultaneous metric performance for each plot was evaluated using Principal Components Analysis (PCA) in PC-ORD (McCune and Mefford 1999).

Various estimates of overall bank or bank subarea characteristics were calculated from the random plot data:

> 1) The areal cover of open water and unvegetated open water was recorded in the field for each random plot. "Open water" was defined as inundated areas without rooted emergent vegetation although submersed (e.g. *Elodea canadensis*) or floating (e.g. *Potamogeton nodosus*) aquatic plants could be present; "unvegetated open water" was defined as areas lacking or nearly lacking in any vegetation including submersed or floating aquatic plants. The %open water or %unvegetated open water was calculated by averaging the cover values for these parameters.
>
> 2) The area cover of perennial native hydrophytes was calculated in four steps. First, the relative cover of plant species in each random module was calculated. Second, the species occurring in the module were coded as native/adventive, perennial/bienniel/annual/woody, and hydrophytes (FAC, FACW, OBL)/upland/not listed. Third, the

relative cover values of native perennial (including woody species) hydrophytes were summed. Finally, the summed relative cover values from each random plot were averaged to obtain the estimate for perennial native hydrophyte cover at the bank or bank subarea. The same procedure was used to calculate areal cover of other metrics like percent tolerant and sensitive species.

3) Whether the plot was a "jurisdictional" wetland was determined. The three parameter approach in the 1987 Delineation Manual was used and a plot was determined to be "wetland" if hydric soils were present, wetland hydrology was present, and the vegetation was dominated by hydrophytes (FAC, FACW, OBL species).

4) Each random plot and the data collected within it was assigned a unique alpha-numeric identifier and coded by community type (forest, shrub, marsh, wet meadow, upland forest, upland thicket, pond, old field). The data from each community type within a bank subarea was aggregated and Vegetation IBI scores and metric values and other attributes of interest were then calculated using the aggregated data. For example, at Big Island Area A, 10 random plots were sampled; 5 plots were coded as "forest", 4 plots were coded as "marsh" and 1 plot was coded as wet meadow. Data from the 5 forest plots was combined into a single data set and treated like a focused plot (in effect a 10m x 50m plot) for purpose of calculating relevant scores and attributes.

Table 5 summarizes the focused and aggregated plots by community, HGM class, and site.

Amphibian data from trap collections at the mitigation banks was reduced and analyzed using standard procedures found in Micacchion (2004). AmphIBI scores and their component metrics were calculated for each bank using the metrics and scoring ranges from Micacchion (2004). Average values from mitigation bank areas were then compared to Ohio EPA's reference wetland data set using box and whisker plots, ANOVA and Tukey's multiple comparison test. All calculations were performed using Minitab v. 12.0. Amphibian community characteristics were evaluated using PCA in PC-ORD (McCune and Mefford 1999).

RESULTS

There were 34 subareas sampled at the 12 banks included in the study with a total area of approximately 400 ha. A total of 42 focused plots (~10 per 100 ha assessed) and 331 random plots (~8 per 10 ha assessed) were sampled that were grouped into 61 aggregated random plots (Table 2). A total of 1040 funnel traps were deployed for a total of 24,960 trap hours in three trapping runs; 104 qualitative dip net samples were also collected.

Basic vegetation and wetland establishment

Basic "wetland establishment" was evaluated in three ways. First, amount of "open water at the banks was evaluated. "Open water" is defined as areas of inundation with or without rooted emergent vegetation, and does not meet the hydrophytic vegetation criterion of the 1987 Delineation Manual (dominance of rooted emergent hydrophytes, although they may be vegetated with submersed or floating aquatic plants and be considered "special aquatic sites") (Environmental Laboratory 1987). "Open water" acreage at the banks ranged from a low of 0% to a high of 62%. Of the total bank acreage assessed, 28% or 111.7 ha was non-wetland open water (Table 6). Since the basic performance standard for all the Ohio banks is that acreage must be considered "jurisdictional" wetland (i.e. meet the soil, hydrology, and hydrophyte criteria), this can be considered a "net-loss" of over 100 ha of wetland for impacts mitigated at Ohio bank sites. Considering just the net-loss at banks that have sold all of their credits (or have approval to sell all or nearly all of their credits and thus do not have an opportunity to reduce their credit load to account for failed acreage), over 70 ha of wetland loss has occurred (Big Island, Hebron, Sandy Ridge, Trumbull Creek have most or all of their credits released).

Second, basic wetland establishment was evaluated by estimating the amount of "unvegetated" open water, since areas of open water vegetated with submersed or floating aquatic vegetation are ecological "wetlands" if not "jurisdictional" wetlands. Unvegetated open water at the banks ranged from 0% to 52% (Table 7). Total acreage of unvegetated open water at the 12 banks assessed was 77.9 ha or 20% of the total bank acreage assessed. If only sold-out banks are considered, this represents a net loss of over 50 ha of wetland for impacts mitigated at these banks.

Finally, areas of wetland acreage at the 12 bank sites was estimated by determining which random plots individually met the 3 criteria for wetland (hydric soil, hydrophytic vegetation, wetland hydrology) (For this analysis, submersed and floating aquatic plants were included in the calculation for determining dominance by hydrophytes, even though technically they are excluded by the 1987 Manual). Percent of each site that was "wetland" ranged from 40% to 100% with an estimated net-loss of wetland acreage of 70 ha (Table 8).

The dominant community types created or restored at the banks was evaluated. Emergent communities (marsh, wet meadow) accounted for 63% of the bank acreage created or restored (Table 9). Wetland forest communities accounted for only 11% of the acreage created and restored, and of this only the plots at Big Island can be considered actual wetland forest restoration where secondary succession has been initiated; the forested areas at 3 Eagles, Grand River Lowlands, and Trumbull Creek banks were all existing forests with hydrologic "enhancements" (Table 9). The rarest community type at all mitigation banks was wetland shrub swamps (2%). No good examples of typical Ohio shrub communities (e.g. buttonbush swamp, alder swamp, mixed shrub swamp) were observed at any of the bank sites. Finally, 12% of the plots were classified as upland habitats (usually old field vegetation), and 10% of the plots were classified as "pond", i.e. inundated areas with no vegetation. To be included in the "pond" classification the plots had to be completely lacking in vegetation, otherwise they were included in the "marsh" class.

One of the few quantitative standards included in many instruments of many Ohio banks is the requirement that the be dominated by perennial native hydrophytes (>75% coverage) and have low cover of invasive plants like *Phalaris arundinacea* and *Phragmites australis* (usually <10%). Using data derived from the random plots, 31.3% of the bank subareas sampled had greater than 75% areal cover of perennial native hydrophytes (FAC, FACW, OBL spp.) an additional 15.6% of the bank subareas were close to that goal and would be considered to be on a trajectory to reaching it (Table 10). When data from focused and aggregated random plots was analyzed, i.e. areas vegetated enough to be "wetland" and excluding random plots coded as "pond," 23.8% of the plots evaluated (34 out of 101) had 75% or greater cover of perennial native hydrophytes and 41.5% had greater than 65% cover and would be considered to be on a trajectory to reach it (Tables 11 and 12). As a comparison, the relative cover of *just* FACW and OBL species (excluding FAC species) at natural reference wetlands in Ohio EPA's data set was 65.6%, 73.5% and 81.% for low, medium, and high quality wetlands, respectively.

The relative cover of invasive species listed in Table 1 of ORAM v. 5.0 ranged from 0 to 94% (Table 11) (*Lythrum salicaria, Myriophyllum spicatum, Najas minor, Phalaris arundinacea, Phragmites, australis, Potamogeton crispus, Ranunculus ficaria, Rhamnus frangula, Typha angustifolia, T.* x*glauca*). Thirty-four plots (33.7%) had no Table 1 species, 73 plots (72.2%) had <10% cover of Table 1 species, and 69 plots (68.3%) had <5% cover of Table 1 species (Table 12). Similar proportions were observed for nonnative and adventive species cover (Table 12).

Plant community evaluation

The quality of the mitigation banks was assessed using the score and metric values from the Vegetation IBI (Mack 2004c). Vegetation IBI scores and metric values were calculated for each focused plot and from aggregated random plots of that community type (marsh, wet meadow, forest, shrub) in a bank subarea (Tables 13 and 14). Mean VIBI scores for bank plots (36.5) was significantly lower than good (49.6) to high (77.5) quality natural reference wetlands, but were significantly higher than low quality natural wetlands (17.5) ($p < 0.05$) (Figure 8). Scores from bank plots were, on average, higher but were not significantly different from scores from typical individual mitigation sites (27.8) previously sampled by Ohio EPA (Figure 7).

Vegetation IBI scores from the bank plots were compared to Wetland Tiered Aquatic Life Use (WTALU) categories (Mack 2004c). The scoring ranges for the WTALUs are calibrated with HGM class, dominant plant community and ecoregion. Data from the random plots can be equated to the area of a bank site with that quality wetland (Table 15). Of the acreage of banks that was "wetland", 79.9 ha (25.8%) was Limited Quality Wetland Habitat (LQWLH) ("poor" quality), 198.7 ha (64.3%) was Restorable Wetland Habitat (RWLH) ("fair" quality), and 30.5 ha (9.9%) was Wetland Habitat (WLH) ("good" quality). No plots assessed at the bank sites were Superior Wetland Habitat (SWLH) ("exceptional" quality). However, 11 plots were only 2-4 points less than the cut-off for WLH. If these are included in WLH, the percentage of WLH quality wetland increases to 54.7 ha (17.7%).

The average metric values for the bank plots were compared to natural reference wetlands and individual mitigation sites (Table 16). Average metric values for banks and individual mitigations were not significantly different for the 11 metrics that could be compared (Table 16). Bank plots had significantly better metric values than degraded natural reference wetlands (1st ORAM tertile) for only 3 of 17 metrics significantly higher (hydrophyte metric where higher is "better"; or %invasive graminoid and biomass metrics where lower is "better"). For fair to good quality natural reference wetlands (2nd ORAM tertile), metric values for bank plots were not significantly different for 11 of 17 metrics. High quality natural reference wetlands (3rd ORAM tertile) performed better than average values from bank plots on 14 of 17 metrics. So, considering each metric individually, banks had metric values that were more similar to (not significantly different from) natural wetlands in the 2nd ORAM tertile.

Simultaneous metric performance for natural, bank, and individual mitigation plots was evaluated using PCA. Emergent sites (the majority of bank plots) and forested sites were compared separately. Natural emergent reference wetlands ordinated along Axis 1 from poor to high quality with the *Carex*, dicot, FQAI, hydrophyte, %sensitive and shrub metrics associating with good condition and biomass, %invasive graminoids and %tolerant species associating with poor condition (Figure 10). Of note are plots from several bank sites that are intermingled with good to high quality natural wetlands (Panzner Field E and B, Cherry Valley Area 1 and 3 marshes, Big Island Area A and C, Trumbull Creek Berm 5 focused plot) although this pattern was not observed when Axes 1 and 3 and 2 and 3 were compared (Figures 11 and 12). Most emergent bank plots and individual mitigations ordinated apart from all natural wetlands (Figures 10-12). Axis 2 in these plots was associated with biomass and annual/perennial species ratios (Sites with low standing biomass tend to have higher wetland annual richness; disturbed natural wetlands tend to have high biomass due to dominance by invasive graminoids like *Typha* spp.).

Natural forested wetlands ordinated along a condition gradient (Figure 13). A few enhanced bank forests ordinated near good to high quality natural forests, although it was not possible to determine in the field how much of the plant community in these areas was present prior to "enhancing" the hydrology at these sites. Early successional forests at Big Island and "green tree" forests at Grand River Lowlands and Trumbull Creek ordinated apart from natural wetland forest plots due to the open canopy and strong presence of full sun, non-forest species (Figure 13).

Amphibian community evaluation

Given the predominance of emergent communities and permanent hydroperiods at the Ohio banks, it is not surprising that amphibian communities was markedly different from natural forest and shrub wetlands with seasonal hydrology. Nine species of amphibians and one hybrid were collected in the traps deployed during the study. Ohio mitigation banks were dominated by several tolerant, early colonizing amphibian species: *Rana clamitans* (Green frogs), *Rana catesbeiana* (bullfrogs), *Rana pipiens* (leopard frogs), and *Bufo spp.* (toads (tadpoles of *Bufo americanus* and *Bufo fowleri* cannot be distinquished). Depending on the bank, one or several of these species were extremely abundant. By far the most common amphibian was the green frog. Overall, green frogs accounted for 37.7% of the taxa collected, toads 22.2%, leopard frogs 19.1% and bullfrogs 12.3%. No other species comprised more than 4.9% of the total individuals encountered. Other amphibian species occasionally observed included *Pseudacris crucifer* (spring peeper) (4.9%), *Pseudacris triseriata* (western chorus frog) (2.5%) , *Hyla versicolor* (gray tree frog[2]) (0.5%), *Ambystoma texanum* (smallmouth salamander) (0.75%), and Ambystomatid salamander hybrids (0.01%) (Table 17). The only two sensitive species collected were tiger salamander (*Ambystoma tigrinum*) (0.08%) and red spotted newt (*Notophthlamus viridescens*) (0.04%). Tiger salamanders were collected at Slate Run Southeast near an existing wetland forest and red spotted newts were

[2] This may have included the tetraploid hybrid, *Hyla chyrsoscelis* (Cope's gray tree frog), which can be only be differentiated by its song.

encountered in all three Trumbull Creek subareas; Berm 5, 7E, and 7F, which are located within or adjacent to large acreages of mature intact forest. Spotted salamanders (*Ambystoma maculatum*) and wood frogs (*Rana sylvatica*), species associated with high quality natural wetlands in Ohio (Micacchion 2002, 2004), were not collected at any of the mitigation banks.

The quality of amphibian habitat at Ohio mitigation banks was evaluated using the Amphibian Index of Biotic Integrity (AmphIBI). The AmphIBI is a measure of the quality of the amphibian community utilizing data from natural wetlands that correlates well with the degree of human disturbance experienced by those wetlands (Micacchion 2002, 2004). AmphIBI scores can vary from 0 to 50: scores of 0 to 9 indicate poor quality, 10 to 19 fair quality, 20 to 39 good quality and 40 to 50 exceptional quality (Micacchion 2004). All but four of the bank subareas sampled had AmphIBI scores of 0, and all four of those had a score of 3. The AmphIBI scores of the Ohio banks were also significantly lower than scores from natural wetlands dominated by emergent vegetation (marshes, wet meadows) (Figure 14).

Finally, PCA was used to compare the amphibian communities at the mitigation banks with amphibian species relative abundance data from 111 natural emergent and woody dominated (forest and shrub) wetlands and also with data from individual Ohio wetland mitigation projects (Figure 15). The natural wetlands spanned the range of disturbance from least impacted to highly disturbed. Amphibian communities at Ohio mitigation banks clearly ordinated apart from other sites and were furthest removed from natural forest and shrub dominated wetlands. Individual mitigation sites clustered together most closely to the mitigation bank sites. Natural emergent wetlands also clustered together in the middle of the graph separated from individual mitigation and mitigation bank sites as well as high quality natural forest and shrub sites. Spotted salamanders and wood frogs are species separating the natural forest and shrub sites from other sites whereas green frogs, leopard frogs and toads are separating out the individual mitigation and mitigation bank sites.

Forest succession

Only one bank (Big Island) had large areas where secondary succession of wetland forest had been clearly initiated (Areas A and D) (a small area at Hebron Bank also appeared to be reverting to forest) (Tables 18 and 19). Stem densities of wetland tree species averaged 1065 stems/ha in the Big Island plots (Table 18). Forest subcanopy trees and shrubs (e.g. *Lindera benzoin*) were absent at Big Island, but several plots had relatively high densities of willows and dogwoods (Table 19). Four other banks had areas of "enhanced" forest:

1) At 3 Eagles Bank hydroperiod and water depth were increased by impounding water into areas of mesic floodplain forest. These areas remain dominated by mesic forest species (Tables 18 and 19). The main effect of enhancing the hydrology has been to kill mesic tree species but these have not been replaced with wetland tree species (standing dead ranged from 163-300 stems/ha) (Table 18);

2) At Grand River Lowlands (Area F), dikes were built around and through existing forest dominated by *Quercus palustris* (pin oak) and Q. *bicolor* (swamp white oak). In the bank instrument, this area was characterized as mostly non-

wetland but sampling for this study strongly suggests that this was a pre-existing oak swamp. Importance values for pin oak and swamp white oak were 0.436 and 0.347, respectively (Table 19). The impoundment in Area F has killed many trees with stem densities of standing dead trees ranging from 1150 to 1750 stems/ha (Table 18). Areas of existing second growth forest in Areas A-D and B-C of Grand River Lowlands have been also been killed (standing dead 2950 and 2400 stems/ha, respectively) (Table 18);

3) At Trumbull Creek (Berm 7F), a large hummock-hollow wooded area dominated by *Fraxinus pennsylvanica*, had large dikes built around and through it to impound water into the forest. As at Grand River Lowlands, this area was characterized as mostly upland forest due to a lack of hydrology. Importance values indicated a highly diverse preexisting forest with the following tree species having importance values >0.10: *Acer rubrum* (0.201), *A. saccharum* (0.133), *Fagus grandifolia* (0.164), *Fraxinus pennsylvanica* (0.361), *Liriodendron tulipifera* (0.164), standing dead (0.379) (reflecting the effect of the impoundment) and *Ulmus rubra* (0.252) (Table 19). Stem densities of standing dead trees ranged from 1183 to 2570 stems/ha in Berm 7F (Table 18). Areas of existing second growth forest were also killed in area Berm 7E, Berm 6, and Berm 5.

4) At White Star Expansion, hydrology was enhanced in an existing *Fraxinus pennsylvanica* (green ash) dominated forest with prickly-ash (*Zanthoxylum americanum*) and black-haw (*Viburnum prunifolium*) thickets. Extensive areas of mesic forest with *Quercus rubra, Tilia americana,* and *Carya ovata* were also present outside the limits of inundation but within the bank boundaries. The enhancement seems to be effective with considerable die back or stress of upland shrub and tree species observed while wetland species appear to be thriving. The bank has plans to plant wetland trees and shrubs in subsequent years.

In addition to areas of "enhanced" (usually dead or dying) forest noted above, existing young to well-established second growth forest was killed by the impoundment of deep permanent water in Big Island Area B and Sandy Ridge Area 1 (Tables 18 and 19).

Only a few areas at any of the banks (parts of Big Island Area A, B, and D), south end of Chippewa, parts of Panzner Areas B and C, parts of White Star South) (Table 18) could be considered dominated by wetland shrubs and no examples of typical wetland shrub communities in Ohio were observed at any bank (Table 19). In fact, common wetland shrub species were only occasionally observed: *Cephalanthus occidentalis* (9 plots), *Cornus amomum* (23 plots), *C. sericea* (1 plot), *Lindera benzoin* (6 plots), *Rosa* palustris (1 plot), Viburnum *recognitum* (8 plots) (Table 19).

Hydrology

A total of 38 wells were installed in 31 of the 33 subareas sampled. Wells were not able to be installed in every subarea of every bank due to logistical constraints (Table 20). Because each bank had distinct hydrologic characteristics, the hydrological attributes and hydrographs for each bank are discussed individually. Summer *surface* *water* depths were measured in the center of each random plot using a tape measure; the measurements from all of the random plots were then averaged. Average surface water depths greater than 20cm is indicative of permanent, often deep inundation. *Ground water* levels refer to the median water level recorded in the monitoring wells, usually a negative number. Positive ground water levels indicate periods of time that water was above the ground surface. In most locations, wells were not installed to their calibration point and a portion of well screen and water level probe was above the ground and able to measure surface water inundation at the well. Median ground water levels in the range of -30cm to -60cm is indicative of a seasonal hydrology with long periods when the well is basically dry. Values of -10 to positive numbers are indicative of water levels above the ground surface at the well (inundation), permanently saturated conditions to nearly the ground surface, or a piezometric head in the well. Maps of bank areas are in Appendix C.

Big Island. Wells were installed at the north end (Area A), south and southwest sides (Area B) and on the east side (Area D). The hydrology for Areas A and B is largely determined by the water levels maintained at outlet control structures in the dike constructed along the south side of Area B. Areas C (not monitored) and D were basically depressions with no managed dikes or water control structures to maintain their hydrology. Although fluctuations and drawdowns of water levels were observed in 2003 in Areas A and B, inundation became basically permanent by September 2003 (Figure 16). Average summer surface water depths were 14.7cm, 51.5cm, 1.0cm, and 11.1cm for Areas A, B, C, and D, respectively (Table 20). The wells installed in Areas A and B were inundated 56-92% of the time (Table 21). In contrast, Area D exhibits a strongly depressional hydrologic signature with a complete dry down during the summer and fall (Figure 16). Area C had a similar hydroperiod (Mack, personal observation). These differences are reflected in the median water depth recorded at the wells for these areas: Area A (+0.8 cm), Area B center (+5.3cm), Area B southwest (+23.4 cm), Area D (-53.7 cm).

Cherry Valley. Wells were installed in Areas 1 and 3. Two wells were installed in Area 1: one in a wet meadow zone near the south-center side of Area 1 and one at the edge of a large, inundated marsh area in the southwest corner of Area 1. The Area 3 well was installed at the edge of a large, inundated marsh area in the northwest part of Area 3. The marshes in Area 1 and 3 experienced periodic drawdowns during the summer but were highly responsive to rain events and would rapidly refill, and then drawdown again (Figure 17). A similar pattern was observed in the wet meadow in Area 1 except the drawdown was more extreme (Figure 17). Average summer surface water depths in Areas 1 and 3 were 4.3cm and 7.7cm, respectively (Table 20). All of the areas monitored become saturated to the surface to slightly inundated by the fall and remained that way through the winter (Figure 17). Median ground water levels were 2.0cm (Area 1 Marsh), -4.8cm (Area 1 Meadow), and -1.3cm (Area 3).

Chippewa Central. The site has a north-south axis with a slight decrease in elevation from north to south. Wells were installed at the north and south ends of the site. Both hydrographs exhibit a strong seasonal signature with water levels declining during the growing zone. Superimposed are flashy flood events. The flashiness index score was one of the highest observed at the banks (2.4 to 2.9). A very large flood event occurred during December-January (2004-2005) where the wells were nearly submersed. Median water levels were -34.5 and -16.3 in the north and south wells respectively.

The north end of the site is a reed canary grass meadow above the limits of any impoundment effect of the low berms constructed along Chippewa Creek. Impoundment (and reduction in reed canary grass coverage) was more effective towards the south end of the site and this is reflected in the hydrographs and in the percent time water was in the "root zone," i.e. 0 to -30cm (31% versus 81% in north and south wells respectively) (Table 21; Figure 18). Average summer surface water depth measured in the Chippewa Central random plots was 8.6cm (Table 20).

Grand River Lowlands. Wells were installed in Areas A-D, B-C and F. Areas A-D and B-C are hydrologically connected. Water enters Area B-C from upgradient of the bank and is discharged through a series of outlet structures set at different elevations into Area A-D. Area A-D discharges water through several outlet structures to water courses that eventually reach the Grand River. Area F is hydrologically separated from Areas A-D and B-C by a large dike and discharges via a single outlet structure to a water course that eventually reaches the Grand River. Area E was not monitored as part of this study but is located "upstream" of Area F and discharges water into Area F. All of the Grand River hydrographs exhibit an extremely flashy hydrology especially area A-D which swung from extremely dry to inundated multiple times during the growing season (Figure 19). These flood events were observed in the field during sampling with Areas B-C and A-D rapidly filling and then discharging the stored water (Mack, personal observations). For example between 8:00pm and 8:00am on July 30-31, 2004, water level in the Area A-D well changed from -63.5cm to +5.3cm. A similar large event occurred on September 8-9 when water levels changed from -55.6cm to +4.1cm. The hydrologic pulses observed in Area A-D were mirrored in the Area B-C hydrograph (Figure 19). The Area F hydrology, while responsive to some of the same events reflected in the Area A-D and B-C hydrographs was more stable. Some parts of all three areas remained inundated year round. Average summer surface water depths were 14.8cm, 6.1cm, and 15.5cm, respectively for Areas A-D, B-C and F (Table 20). The inundated areas expanded in the fall to include most of the wettable areas of the impoundments (Figure 19). Median water levels for Areas A-D, B-C and F (-11.4, -16.8, -1.8 respectively), %time inundated (33%, 38%, 42%), and %time in root zone (26%, 26%, 54%) reflect that Grand River Lowlands does experience periodic drawdowns in the locations where the wells were installed.

Hebron. A single well was installed in each of the two cells constructed at Hebron Bank (Large Cell, Small Cell). Bank cells experience drawdowns during the growing season (Figure 20) but are inundated or have water in the root zone (i.e. are saturated) more than 90% of the year (Table 21). Both cells have a moderately large areas of shallow, unvegetated water, but are otherwise densely vegetated. Median water levels were 8.3cm (large cell) and 1.8cm (small cell). In 2004, water levels markedly increased in the large cell possibly due to beaver activity (Figure 20). Average summer surface water in the large and small cells were 17.6cm and 34.6cm, respectively (Table 20).

Little Scioto. Two wells were installed at Little Scioto Bank. Since the NE and NW Marsh subareas were nearly identical in size, shape, and hydrology, a single well was installed in the NW marsh. Both of these areas are generally oriented north-south and have low berms and outlet structures at their south end with water discharging into the Little Scioto River. A well was also installed in diked areas south of the Little

Scioto River (Little Scioto South). Average summer surface water depths were 38.5cm and 19.2cm for the NE and NW areas, respectively (Table 20) (random plots were not sampled in south diked area but this part of the bank remained permanently inundated throughout the course of the study (Mack, personal observation))[3]. In both areas, there was inundated or saturated conditions at the well nearly 100% of the time (wells were installed upgradient from areas of inundation) (Table 21). Median ground water levels were 0.5cm and 5.7cm, respectively for the NW and South wells. The hydrograph for the NW marsh (and by extrapolation the NE marsh) exhibited a slight drawdown during the growing season with frequent brief pulses, but basically reflects a shallow permanent inundation (Figure 21). The South area is also permanently inundated with a slight fall draw down. Of note in both areas are two very large flood events which completely submersed the wells (Figure 21). The outlet structure on the South area was not functioning (reflected in very high water levels). The reduction in water levels in the South area towards the end of 2004 is due to repair of the outlet structure (Figure 21).

Panzner. The Panzner Bank is the only bank in Ohio that has a predominately ground water driven hydrology. It is located in the Summit Interlobate subregion and was likely a large fen-marsh complex prior to being drained and farmed. Given the complex ground water hydrology present at the Panzner Bank, 7 wells were installed, 2 each in Fields A, B, and E and 1 in Field C. Field A is the largest bank area and is large relatively flat area of seasonally saturated muck soils with several deeper depressions where standing water accumulates.[4] Field B consists of areas of strong ground water expression along the western edge where marl meadows appear to be redeveloping (Mack, personal observation). Parts of Field B were excavated to create a deeper water zone. Field C receives water from Field B. Field E was graded to reaccess the ground water table and slopes downhill from west to east. Fields A, C, and parts of Field E are within the floodplain of channelized Pigeon Creek and occasionally receive flood waters (Panzner, personal communication). Periods of inundation were very infrequent throughout the Panzner bank (Table 20). Average summer surface water depths recorded in the random plots was 0cm (Field A), 20.8cm (Field B)[5], 5.6 cm (Field C) and 0cm (Field E). Two wells exhibited effects of ground water pressure pushing water above the ground surface in the well screen (Field B west, Field E west) (Table 21). Percent time water was in the root zone ranged from 54 to 100% and median ground water levels ranged from -28.6cm to +2.8cm (Table 21). Both Field A wells exhibited a strong seasonal drawdown in ground water levels with occasional pulses due to rain events. Soils in Field A were saturated to or near the surface by late fall (Figure 22). Field B exhibits a very stable ground water driven hydrology with permanent saturation year round (Figures 22 and 23). In contrast, the ground water input in Field E is much more periodic exhibiting a strong seasonal signature and frequent pulses (Figure 23). Finally, Field C has a relatively stable hydrology which

[3] Subsequently, the bank manager installed additional water control structures in this area and water levels have declined substantially since 2003-2004.

[4] In order to farm Field A, over 6 miles of tile was laid in the 60 acre field. One million gallons per days was pumped out of the tile system in order to allow equipment access for farming (Panzner, personal communication).

[5] Most of Field B is saturated to inundated <10cm, but a portion of Field B was intentionally over excavated.

generally mirrors the peaks and valleys in the Field B hydrographs (Figure 23).

Sandy Ridge. Two wells were installed at Sandy Ridge bank. The bank is basically a single large diked area with a one outlet control structure in the northwest corner. It was divided into three subareas based on a low berm which mostly separates Area 1 from Area 2 and due to changes in vegetation from the north to the south separating Areas 1 and 2 from Area 3. Wells were installed in Areas 1 and 3. Mean summer surface water depths were among the highest recorded for any Ohio bank averaging 48cm, 57.3cm and 23.4cm in Areas 1, 2, and 3, respectively (Table 20). Areas 1 and 3 were inundated or saturated nearly 100 percent of the time and median ground water levels were 3.0cm (Area 1) and -0.8cm (Area 3) (Table 21). The hydrograph for Area 1 had a slight seasonal drawdown but shows permanent inundation in Area 1 (Figure 24). Of note is the change in hydroperiod from 2003 to 2004. Both areas, and especially Area 3, had strong seasonal drawdowns in summer 2003, but a similar drawdown did not occur in 2004 (Figure 24).

Slate Run. One well was installed in each Slate Run subarea monitored (Center, NW, SE, and SW. All of the Slate Run subareas are impoundments created with dikes on predominately non-hydric soils. Mean summer water depth was 24.1cm (Center), 35.2 (NW), 17.7cm (SE) and 45.7cm (SW) (Table 20). Periods of inundation and saturation were between 75-100% and median ground water levels between -0.5 to -9.5 in the subareas, reflecting the large areas of shallow inundation characteristic of this bank (Table 21). Although the subareas were basically designed as hydrologically independent impoundments, their hydrographs showed a high degree of synchronicity during 2003 to summer 2004 (Figure 25). During the severe drought in summer 2004, the pool size of the subareas contracted and the hydrographs desynchronized (Figure 25).

Three Eagles. The Three Eagles Bank consists of three main community types (enhanced forest, marsh and wet meadow) divided into nine subareas. Because logistical constraints precluded monitoring all nine subareas, the three largest and most characteristic areas were monitored (NE Marsh, East Forest, and West Meadow). One well was installed on the west side of the NE Marsh near the upland-wetland boundary; one well was installed in the center of the West Meadow near the edge of a small cattail depression (wetland hydrology and vegetation did not develop over most of the West Meadow and the well was installed near one of the few "wet" locations in this subarea); and one well was installed on the west side of the East Forest near the edge of an inundated pool. Average summer water depths were 13.7cm (East Forest), 12.3cm (NE Marsh) and 0cm (West Meadow); median ground water levels were -15.5cm, -9.7cm, and -21.8cm in these areas respectively. Relatively limited periods of inundation occurred at the wells (although large areas of the East Forest and NE Marsh were inundated year round (Mack, personal observation; Table 21). Percent time water levels were in the root zone was 73% (East Forest), 88% (NE Marsh), and 65% (West Meadow) (Table 21). Given the failure to establish wetland hydrology and vegetation over most of the West Meadow, the well readings are encouraging in that raising the water table modestly might be enough to shift this area from upland old field to wet meadow. The hydrology at each subarea appears to be quickly responsive to rain events as evidenced by frequent rising and falling of water levels (Figure 26). A distinct summer drawdown was observed in 2003 but water levels stabilized at a high level in 2004 and did not drawdown despite a drought in summer 2004 (Figure 26).

Trumbull Creek. Trumbull Creek Phase 1 included three separate impoundments Berm 5, 6 and 7 in a series of three large dikes moving up a gradual slope (Berm 7 lowest and largest to Berm 6 in the middle, and then Berm 5, the smallest unit). Berm 7 consisted of a large open water zone (Berm 7E) and a large forested area (Berm 7F). Berm 5 and 6 were very similar in hydrology and plant communities so only Berm 5 was monitored. Two wells were installed in Berm 7, one at the south side of the site in the Berm 7F area, and the other in the Berm 7E area. Average summer water depths in Berm 7E were the highest recorded in the study (64.2cm); depths in Berm 5 and Berm 7F were 13.5cm and 19.0cm (Table 20). Inundation at the well in Berm 5 was permanent (98%) with median ground water levels +8.4cm. Although the two Berm 7 wells were installed at the upgradient edge of inundation, percent time the water level was above the ground surface at the well (16% Berm 7E, 26% Berm 7F) and percent time in the root zone (38% Berm 7E, 46% Berm 7F), were lower than expected given the obviously permanent inundation observable year-round at the site. Median ground water levels in Berm 7E and 7F were -26.3 and -19.7, respectively. This "disconnect" between surface and subsurface hydrology has been observed by Ohio EPA at other mitigation wetlands (Fennessy et al. 1994). Hydrographs for Berm 7E and 7F reflect this pattern with abrupt rise and a tapering decline through 2004 into early 2005, but then water levels gradually rise to very high levels and stabilize by summer 2004 (Figure 27). In contrast, Berm 5 has a stable water levels year round with no seasonality (Figure 27).[6]

[6] Based on preliminary data from this study, the bank manager began reducing and fluctuating water levels in Phase 1 of the bank in 2004-2005.

White Star. The White Star Bank Expansion area was constructed in a region with shallow soils over limestone bedrock. The site consists of a large forest bisected by an east-west flowing agricultural ditch. Because the ditch could not be filled because of upstream landowners, low berms were installed on the north and south sides of the ditch to reestablish/enhance hydrology in the forest (the existing forest consisted of mesic forest with some wetland forest inclusions). Two wells were installed in the south area, one in the enhanced forest zone and one in a open marsh area at the northeast corner of the area; one well was installed in the north area. Because of the shallow soils over bedrock, 50cm well screens (instead of 100cm) had to be used. Average summer water depths recorded in the random plots were 2.3 cm (White Star North) and 3.6cm (White Star South) (Table 20). Median ground water levels in the north area were -39.4cm, and were -45.5cm (marsh) and -49.3cm (forest) in the south area wells (Table 21). Percent time of inundation and saturation was 13% (north well), 24% (south forest), and 31% (south marsh) (Table 21). The hydrographs for all three wells show a very strong seasonal signature with water levels in the root zone until summer with very quick drawdowns during the height of the growing season (Figure 28).

Soils

Median and 25th and 75th percentiles of soil samples collected in the random plots were calculated (Table 22). These were compared to values obtained from natural wetlands previously studied by Ohio EPA (Fennessy et al. 2004) (Table 23) Percent N values were uniformly low (0.10% to 0.25% range). Only three banks had values of %N approaching or exceeding the lower 25th percentile (0.50) of N values found at natural marshes: Panzner Field A, B, C, and D, Chippewa, and White Star North. Percent C and %Organic Matter (OM) were also very low at most sites. Excluding the Panzner Bank areas which are effectively outliers given that this is the only muck soil bank in the Ohio, only Chippewa and White Star banks had 75th percentiles of %C approaching or exceeding the lower 25th percentile of natural marshes (5.7) (Tables 22 and 23). Several banks had consistently low soil C (Cherry Valley, Grand River Lowlands, Sandy Ridge, Slate Run, Trumbull Creek) with %C between 1 and 1.8% (Table 22). Thirteen of 33 banks had P (Bray 1) levels higher than the median levels observed in natural marshes (Tables 22 and 23). For Ca, K, and Mg, many areas had higher concentrations of these parameters than the natural marshes (Tables 22 and 23).

DISCUSSION

Synthesizing the results presented here into their most basic form, one obtains the following: of the bank area assessed (nearly 400 ha), approximately 25% was not "wetland" but was primarily shallow unvegetated pond; of the remaining "wetland" acreage, approximately 24% was poor quality, 58% was fair quality, 18% was good quality when compared to the Vegetation IBI scores of a large natural reference wetland data set. (Figure 8). Considering the amphibian community, no Ohio mitigation bank has created anything other than very poor quality amphibian communities when compared to results from natural shrub or forest wetlands. Not one bank site provided habitat for wood frogs or spotted salamanders, two species indicative of high quality sites (Micacchion 2002).[7] Considering that 50% or more of permitted wetland impacts are to forested wetlands, this is a serious omission in bank restorations (Porej 2003). Amphibian communities at banks were overwhelming comprised of tolerant frog and toad species. While some bank sites had large populations of tolerant breeding frog species, sensitive amphibian species were rare occurrences at all the bank sites we monitored.

Obviously, results like this raise serious concerns with one of the fundamental premises of mitigation banking, i.e. mitigation banks are more likely than individual mitigations to be successful, either on a pure acre-for-acre basis or in terms of ecological quality. This said, some mitigation banks and some areas of some banks have been successful, so the reasons for "failure" are not inherent to wetland creation and restoration at banks.

In addition to the assessment performed here, all Ohio banks have been required to collect and report data on their performance. There is presently much variation in the monitoring protocols and performance standards at Ohio mitigation banks, although Ohio EPA has recently proposed standardized monitoring and performance protocols (Mack et al. 2004). Some bank's have virtually no quantitative goals while others have at least some quantifiable performance targets. Typical performance standards found in the instruments for the 12 banks assessed here include the following: 1) 50-75% of the area of the bank shall be vegetated with native perennial hydrophytes; 2) less than 10% of the bank shall be vegetated with invasive plant species such as *Lythrum salicaria, Phalaris arundinacea,* and *Phragmites australis*; 3) the bank area that will be sold for mitigation credits shall be "jurisdictional" wetland, i.e. it shall have hydric soils (usually determined by Munsell color), be dominated by hydrophytic vegetation, and it shall have wetland hydrology (one primary, or two secondary

[7] A serious omission when 50% or more of permitted wetland impacts are to forested wetlands (Porej 2003).

indicators of hydrology); 4) general narrative hydrologic targets such as 20% of the bank shall be seasonally inundated or saturated, 60% of the bank shall be regularly inundated, and 20% of the bank shall be permanently inundated, although these types of goals are very heavily qualified (quantitative hydrologic data is almost never collected, with the exception of Cherry Valley bank which had an extensive piezometer network); 5) a whole series of broad narrative goals regarding increasing wetland functions and values, increasing biodiversity of plants, birds, mammals, etc.; 6) in a few instruments, other quantitative goals were included such as reduction in coverage of a particular plant species, e.g. less than 25% coverage of *Juncus* (Sandy Ridge), or attaining a mean Coefficient of Conservatism (Andreas et al. 2004) of 2.0 or higher (Panzner).

Typical monitoring protocols include the establishment of several permanent transects with permanent plots (e.g. 1m x 2m). Location of the transects and plots was qualitatively determined although they were generally positioned to cross the various areas and habitats of the bank. At each plot, a wetland determination was made (so that at least the dominant plants, e.g. >20% cover, were recorded). Occasionally, all plant species in the plot were recorded.

Data collected using the bank's monitoring protocols were typically submitted to the regulatory agencies in annual monitoring reports. These reports usually discussed the data from that year in narrative fashion with little or no year to year evaluation of trends. The simplest of graphs or summary tables were almost universally avoided and data in annual monitoring reports and raw data from the plots was only included in appendices to the report. Any kind of even the most basic statistical analyses was completely absent. Credit releases at the banks were almost always determined by delineating the perimeter of the bank site with the assumption that everything within the wetland perimeter was "wetland."[8] For example, during the 5th year review of the Sandy Ridge bank, in which the bank was requesting to be released from monitoring, no analysis of the data from the permanent transects and plots was presented by the banker. The raw data from the field data sheets attached to the earlier monitoring reports was entered and reduced into analyzable form by Ohio EPA and graphed against time. This obvious analysis immediately revealed serious performance failures at the bank which should and could have been easily detected by the bank itself by simply analyzing its own monitoring data (Appendix B).

One omission in this study is the fact that it did not assess the usage of the banks by birds. The reasons for this were mostly pragmatic: sampling resources precluded monitoring every taxa group of interest; bird IBIs are uncommon and have not been developed in Ohio; and no Ohio bank does quantitative bird monitoring or has quantitative goals regarding breeding or migratory bird usage. Several banks are well-known to local birders, have long species lists of birds observed there, and this is often proposed as a reason a bank is "successful" even when it is otherwise not meeting its performance goals. Since the bird data is often anecdotal or at least non-quantitative, it is difficult to use in evaluating bank success. Of note is a recent study of bird usage at Ohio mitigation

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[8] Nearly all of the banks in this study had very loosely defined performance standards. Most often banks were only required to show that credits would meet wetland criteria with often just a narrative goal that the bank would result in wetlands of moderate quality. Credit releases were aggressive and bank agreements allowed for a 50% release of the total bank credits at the end of construction. This meant half of all credits were released before a demonstration of any ability of those credits to meet even the limited performance standards in the agreements.

wetlands including several of the bank sites studied here (Porej 2004) which found that diversity and density of breeding, non-breeding, and spring migratory bird species was highest in wetlands with high emergent vegetation cover and was also positively associated with the size of the wetland complex. Other studies have found that water depth is negatively correlated with bird usage (e.g. Frederickson and Reid 1996). Lack of vegetation and deep water were the single largest reason for bank failure in this study. Finally, the creation of "habitat" for birds is not necessarily the same as the creation of a wetland "ecosystem"; the latter is clearly the goal of compensatory mitigation and of the mitigation bank process.

The overall conclusion of this study is that mitigation banks are successful (or fail) for the same reasons that other wetland restorations, including individual mitigations, succeed or fail: poor design, planning, and/or management. When they succeed, it is often for the reasons outlined in the federal mitigation guidance: economies of scale, consolidation of scientific, planning, management resources, etc. Based on the data collected here, successful banks are defined as maximizing areas defined as "wetland," minimizing areas of open water, having hydroperiods which mimic hydroperiods of natural wetlands, maximizing cover of perennial native hydrophytes, minimizing cover of invasive plant species, and have mean VIBI scores of 40-60 (fair to good) . Based on these criteria, 3 banks were mostly successful, 5 banks were partially successful, and 4 banks were mostly not successful (Table 24). Considering wetland forest or shrub swamp restoration, only parts of one bank (Big Island) are successful; consdierating amphibian community restoration, no bank has restored an amphibian community equivalent to natural referents.

The reasons for success (and conversely failure) at Ohio mitigation banks can be summarized in six broad categories:

1. Active versus self-design. Contrary to some suggestions in the wetland restoration literature (e. g. Mitsch et al. 1998, Mitsch and Jorgensen 2004), restoring wetlands that are similar (florally, faunally, biogeochemically) to hydrogeomorphically equivalent natural wetlands does not appear to occur without active reintroduction of key floral and faunal assemblages (at least during time frames that are meaningful for evaluating mitigation success (Fennessy et al. 2004). Wetland restoration from drained farm fields has often relied on presumed relict wetland seed banks. But these seed banks are absent or comprised of a few long-lived early colonizer species like *Juncus effusus* or annual emergent species. Stable, perennial assemblages, unless they are present in immediately adjacent areas (i.e. within meters of the site), do not appear to readily recolonize restoration areas unless they are actively reintroduced. This is even more the case with long-lived woody species like shrubs and trees. Restoration of wetland shrub and forest communities with planning time frames that are relevant to regulatory programs (5-20 years) require active re- "shrubification"[9] or re-forestation efforts.

2. Good site selection, design and planning. This can be termed the square-peg-in-a-round-hole problem. The most successful banks in this study have "inserted" their wetland restorations into a landscape context in which they "fit." That landscape context would include a

[9] The restoration of wetland shrub communities remains the rarest type of wetland restoration attempted or achieved, despite the fact that shrub communities are very common and should be intermediate between emergent and forest communities and an obvious restoration goal.

high percentage of the soils that are hydric or non-hydric with hydric inclusions. Additionally, the best sites are areas where hydrologic restoration can be accomplished by simple alterations (tile destruction, ditch plugging, turning off pumps, construction of low berms, etc.) to the drainage systems installed over the years.

3. Stringent hydrologic and invasives management. The two most successful banks in this study (Cherry Valley and Panzner) are notable for the weekly, if not daily, hydrologic and invasive species management undertaken by the bank managers. These banks are constantly monitored and minor interventions undertaken as conditions change. At least in the early years post-restoration, vigilant and thoughtful intervention appears to be critically necessary. It is unreasonable to expect recently restored ecosystems to move on to ecological trajectories towards high quality natural ecosystems without frequent nudges and pushes.

4. Shallow ponds are not "wetlands." This can be termed the "pond problem" or the "over-designing to achieve hydrology" problem and is an unfortunate consequence of the highly conservative three-parameter approach taken in the 1987 Delineation Manual and the desire to maximize the credit load at a bank. The overwhelming majority of failed bank acreage can be considered "failed" because it is little more than shallow, turbid "pond." While perhaps not completely lacking in "habitat" value (i.e. ducks can land on it), it has no natural wetland referents and is lacking in nutritional value (i.e. after landing, any waterfowl move to vegetated areas for feeding). Of the bank failure outlined in this study, this is the largest single cause. The best areas of Big Island bank can be considered "depressions" (not human impoundments) and are not actively controlled dikes and water control structures. Cherry Valley bank has low berms without active control structures. Panzner bank is based on re-accessing ground water inputs without active control structures. Hebron and White Star Expansion banks have control structures but the dikes largely act as a reestablishment of a formerly "depressional" hydrology. Of the failed banks, large dikes with active control structures is a consistent feature, although "active" is perhaps a misnomer, since these sites during the period data was collected for this study were consistently kept at maximum inundation (i.e. the water control structures were *not* utilized to manipulate the hydroperiod). In addition, to the active versus passive hydrologic theme, the managers at Cherry Valley and Panzner both frequently intervene with what can be considered micro-hydrologic management by opening and closing micro-dams to achieve localized hydrologic effects in the relevant restoration. A natural, beaver-induced equivalent has been observed in the large, relatively intact wetland complexes of the upper Cuyahoga River in Geauga County (Mack, personal observation).

An associated problem with the shallow pond approach is the condition of the substrates. In the construction of large berms portions of the bank site soils are often excavated out for berm material and become the deeper water zones. The substrates that remain in these areas are then comprised largely of subsoil that has been compacted repeatedly by heavy equipment. These areas are extremely low in total carbon and other essential nutrients needed for plant growth. The result is that these areas remain wholely or largely unvegetated or they become dominated by invasive pioneer species such as the non-native, *Najas minor* which can tolerate these depauperate conditions to the exclusion of any other plant species.

5. Forest enhancement and succession. Forest "enhancement" at Ohio mitigation banks

has largely been a euphemism for poor "green-tree" wetland management: increasing hydrology from ephemeral to permanent in order to kill all trees in that management area. At several banks (Grand River Lowlands, Sandy Ridge, Trumbull Creek), existing successional wetland forest stands were killed in the name of hydrologic enhancement to be replaced by shallow pond or poorly vegetated deep marsh with standing dead trees.[10] Initiation of actual secondary wetland forest succession has only occurred extensively at Big Island bank.[11] Considering that 50% or more of permitted wetland impacts are to forested wetlands, this is a serious omission in bank restorations (Porej 2003).[12]

6. Amphibian community restoration. Sensitive or forest dependent amphibians cannot be expected to appear at new wetlands constructed in and surrounded by areas where farm fields or other intensive land uses existed previously. These species are highly dependent on food, water, cover and breeding habitat all being within the areas of their home ranges. As an example, for most pond-breeding salamanders, any wetland that is not within 200m of all of it's life cycle habitat needs will not be utilized (Semlitsch 1998). In fact, most of the pond-breeding amphibian species are dependent upon the landscape surrounding breeding wetlands being comprised of a large percentage of forested habitat (Porej et al. 2004). These species need adjacent forested habitat to satisfy the requirements of the temporally dominant terrestial stage of their life cycle. Without enough forested habitat present they cannot be excepted to be found utilizing newly constructed wetlands for breeding.

There were several other limitations on amphibian utilization of bank subareas. The presence of predatory fish is well known to be limiting on amphibian species diversity especially for pond-breeding salamander and frog species which are adapted to fish-free environments (Hecnar and M'Closkey 1997) (Porej and Hetherington 2005). Twenty-three of the subareas had populations of predatory fish. Many bank areas had permanent hydrology. Permanent inundation does not meet the habitat preferences of pond-breeding amphibians that are adapted to wetlands that dry up seasonally. Constructed subareas were almost totally comprised of areas of emergent vegetation or areas of open water, sometimes with submersed vegetation, but most often unvegetated. Many of the sites had severe slopes, due to the design of the berms or the nature of the excavations undertaken, with drastic transitions to deep water areas with little or no areas of vegetated shallows. Again these subareas did not replicate the preferred habitat of pond-breeding amphibians adapted to the habitat features of shallowly sloped forest and shrub dominated wetlands.

7. Regulatory oversight. The most frequent complaint from bankers is the length of review times in order to have new proposals or modifications of existing proposals reviewed and credit releases approved. Next would be lack of predictability in decision-making. Although banking was expected to reduce and improve

[10] At Three Eagles and White Star Expansion, existing mesic (but not wetland forest stands) were being killed to be replaced with wetland forests. At White Star this appears to be occurring because green ash is a dominant tree in the existing stand and mostly to partly closed canopy remains in place; at Three Eagles, the forest community appears to be converting to marsh.

[11] A few areas of Hebron bank also appear to be reverting to wetland forest.

[12] In response to this lack and to the performance problems in Phase 1, Phase 2 of the Trumbull Creek Bank was voluntarily modified by the banker from a traditional dike and impound design to a wetland forest reforestation project.

regulatory review time, in practice, regulatory management of mitigation banking requires the involvement of at least one full time equivalent. An active banking system would have one to several dozen banks on-line (Ohio presently has over 20 with multiple new proposals in review). These existing banks have new credit release requests, site visits, review of annual monitoring data, review of modification and adaptive management proposals as regular activities during any given year. Proposals for new banks require intensive review of proposed bank instruments, designs, service areas, performance standards, monitoring protocols, and often multiple site visits. Given that the designs and performance goals of most of the banks in this study were approved by the Mitigation Banking Review Team (MBRT) for Ohio, there is an argument that if better plans had been required and the banks more closely monitored, bank success in Ohio would have been more consistent. However, given the information available on banking and large site restoration to the MBRT, bankers were largely relied on to be able to develop quality wetland systems based on the plans they presented.

Much has been learned from the process and detailed quantitative performance standards and credit release schedules based on performance are now required for banks coming on line in Ohio (Mack et al. 2004).

CONCLUSION

The overall report card is then mixed: some banks or subareas of banks can be considered successful considering acres restored, the present or expected future ecological quality of that acreage, and the possibility that secondary wetland forest succession has been initiated; some bank or subareas can be considered to be moderately successful; and some banks and bank subareas can be considered largely failures. Unfortunately, this is not the proportion of success and failure that was at least implicitly promised in the Federal Bank Guidance. Mitigation banks were to be the best of what was achievable in terms of wetland restoration. The economies of scale possible with mitigation banks and the consolidation of design, planning, monitoring, scientific, and management resources was to provide a consistently higher quality "product" of wetland restoration than was achievable by individual restorations. This "promise", although still clearly achievable, has not been consistently attained in practice. Too often, mitigation banks have simply meant more acres of poor quality wetland restoration than a comparable, small individual mitigation site. This is clearly not acceptable nor what was intended. But the basic practical fact remains, that a workable regulatory compensatory mitigation program needs a mitigation banking system that is successful acre for acre and also ecologically. This study shows that, although not consistently achieved to date in Ohio, it is in fact achievable. What is needed is a re-appreciation that this is not easy work, that the "devil" is in the details at all levels (theory, planning, design, and management), and that "nature" does know "best" (or at least is our best referent for "success").

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Table 1. Summary table of Ohio mitigation banks sampled in this study.

site	year(s) sampled	year established	description
Big Island	2001, 2003	1994	Marion County. Eastern Corn Belt Plains ecoregion. Devoloper: Ohio Wetlands Foundation. Owner and manager: Ohio Department of Natural Resources-Division of Wildlife (Ohio DNR-DOW). Consultant: Envirotech Consultants, Inc. Approx. 118ha (292ac) on former Sandusky Plains prairie soils, most of bank was cropped as recently as 1994 but existing large area of forested wetlands included in property and hydrology was enhanced by breaking of field tiles.
Cherry Valley	2004	2000	Ashtabula County. Erie-Ontario Drift and Lake Plains ecoregion, Mosquito/Pymatuning Creek Lowlands subregion. Developer: Wetland Preservation, Ltd. Future owner and manager: Mount Pleasant Rod and Gun Club. Consultant: HzW Environmental Consultants, Inc. Approx 37ha (92ac). Formerly agricultural land on very poorly drained hydric soils. Small areas of existing wetlands.
Grand River Lowlands	2004	2000	Ashtabula County. Erie-Ontario Drift and Lake Plains ecoregion, Mosquito/Pymatuning Creek Lowlands subregion. Developer: Wetland Preservation, Ltd. Future owner and manager: Mount Pleasant Rod and Gun Club. Consultant: HzW Environmental Consultants, Inc. Approx 38ha (94ac). Formerly agricultural land on very poorly drained hydric soils. Areas of existing wetland and reverting wetland woods.
Hebron	2001, 2003	1993	Licking County. Eastern Corn Belt Plains ecoregion. Developer: Wetlands Resource Center. Owner and manager: Wetlands Resource Center and Ohio DNR-DOW. Consultant: Envirotech Consultants, Inc. Approx. 14ha (34ac) Constructed adjacent to existing swamp forests and adjacent to the Hebron Fish Hatchery on hydric soils of formerly large wetland complex. Land previously used for row cropping or fish hatchery.
Little Scioto (Phase 1)	2001, 2003	2000	Marion County. Eastern Corn Belt Plains ecoregion. Devoloper: Wetland Resource Center. Future owner and manager: Ohio DNR-DOW. Consultant: EMH&T, Inc. Approx. 70ha (172ac). Formerly agricultural land located north and south of Little Scioto River on poorly drained hydric soils in former Sandusky Plains prairie region. Ohio EPA only sampled in Northwest and Central Parcel areas of bank owned by Wetland Resource Center.
Chippewa Central	2004	2001	Medina County. Erie-Ontario Drift and Lake Plains ecoregion. Developer: North Coast Regional Council of Park Districts. Owner and manager: Medina County Park District. Consultant: Envirotech Consultants, Inc. Approx. 38ha (95ac). Formerly farmed wetlands reverted to wet meadow. Enhancement bank with main goal reduction in reed canary grass cover.
Panzer	2004	2001 (Field B), 2002 (Fields C, E), 2003 (Field A)	Summit County. Erie-Ontario Drift and Lake Plains ecoregion in Summit Interlobate subregion. Developer: Panzner & Sons, Inc. Owner and manager: Panzner & Sons, Inc. Consultants: several. Approx. 36ha (96ac) (excluding Field D). Former truck farm on deep muck soils in former Copley Swamp area with abundant ground water discharge.
Sandy Ridge	2003, 2004	1998	Lorain County. Erie-Ontario Lake Plains. Devoloper: Ohio Wetlands Foundation. Owner and manager: Lorain County Metroparks. Consultants: Davey Resource Group. Approx. 44ha (109ac). Former farm located north of relict beach ridge. Existing high quality mature swamp forest located north of fields.

Table 1. Summary table of Ohio mitigation banks sampled in this study.

site	year(s) sampled	year established	description
Slate Run	2001, 2003	1999	Pickaway County. Eastern Corn Belt Plains. Devoloper: Ohio Wetlands Foundation. Owner and manager: Columbus Metroparks. Consultant: Geotechnical Consultants, Inc. Approx. 64ha (158ac). Former farm fields. 13 separate cells constructed (five were sampled: southwest (W-1), center (W-2), south center (W-4, amphibians only), northwest (W-5), and southeast(W-8)).
Three Eagles	2003, 2004	1999	Sandusky County. Huron-Erie Lake Plains. Developer: Ohio Wetlands Foundation. Owner and manager: Ohio Wetlands Foundation. Consultant: Davey Resource Group. Approx. 64ha (158ac) of which approx 4ha of existing wetlands and 44ha (108ac) of restored wetland. Former farm fields and mesic floodplain forest along original Green Creek Channel.
Trumbull Creek (Phase 1A Berms 5, 6, and 7)	2004	2001	Geauga and Ashtabula Counties. Erie-Ontario Drift and Lake Plains ecoregion, Mosquito/Pymatuning Creek Lowlands subregion. Developer: Ohio Wetlands Foundation. Future owner and manager: Ohio DNR-DOW. Consultant: Davey Resource Group. Approx. 36ha (90ac) for Berms 5, 6, and 7 (incl. future phases 190ha (462ac)). Former farm fields and existing mesic to wetland forest.
White Star Park	2004	2003	Sandusky County. Huron-Erie Lake Plains ecoregion. Developer: North Coast Regional Council of Park Districts. Owner and manager: Sandusky County Park District. Consultant: Envirotech Consultants, Inc. Approx. 39ha (95ac). Existing drained mesic woods. Reestablishment of wetland hydrology and reduction in mesic trees and shrubs and replacement by wetland trees and shrubs.

Table 2. Summary of bank sites, subareas of bank assessed, number of 10m x 10m cells, area of bank sampled, number of random and focus plots, number of qualitative dip net samples and number of funnel traps collected at each site. Of the 34 subareas sampled, there were 33 areas where vegetation sampling occurred and 30 subareas where amphibian and macroinvertebrate sampling occurred. In 4 bank subareas (Cherry Valley Area 1, Chippewa Central, Sandy Ridge Area 1, White Star South), multiple areas within the subarea were trapped.

site	subarea	cells	area (ha)	area (ac)	random plots	fixed plots	quals	traps
Big Island	Area A	1397	14.0	34.5	10	2	3	30
Big Island	Area B	3643	36.4	90.0	19	2	3	30
Big Island	Area C	1546	15.5	38.2	10	1	3	30
Big Island	Area D	1040	10.4	25.7	9	1	3	30
Cherry Valley	Area 1	1865	18.7	46.1	20	2	6	60
Cherry Valley	Area 3	721	7.2	17.8	10	1	3	30
Chippewa Central	none	3825	38.3	94.5	15	2	9	90
Grand R Lowlands	Area A-D	877	8.8	21.7	10	1	3	30
Grand R Lowlands	Area B-C	698	7.0	17.2	10	1	3	30
Grand R Lowlands	Area F	619	6.2	15.3	10	1	3	30
Hebron	Large Cell	941	9.4	23.2	10	1	3	30
Hebron	Small Cell	247	2.5	6.1	5	1	3	30
Little Scioto	Northeast (1)	1616	16.2	39.9	10	1	3	30
Little Scioto	Northwest (2)	1237	12.4	30.6	10	1	3	30
Little Scioto	South (3)	635	6.4	15.7	0	1	3	30
Panzner	Field A	2685	26.9	66.3	10	1	3	30
Panzner	Field B	400	4.0	9.9	5	2	3	30
Panzner	Field C	211	2.1	5.2	5	1	3	30
Panzner	Field E	329	3.3	8.1	5	2	0	0
Sandy Ridge	Area 1	1975	19.8	48.8	10	1	6	60
Sandy Ridge	Area 2	1043	10.4	25.8	10	1	3	30
Sandy Ridge	Area 3	1413	14.1	34.9	10	2	0	0
Slate Run	Center	488	4.9	12.1	10	1	0	0
Slate Run	South Center	na	5.5	13.6	0	0	3	30
Slate Run	Northwest	517	5.2	12.8	10	1	3	30
Slate Run	Southeast	49	0.5	1.2	3	1	3	30
Slate Run	Southwest	433	4.3	10.7	10	1	0	0
Three Eagles	East Forest	653	6.5	16.1	10	1	3	30
Three Eagles	Northeast	1147	11.5	28.3	10	1	3	30
Three Eagles	West Meadow	875	8.8	21.6	10	1	2	20
Trumbull Creek	Berm 5	371	3.7	9.2	5	1	3	30
Trumbull Creek	Berm 7 E	1335	13.4	33.0	10	1	3	30
Trumbull Creek	Berm 7 F	1213	12.1	30.0	10	1	3	30
White Star	North	1239	12.4	30.6	10	1	3	30
White Star	South	2607	26.1	64.4	20	2	6	60
		TOTALS	404.4	999.2	331	42	104	1040

Table 3. Description of metrics used in 2004 version of VIBI-E, VIBI-F, VIBI-SH. "E" = emergent, "$E_{coastal}$" = Lake Erie Coastal Marsh, "$E_{MITIGATION}$" = Mitigaiton Marshes, "F" = forested", "SH" = shrub.

metric	E, F, SH	code	type	metric increase or decrease w/ disturbance	description
Carex spp.	E, SH	carex	richness	decrease	Number of species in the genus *Carex*
cyperaceae spp.	$E_{coastal}$	cyperaceae	richness	decrease	Number of species in the Cyperaceae family
native dicot spp.	E, SH	dicot	richness	decrease	Number of native dicot (dicotyledon) species
native shade spp.	F	shade	richness	decrease	Number of native shade[13] tolerant or shade facultative species
native, wetland shrub spp.	E, SH	shrub	richness	decrease	Number of shrub species that are native and wetland (FACW, OBL) species
hydrophyte spp.	E, SH	hydrophyte	richness	decrease	Number of vascular plant species with a Facultative Wet (FACW) or Obligate (OBL) wetland indicator status (Reed 1988; 1997; Andreas et al. 2004).
ratio of annual to perennial spp.	E	A/P	richness ratio	decrease	Ratio of number of nonwoody species with annual life cycles to number of nonwoody species with perennial life cycles. Bienniel species excluded from calculation
seedless vascular plant (SVP) spp.	F, SH	SVP	richness	decrease	Number of seedless vascular plant (ferns, fern allies) species
FQAI score	E, F, SH	FQAI	weighted richness index	decrease	The Floristic Quality Assessment Index score calculated using Eqn. 7 and the coefficients in Andreas et al. (2004)
relative cover of bryophytes	F, SH	%bryophyte	dominance ratio	decrease	Sum of the relative cover of all bryophyte species. Bryophytes include all mosses (Musci) and aquatic lichens *Riccia* and *Ricciocarpos*
relative cover of shade tolerant hydrophyte spp.	F	%hydrophyte	dominance ratio	decrease	Sum of the relative cover of shade or partial shade tolerant FACW and OBL plants in the herb and shrub stratums
relative cover of sensitive plant spp.	E, F, SH	%sensitive	dominance ratio	decrease	Sum of the relative cover of plants in herb and shrub stratums with a Coefficient of Conservatism (C of C) of 6,7,8,9 and 10 (Andreas et al. 2004)
relative cover tolerant plant spp.	E, F, SH	%tolerant	dominance ratio	increase	Sum of the relative cover of plants in herb and shrub stratums with a C of C of 0, 1, and 2 (Andreas et al. 2004)
relative cover of invasive graminoid spp.	E	%invgram	dominance ratio	increase	Sum of the relative cover of *Typha* spp., *Phalaris arundinacea,* and *Phragmites australis*
relative density of small trees (pole timber)	F	pole timber	density ratio	increase	The density (stems/ha) of a tree species in size classes between 10 and 25 cm dbh divided by the density of all trees

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

Table 3. Description of metrics used in 2004 version of VIBI-E, VIBI-F, VIBI-SH. "E" = emergent, "$E_{coastal}$" = Lake Erie Coastal Marsh, "$E_{MITIGATION}$" = Mitigaiton Marshes, "F" = forested", "SH" = shrub.

metric	E, F, SH	code	type	metric increase or decrease w/ disturbance	description
importance of native shade subcanopy spp.	F, SH	subcanopy IV	importance value	decrease	Sum of the mean importance value of shade tolerant subcanopy (shrub, subcanopy tree) species plus the mean importance value of facultative shade subcanopy (shrub, small tree) species. Importance value is the average of relative size class frequency[14], relative density, and relative basal area. Subcanopy trees are tree species which only grow in the subcanopy, e.g. *Carpinus caroliniana*
importance canopy spp.	F	canopy IV	importance value	decrease	The mean of the importance values of trees in the canopy of the forest where importance value is calculated by averaging relative size class frequency, relative density, and relative basal area. Canopy tree species are species which at maturity will inhabit the upper canopy of the forest even if at the time of sampling they are growing in the subcanopy
unvegetated and annual cover	$E_{MITIGATION}$	%unvegetated	dominance ratio	increase	The sum of the relative cover of annual plant species (percent annual spp. cover divided by total spp. cover) and the percent cover of unvegetated areas
standing biomass	E	biomass	primary production	increase	The average grams per square meter of clip plot samples collected at each emergent wetland

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

Table 4. Scoring ranges for assigning metric scores for Vegetation IBIs. Descriptions of metrics are found in Table 3. E = Emergent, SH = Shrub, F = Forest, $E_{COASTAL}$ = Lake Erie Coastal Marshes, MITIGATION = emergent mitigation wetlands.

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

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

Table 5. Description of areas where scores, metric values and other attributes calculated from data from focused or random plots at Ohio Mitigation Banks. ECBP = Eastern Corn Belt Plains, EOLP = Erie-Ontario Drift and Lake Plains, HELP = Huron-Erie Lake Plains. Prefix "r" = aggregated random plot, f = forest, md = wet meadow, ma= marsh.

site	subarea	site code	year	County	ecoregion	HGM class	veg class	veg type
3 EAGLES	East Forest	3EAGLEF	2003	Sandusky	HELP	riverine mainstem	forest	oak-maple-ash swamp
3 EAGLES	East Forest	r3EEFf	2003	Sandusky	HELP	impoundment	forest	mixed swamp forest
3 EAGLES	East Forest	r3EEFma	2003	Sandusky	HELP	impoundment	emergent	mixed emergent marsh
3 EAGLES	Northeast Marsh	3EAGLNEM	2003	Sandusky	HELP	impoundment	emergent	cattail marsh
3 EAGLES	Northeast Marsh	r3ENMma	2003	Sandusky	HELP	impoundment	emergent	mixed emergent marsh
3 EAGLES	Northeast Marsh	r3ENMmd	2003	Sandusky	HELP	impoundment	emergent	juncus-carex meadow
3 EAGLES	West Meadow	3EAGLWMw	2003	Sandusky	HELP	impoundment	emergent	cattail marsh
3 EAGLES	West Meadow	r3EWMma	2003	Sandusky	HELP	impoundment	emergent	mixed emergent marsh
3 EAGLES	West Meadow	r3EWMmd	2003	Sandusky	HELP	impoundment	emergent	juncus-carex meadow
BIG ISLAND	Area A	BGAEAST	2003	Marion	ECBP	depression	forest	oak-maple-ash swamp
BIG ISLAND	Area A	BGAWEST	2003	Marion	ECBP	depression	emergent	prairie sedge meadow
BIG ISLAND	Area A	rBGAf	2003	Marion	ECBP	depression	forest	maple-ash swamp
BIG ISLAND	Area A	rBGAma	2003	Marion	ECBP	depression	emergent	mixed emergent marsh
BIG ISLAND	Area A	rBGAmd	2003	Marion	ECBP	depression	emergent	prairie sedge meadow
BIG ISLAND	Area B	BGB	2003	Marion	ECBP	impoundment	emergent	cattail marsh
BIG ISLAND	Area B	rBGBf	2003	Marion	ECBP	impoundment	forest	maple-ash swamp
BIG ISLAND	Area B	rBGBma	2003	Marion	ECBP	impoundment	emergent	mixed emergent marsh
BIG ISLAND	Area B	rBGBmd	2003	Marion	ECBP	depression	emergent	prairie sedge meadow
BIG ISLAND	Area C	BGC	2003	Marion	ECBP	depression	emergent	wet prairie
BIG ISLAND	Area C	rBGCma	2003	Marion	ECBP	depression	emergent	mixed emergent marsh
BIG ISLAND	Area C	rBGCmd	2003	Marion	ECBP	depression	emergent	wet prairie
BIG ISLAND	Area D	BGD	2001	Marion	ECBP	depression	emergent	mixed emergent marsh
BIG ISLAND	Area D	rBGDf	2003	Marion	ECBP	depression	forest	maple-ash swamp
BIG ISLAND	Area D	rBGDma	2003	Marion	ECBP	depression	emergent	mixed emergent marsh
BIG ISLAND	Area D	rBGDmd	2003	Marion	ECBP	depression	emergent	prairie sedge meadow
CHERRY VALLEY	Area 1	C1VMa	2004	Ashtabula	EOLP	depression	emergent	mixed emergent marsh
CHERRY VALLEY	Area 1	C1VMd	2004	Ashtabula	EOLP	depression	emergent	bulrush-soft rush meadow
CHERRY VALLEY	Area 1	rC1Vma	2004	Ashtabula	EOLP	impoundment	emergent	mixed emergent marsh

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site	subarea	site code	year	County	ecoregion	HGM class	veg class	veg type
CHERRY VALLEY	Area 1	rC1Vmd	2004	Ashtabula	EOLP	impoundment	emergent	juncus-carex meadow
CHERRY VALLEY	Area 3	C3V	2004	Ashtabula	EOLP	depression	emergent	mixed emergent marsh
CHERRY VALLEY	Area 3	rC3Vma	2004	Ashtabula	EOLP	impoundment	emergent	mixed emergent marsh
CHERRY VALLEY	Area 3	rC3Vmd	2004	Ashtabula	EOLP	impoundment	emergent	juncus-carex meadow
CHERRY VALLEY	Area 3	rC3Vsh	2004	Ashtabula	EOLP	impoundment	shrub	mixed shrub swamp
CHIPPEWA	none	CHIPNRTH	2004	Medina	EOLP	riverine mainstem	emergent	reed canary grass meadow
CHIPPEWA	none	CHIPSOTH	2004	Medina	EOLP	riverine mainstem	emergent	reed canary grass meadow
CHIPPEWA	none	rCHIPma	2004	Medina	EOLP	impoundment	emergent	mixed emergent marsh
CHIPPEWA	none	rCHIPmd	2004	Medina	EOLP	impoundment	emergent	reed canary grass meadow
GR LOWLANDS	Area A-D	GRAD	2004	Ashtabula	EOLP	impoundment	emergent	mixed emergent marsh
GR LOWLANDS	Area A-D	rGRADf	2004	Ashtabula	EOLP	impoundment	forest	dead forest
GR LOWLANDS	Area A-D	rGRADma	2004	Ashtabula	EOLP	impoundment	emergent	mixed emergent marsh
GR LOWLANDS	Area A-D	rGRADmd	2004	Ashtabula	EOLP	impoundment	emergent	reed canary grass meadow
GR LOWLANDS	Area B-C	GRBC	2004	Ashtabula	EOLP	impoundment	emergent	mixed emergent marsh
GR LOWLANDS	Area B-C	rGRBCf	2004	Ashtabula	EOLP	impoundment	forest	pin oak swamp
GR LOWLANDS	Area B-C	rGRBCma	2004	Ashtabula	EOLP	impoundment	emergent	mixed emergent marsh
GR LOWLANDS	Area B-C	rGRBCmd	2004	Ashtabula	EOLP	impoundment	emergent	juncus-carex meadow
GR LOWLANDS	Area F	GRF	2004	Ashtabula	EOLP	impoundment	forest	pin oak swamp
GR LOWLANDS	Area F	rGRFf	2004	Ashtabula	EOLP	impoundment	forest	pin oak swamp
GR LOWLANDS	Area F	rGRFma	2004	Ashtabula	EOLP	impoundment	emergent	mixed emergent marsh
HEBRON	Large Cell	HEBLC	2003	Licking	ECBP	impoundment	emergent	reed canary grass meadow
HEBRON	Large Cell	rHBLma	2003	Licking	ECBP	depression	emergent	mixed emergent marsh
HEBRON	Large Cell	rHBLmd	2003	Licking	ECBP	depression	emergent	reed canary grass meadow
HEBRON	Small Cell	HEBSC	2003	Licking	ECBP	impoundment	emergent	mixed emergent marsh
HEBRON	Small Cell	rHBSma	2003	Licking	ECBP	depression	emergent	mixed emergent marsh
HEBRON	Small Cell	rHBSmd	2003	Licking	ECBP	depression	emergent	bulrush-soft rush meadow
LITTLE SCIOTO	Area 3 (South)	LS3	2003	Marion	ECBP	impoundment	emergent	mixed emergent marsh
LITTLE SCIOTO	Northeast	LS1NE	2003	Marion	ECBP	riverine mainstem	emergent	mixed emergent marsh
LITTLE SCIOTO	Northeast	rLSNEma	2003	Marion	ECBP	riverine mainstem	emergent	mixed emergent marsh

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site	subarea	site code	year	County	ecoregion	HGM class	veg class	veg type
LITTLE SCIOTO	Northwest	LS2NW	2003	Marion	ECBP	riverine mainstem	emergent	mixed emergent marsh
LITTLE SCIOTO	Northwest	rLSNWma	2003	Marion	ECBP	riverine mainstem	emergent	mixed emergent marsh
PANZNER	Field A	PANZA	2004	Summit	EOLP	slope	emergent	mixed emergent marsh
PANZNER	Field A	rPNZAma	2004	Summit	EOLP	slope	emergent	mixed emergent marsh
PANZNER	Field B	rPNZBma	2004	Summit	EOLP	depression	emergent	mixed emergent marsh
PANZNER	Field B	rPNZBmd	2004	Summit	EOLP	slope	emergent	fen
PANZNER	Field B	rPNZCma	2004	Summit	EOLP	riverine mainstem	emergent	mixed emergent marsh
PANZNER	Field B NW	PANZBNW	2004	Summit	EOLP	slope	emergent	sedge-juncus meadow
PANZNER	Field B SW	PANZBSW	2004	Summit	EOLP	slope	emergent	sedge-juncus meadow
PANZNER	Field C	PANZC	2004	Summit	EOLP	slope	emergent	mixed emergent marsh
PANZNER	Field E	PANZEMa	2004	Summit	EOLP	slope	emergent	mixed emergent marsh
PANZNER	Field E	PANZEMd	2004	Summit	EOLP	slope	emergent	sedge-juncus meadow
PANZNER	Field E	rPNZEma	2004	Summit	EOLP	riverine mainstem	emergent	mixed emergent marsh
PANZNER	Field E	rPNZEmd	2004	Summit	EOLP	slope	emergent	fen
SANDY RIDGE	Area 1	SANDRD1	2003	Lorain	EOLP	impoundment	emergent	submergent marsh
SANDY RIDGE	Area 1	rSR1Af	2003	Lorain	EOLP	impoundment	emergent	mixed emergent marsh
SANDY RIDGE	Area 1	rSR1Ama	2003	Lorain	EOLP	impoundment	emergent	mixed emergent marsh
SANDY RIDGE	Area 2	SANDRD2	2003	Lorain	EOLP	impoundment	emergent	submergent marsh
SANDY RIDGE	Area 2	rSR2Ama	2003	Lorain	EOLP	impoundment	emergent	mixed emergent marsh
SANDY RIDGE	Area 3	SANDRD3	2003	Lorain	EOLP	impoundment	emergent	mixed emergent marsh
SANDY RIDGE	Area 3	rSR3Ama	2003	Lorain	EOLP	impoundment	emergent	mixed emergent marsh
SANDY RIDGE	Area 3	rSR3Amd	2003	Lorain	EOLP	impoundment	emergent	juncus-carex meadow
SANDY RIDGE	Area 3 south	SANDRD3S	2003	Lorain	EOLP	impoundment	emergent	cattail marsh
SLATE RUN	Center	SLATRNC	2003	Pickaway	ECBP	impoundment	emergent	mixed emergent marsh
SLATE RUN	Center	rSRCma	2003	Pickaway	ECBP	impoundment	emergent	mixed emergent marsh
SLATE RUN	Northwest	SLATRNNW	2003	Pickaway	ECBP	impoundment	emergent	mixed emergent marsh
SLATE RUN	Northwest	rSRNWma	2003	Pickaway	ECBP	impoundment	emergent	mixed emergent marsh
SLATE RUN	Southeast	SLATRNSE	2001	Pickaway	ECBP	impoundment	emergent	cattail marsh
SLATE RUN	Southeast	rSRSEma	2003	Pickaway	ECBP	impoundment	emergent	mixed emergent marsh

Table 5. Description of areas where scores, metric values and other attributes calculated from data from focused or random plots at Ohio Mitigation Banks. ECBP = Eastern Corn Belt Plains, EOLP = Erie-Ontario Drift and Lake Plains, HELP = Huron-Erie Lake Plains. Prefix "r" = aggregated random plot, f = forest, md = wet meadow, ma= marsh.

site	subarea	site code	year	County	ecoregion	HGM class	veg class	veg type
SLATE RUN	Southwest	SLATRNSW	2003	Pickaway	ECBP	impoundment	emergent	mixed emergent marsh
SLATE RUN	Southwest	rSRSWma	2003	Pickaway	ECBP	impoundment	emergent	mixed emergent marsh
TRUMBULL CR	Berm 5	TRUMB5	2004	Geauga	EOLP	impoundment	emergent	mixed emergent marsh
TRUMBULL CR	Berm 5	rTR5Bma	2004	Geauga	EOLP	impoundment	emergent	mixed emergent marsh
TRUMBULL CR	Berm 7E	TRUMB7M	2004	Geauga	EOLP	impoundment	emergent	mixed emergent marsh
TRUMBULL CR	Berm 7E	rTR7Ema	2004	Geauga	EOLP	impoundment	emergent	mixed emergent marsh
TRUMBULL CR	Berm 7F	TRUMB7F	2004	Geauga	EOLP	impoundment	forest	maple-ash swamp
TRUMBULL CR	Berm 7F	rTR7Ff	2004	Geauga	EOLP	impoundment	forest	mixed swamp forest
TRUMBULL CR	Berm 7F	rTR7Fma	2004	Geauga	EOLP	impoundment	emergent	mixed emergent marsh
WHITE STAR	North	WHSTARN	2004	Sandusky	HELP	impoundment	forest	maple-ash swamp
WHITE STAR	North	rWSNf	2004	Sandusky	HELP	depression	forest	maple-ash swamp
WHITE STAR	North	rWSNma	2004	Sandusky	HELP	depression	emergent	mixed emergent marsh
WHITE STAR	South	rWSSf	2004	Sandusky	HELP	depression	forest	maple-ash swamp
WHITE STAR	South	rWSSma	2004	Sandusky	HELP	impoundment	emergent	mixed emergent marsh
WHITE STAR	South	rWSSsh	2004	Sandusky	HELP	depression	shrub	mixed shrub swamp
WHITE STAR	South 1	WHSTARS1	2004	Sandusky	HELP	impoundment	emergent	mixed emergent marsh
WHITE STAR	South 2	WHSTARS2	2004	Sandusky	HELP	impoundment	forest	maple-ash swamp

Table 6. Average percent open water at Ohio banks. "Open water" consists of areas of a bank without rooted emergent vegetation, but includes areas with submersed or floating aquatic plants. "Open water" does not meet the hydrophytic vegetation criterion of the 1987 Manual (Environmental Laboratory 1987) is not a jurisdictional wetland, but it may be a "special aquatic site." Note acreage from Little Scioto South and Slate Run South Center excluded since no random plot data collected in those areas.

site	size (ha)	size (ac)	avg % open water	SE	ha of open water	ac of open water	% of site that is open water
3 Eagles East Forest	6.5	16.1	10.3%	5.5%	0.7	1.7	10%
3 Eagles NE Marsh	11.5	28.3	39.7%	15.8%	4.5	11.2	40%
3 Eagles West Meadow	8.8	21.6	0.0%	0.0%	0.0	0.0	0%
BG Area A	14.0	34.5	4.8%	1.6%	0.7	1.7	5%
BG Area B	36.4	90.0	72.9%	8.9%	26.6	65.6	73%
BG Area C	15.5	38.2	0.0%	0.0%	0.0	0.0	0%
BG Area D	10.4	25.7	11.3%	10.7%	1.2	2.9	11%
Cherry Valley Area 1	18.7	46.1	8.2%	6.9%	1.5	3.8	8%
Cherry Valley Area 3	7.2	17.8	10.2%	8.8%	0.7	1.8	10%
Chippewa Central	38.3	94.5	13.3%	8.2%	5.1	12.6	13%
Grand River A-D	8.8	21.7	41.4%	15.2%	3.6	9.0	41%
Grand River B-C	7.0	17.2	16.7%	6.6%	1.2	2.9	17%
Grand River F	6.2	15.3	23.2%	12.9%	1.4	3.5	23%
Hebron Large Cell	9.4	23.2	12.2%	5.4%	1.2	2.8	12%
Hebron Small Cell	2.5	6.1	26.1%	23.7%	0.6	1.6	26%
Little Scioto NE (1)	16.2	39.9	81.7%	8.9%	13.2	32.6	82%
Little Scioto NW (2)	12.4	30.6	23.9%	9.3%	3.0	7.3	24%
Panzner Field A	26.9	66.3	0.0%	0.0%	0.0	0.0	0%
Panzner Field B	4.0	9.9	38.8%	23.8%	1.6	3.8	39%
Panzner Field C	2.1	5.2	27.9%	17.6%	0.6	1.5	28%
Panzner Field E	3.3	8.1	0.0%	0.0%	0.0	0.0	0%
Sandy Ridge Area 1	19.8	48.8	74.0%	11.1%	14.6	36.1	74%
Sandy Ridge Area 2	10.4	25.8	93.2%	3.8%	9.7	24.0	93%
Sandy Ridge Area 3	14.1	34.9	11.9%	9.5%	1.7	4.1	12%
Slate Run Center	4.9	12.1	22.7%	12.5%	1.1	2.7	23%
Slate Run NW	5.2	12.8	35.5%	14.7%	1.8	4.5	36%
Slate Run SE	0.5	1.2	2.2%	0.7%	0.0	0.0	2%
Slate Run SW	4.3	10.7	58.6%	15.7%	2.5	6.3	59%
Trumbull Ck Brm 5	3.7	9.2	70.5%	26.5%	2.6	6.5	71%
Trumbull Ck Brm 7E	13.4	33.0	91.1%	6.0%	12.2	30.0	91%
Trumbull Ck Brm 7F	12.1	30.0	41.6%	14.4%	5.0	12.5	42%
Whitestar North	12.4	30.6	0.0%	0.0%	0.0	0.0	0%
Whitestar South	26.1	64.4	0.4%	0.4%	0.1	0.3	0%
					118.7	293.2	29%

Table 7. Average percent unvegetated open water at Ohio banks. "Unvegetated open water consists of areas of a bank that are inundated but do not have any vegetation (emergent, floating, or submersed). "Unvegetated open water" does not meet the hydrophytic vegetation criterion of the 1987 Manual (Environmental Laboratory 1987) and is not a jurisdictional wetland. Note invasive aquatic plants like *Najas minor* included in determining whether inundated zone was "vegetated" for this calculation. For example compare %open water and %unvegetated water calculations for Sandy Ridge where there was very high *Najas minor* cover.

site	subarea	size (ha)	size (ac)	avg % unvegetated open water	ha of unvegetated open water	ac of unvegetated open water	% of site that is unvegetated open water
3 Eagles	East Forest	6.5	16.1	6.3%	0.4	1.0	6.3%
3 Eagles	Northeast Marsh	11.5	28.3	37.7%	4.3	10.7	37.7%
3 Eagles	West Meadow	8.8	21.6	0.0%	0.0	0.0	0.0%
Big Island	Area A	14.0	34.5	4.5%	0.6	1.6	4.5%
Big Island	Area B	36.4	90.0	75.8%	27.6	68.2	75.8%
Big Island	Area C	15.5	38.2	0.0%	0.0	0.0	0.0%
Big Island	Area D	10.4	25.7	11.2%	1.2	2.9	11.2%
Cherry Valley	Area 1	18.7	46.1	3.6%	0.7	1.7	3.6%
Cherry Valley	Area 3	7.2	17.8	2.3%	0.2	0.4	2.3%
Chippewa Central	none	38.3	94.5	10.9%	4.2	10.3	10.9%
Grand R Lowlands	Area A-D	8.8	21.7	24.4%	2.1	5.3	24.4%
Grand R Lowlands	Area B-C	7.0	17.2	13.7%	1.0	2.4	13.7%
Grand R Lowlands	Area F	6.2	15.3	0.2%	0.0	0.0	0.2%
Hebron	Large Cell	9.4	23.2	16.7%	1.6	3.9	16.7%
Hebron	Small Cell	2.5	6.1	13.3%	0.3	0.8	13.3%
Little Scioto	Northeast (1)	16.2	39.9	40.1%	6.5	16.0	40.1%
Little Scioto	Northwest (2)	12.4	30.6	10.3%	1.3	3.1	10.3%
Panzner	Field A	26.9	66.3	0.0%	0.0	0.0	0.0%
Panzner	Field B	4.0	9.9	0.6%	0.0	0.1	0.6%
Panzner	Field C	2.1	5.2	27.7%	0.6	1.4	27.7%
Panzner	Field E	3.3	8.1	0.0%	0.0	0.0	0.0%
Sandy Ridge	Area 1	19.8	48.8	20.7%	4.1	10.1	20.7%
Sandy Ridge	Area 2	10.4	25.8	18.9%	2.0	4.9	18.9%
Sandy Ridge	Area 3	14.1	34.9	13.0%	1.8	4.5	13.0%
Slate Run	Center	4.9	12.1	9.7%	0.5	1.2	9.7%
Slate Run	Northwest	5.2	12.8	12.6%	0.6	1.6	12.6%
Slate Run	Southeast	0.5	1.2	3.1%	0.0	0.0	3.1%
Slate Run	Southwest	4.3	10.7	24.7%	1.1	2.6	24.7%
Trumbull Creek	Berm 5	3.7	9.2	40.6%	1.5	3.7	40.6%
Trumbull Creek	Berm 7 E	13.4	33.0	76.6%	10.2	25.3	76.6%
Trumbull Creek	Berm 7 F	12.1	30.0	29.0%	3.5	8.7	29.0%
White Star	North	12.4	30.6	0.0%	0.0	0.0	0.0%
White Star	South	26.1	64.4	0.1%	0.0	0.1	0.1%
					77.9	192.4	

Table 8. Number of random plots at each bank site that was determined to meet the 3 criteria (hydric soil, hydrophytic vegetation, wetland hydrology) to be considered a "jurisdictional" wetland in accordance with the 1987 Delineation Manual (Environmental Laboratory, 1987). Note: submersed and floating aquatic vegetation included in hydrophytic vegetation criterion contrary to 1987 Manual.

	wetland plots*	%wetland	size (ha)	size (ac)	loss (ha)	loss (ac)	%loss
3EAGLES	17 of 30	81%	26.8	66.1	-5.1	-12.6	-19%
BIG ISLAND	35 of 48	73%	76.3	188.4	-20.7	-51.0	-27%
CHERRY VALLEY	22 of 30	73%	25.9	63.9	-6.9	-17.0	-27%
CHIPPEWA CENTRAL	14 of 15	93%	38.3	94.5	-2.6	-6.3	-7%
GRAND R. LOWLANDS	27 of 30	90%	21.9	54.2	-2.2	-5.4	-10%
HEBRON	15 of 15	100%	11.9	29.4	0.0	0.0	0%
LITTLE SCIOTO	19 of 20	95%	28.5	70.5	-1.4	-3.5	-5%
PANZNER	24 of 25	96%	36.3	89.6	-1.5	-3.6	-4%
SANDY RIDGE	27 of 30	90%	44.3	109.5	-4.4	-10.9	-10%
SLATE RUN	30 of 33	91%	14.9	36.7	-1.4	-3.3	-9%
TRUMBULL CR	10 of 25	40%	29.2	72.1	-17.5	-43.3	-60%
WHITESTAR**	14 of 30	47%	38.5	95.0	-20.5	-50.7	-53%
					net loss **	-157.1	

* plots were excluded if they were "upland" or were unvegetated by any type of hydrophytic vegetation

** plan for White Star EA estimated ~50% of total bank area would achieve wetland hydrology upland White Star acreage excluded from net loss

Table 9. Community types established at Ohio mitigation banks. M = marsh, WM = wet meadow, F = wetland forest, dF = dead forest, SH = shrub, PD = pond, OF = old field, UF = upland forest, UTH = upland thicket.

site	M	WM	F	dF	SH	PD	OF	UF	UTH	total
3EAGLES	6	2	8			3	10	1		30
BIG ISLAND	15	11	9			13				48
CHERRY VALLEY	9	12			1		8			30
CHIPPEWA	2	13								15
GR LOWLANDS	14	3	8	4			1			30
HEBRON	8	7								15
LITTLE SCIOTO	20									20
PANZNER	19	5				1				25
SANDY RIDGE	21	3		3		3				30
SLATE RUN	30					3				33
TRUMBULL	5		6	4		7	2	1		25
WHITE STAR	3		6		5			7	9	30
number of plots	152	56	35	13	6	30	21	9	9	331
%type	46%	17%	11%	4%	2%	9%	6%	3%	3%	
type (ha)	180	66	42	15	7	36	25	11	11	
type (ac)	445	164	103	38	18	88	62	26	26	

Table 10. Mean and median relative cover of perennial native hydrophytes from random plots sampled at mitigation bank subareas. Number calculated by summing relative cover values of perennial native hydrophytes for each random plot and then calculating the average or median value for all random plots in that bank subarea. Sites with an asterisk (*) have values that are underestimates since these plots were predominately forested and cover of canopy tree species not included in estimate. Values in boldface would be considered as meeting or on a trajectory to meeting performance goal of >75% cover of native perennial hydrophytes.

subarea	mean PE nat hydro	SE	st dev	median PE nat hydro	min	max
3 Eagles East Forest*	0.468	0.064	0.193	0.425	0.256	0.826
3 Eagles NE Marsh	0.324	0.087	0.195	0.317	0.020	0.524
3 Eagles West Meadow	0.380	0.095	0.134	0.380	0.286	0.475
Big Island Area A	**0.743**	0.065	0.205	**0.819**	0.376	0.958
Big Island Area B	0.491	0.085	0.210	0.558	0.089	0.689
Big Island Area C	**0.682**	0.083	0.262	**0.695**	0.319	0.978
Big Island Area D	**0.732**	0.132	0.395	**0.937**	0.040	1.000
Cherry V. Area 1	0.566	0.059	0.228	0.578	0.027	0.901
Cherry V. Area 3	0.623	0.098	0.259	**0.766**	0.174	0.886
Chippewa	**0.796**	0.079	0.297	**0.932**	0.092	1.000
GR Lowl. A-D	0.264	0.065	0.185	0.247	0.023	0.490
GR Lowl. B-C	0.277	0.087	0.275	0.150	0.0001	0.740
GR Lowl. F*	0.521	0.073	0.211	0.573	0.152	0.775
Hebron Lg. Cell	**0.824**	0.066	0.208	**0.933**	0.472	1.000
Hebron Sm. cell	0.407	0.143	0.319	0.358	0.003	0.876
L. Scioto NE	0.656	0.128	0.385	**0.791**	0.020	1.000
L. Scioto NW	**0.709**	0.069	0.217	**0.724**	0.341	0.963
Panzner A	0.082	0.039	0.116	0.015	0.005	0.337
Panzner B	0.549	0.220	0.491	**0.807**	0.015	0.963
Panzner C	0.438	0.109	0.218	0.424	0.215	0.690
Panzner E	**0.856**	0.020	0.044	**0.854**	0.792	0.913
Sandy R. 1	0.284	0.117	0.352	0.150	0.0002	0.882
Sandy R. 2	0.361	0.125	0.376	0.226	0.020	1.000
Sandy R. 3	**0.810**	0.050	0.149	**0.875**	0.530	0.973
Slate Run Center	0.614	0.096	0.289	**0.689**	0.010	0.869
Slate Run NW	0.588	0.064	0.193	0.584	0.297	0.872
Slate Run SE	**0.669**	0.031	0.054	**0.651**	0.63	0.729
Slate Run SW	0.392	0.115	0.325	0.339	0.047	0.824
Trumbull B7E	**0.693**	0.154	0.308	**0.810**	0.248	0.903
Trumbull B7F*	0.535	0.111	0.295	**0.661**	0.070	0.841
Wh. Star N*	0.438	0.099	0.221	0.418	0.188	0.756
Wh. Star S*	0.493	0.098	0.293	0.621	0.106	0.827
>65% cover	11			15		
>75% cover	4			10		
	34.4%			46.8%		

Table 11. Basic vegetation establishment calculated from focused and aggregated random plots at Ohio mitigation banks. Number is sum of relative cover values for all species in that group in each focused or aggregated random plot. Table 1 spp. are from list of invasive spp. in ORAM v. 5.0 (*Lythrum salicaria, Myriophyllum spicatum, Najas minor, Phalaris arundinacea, Phragmites, australis, Potamogeton crispus, Ranunculus ficaria, Rhamnus frangula, Typha angustifolia, T.* x*glauca*). %cover = sum of relative cover of species in that class, hydro = FAC, FACW, OBL species, adventive = nonnative species plus *Phalaris arundinacea* and *Phragmites australis*. Prefex "r" in subarea = aggregated random plot.

site	subarea	no. Table 1 spp.	%cover Table 1 spp.	% cover PE nat hydro	% cover nonnative	% cover native cover	% cover adventive
3 EAGLES	3EAGLEF	2	0.317	0.660	0.016	0.984	0.333
3 EAGLES	3EAGLNEM	3	0.627	0.262	0.626	0.374	0.634
3 EAGLES	3EAGLWMw	2	0.280	0.453	0.233	0.768	0.308
3 EAGLES	r3EEFf	2	0.006	0.453	0.061	0.821	0.067
3 EAGLES	r3EEFma	2	0.149	0.454	0.124	0.876	0.273
3 EAGLES	r3ENMma	3	0.141	0.433	0.065	0.677	0.069
3 EAGLES	r3ENMmd	0	0.000	0.529	0.267	0.733	0.267
3 EAGLES	r3EWMma	2	0.335	0.592	0.180	0.820	0.208
3 EAGLES	r3EWMmd	2	0.033	0.417	0.158	0.829	0.188
BIG ISLAND	BGAEAST	1	0.180	0.962	0.009	0.991	0.190
BIG ISLAND	BGAWEST	0	0.000	0.905	0.034	0.966	0.034
BIG ISLAND	BGB	1	0.003	0.889	0.018	0.925	0.021
BIG ISLAND	BGC	0	0.000	0.837	0.081	0.919	0.081
BIG ISLAND	rBGAf	1	0.069	0.685	0.167	0.732	0.236
BIG ISLAND	rBGAma	1	0.039	0.869	0.017	0.931	0.056
BIG ISLAND	rBGAmd	0	0.000	0.840	0.004	0.996	0.004
BIG ISLAND	rBGBf	1	0.013	0.580	0.335	0.598	0.348
BIG ISLAND	rBGBma	2	0.167	0.345	0.080	0.410	0.171
BIG ISLAND	rBGBmd	1	0.025	0.624	0.362	0.624	0.387
BIG ISLAND	rBGCma	0	0.000	0.753	0.197	0.793	0.197
BIG ISLAND	rBGCmd	0	0.000	0.652	0.237	0.736	0.237
BIG ISLAND	rBGDf	1	0.002	0.638	0.000	0.665	0.002
BIG ISLAND	rBGDma	1	0.032	0.771	0.014	0.777	0.046
BIG ISLAND	rBGDmd	0	0.000	1.000	0.000	1.000	0.000
CHERRY VALLEY	CVA1Ma	1	0.004	0.369	0.000	0.748	0.004
CHERRY VALLEY	CVA1Md	1	0.021	0.771	0.125	0.845	0.146
CHERRY VALLEY	CVA3	1	0.017	0.299	0.000	0.803	0.017
CHERRY VALLEY	rC1Vma	2	0.149	0.521	0.141	0.675	0.180
CHERRY VALLEY	rC1Vmd	1	0.013	0.540	0.169	0.831	0.182
CHERRY VALLEY	rC3Vma	1	0.027	0.527	0.135	0.800	0.163
CHERRY VALLEY	rC3Vmd	1	0.212	0.740	0.188	0.812	0.400
CHERRY VALLEY	rC3Vsh	1	0.025	0.770	0.025	0.921	0.050
CHIPPEWA	CHIPNRTH	1	0.940	0.981	0.000	1.000	0.940
CHIPPEWA	CHIPSOTH	2	0.057	0.092	0.006	0.316	0.059
CHIPPEWA	rCHIPma	1	0.027	0.032	0.000	0.333	0.027
CHIPPEWA	rCHIPmd	1	0.853	0.862	0.019	0.964	0.871
GR LOWLANDS	GRAD	1	0.002	0.047	0.000	0.492	0.002
GR LOWLANDS	GRBC	1	0.014	0.170	0.016	0.777	0.031
GR LOWLANDS	GRF	0	0.000	0.129	0.000	0.222	0.000
GR LOWLANDS	rGRADf	0	0.000	0.073	0.000	0.653	0.000
GR LOWLANDS	rGRADma	1	0.023	0.160	0.039	0.696	0.062
GR LOWLANDS	rGRADmd	1	0.302	0.362	0.026	0.672	0.328
GR LOWLANDS	rGRBCf	0	0.000	0.087	0.000	0.675	0.000
GR LOWLANDS	rGRBCma	1	0.082	0.203	0.054	0.758	0.136
GR LOWLANDS	rGRBCmd	1	0.000	0.714	0.242	0.758	0.242
GR LOWLANDS	rGRFf	0	0.000	0.393	0.001	0.632	0.001
GR LOWLANDS	rGRFma	1	0.002	0.649	0.000	0.965	0.002
HEBRON	HEBLC	1	0.462	0.927	0.010	0.937	0.472
HEBRON	HEBSC	1	0.009	0.549	0.005	0.995	0.014
HEBRON	rHBLma	1	0.137	0.607	0.000	0.624	0.137
HEBRON	rHBLmd	1	0.587	0.979	0.019	0.981	0.605
HEBRON	rHBSma	1	0.005	0.288	0.000	0.824	0.005
HEBRON	rHBSmd	1	0.038	0.876	0.016	0.984	0.054

Table 11. Basic vegetation establishment calculated from focused and aggregated random plots at Ohio mitigation banks. Number is sum of relative cover values for all species in that group in each focused or aggregated random plot. Table 1 spp. are from list of invasive spp. in ORAM v. 5.0 (*Lythrum salicaria, Myriophyllum spicatum, Najas minor, Phalaris arundinacea, Phragmites, australis, Potamogeton crispus, Ranunculus ficaria, Rhamnus frangula, Typha angustifolia, T.* x*glauca*). %cover = sum of relative cover of species in that class, hydro = FAC, FACW, OBL species, adventive = nonnative species plus *Phalaris arundinacea* and *Phragmites australis*. Prefex "r" in subarea = aggregated random plot.

LITTLE SCIOTO	LS1NE	1	0.004	0.954	0.005	0.995	0.005
LITTLE SCIOTO	LS2NW	0	0.000	0.856	0.004	1.032	0.004
LITTLE SCIOTO	LS3	0	0.000	0.926	0.023	0.977	0.023
LITTLE SCIOTO	rLSNEma	0	0.000	0.600	0.000	0.666	0.000
LITTLE SCIOTO	rLSNWma	0	0.000	0.585	0.040	0.880	0.040
PANZNER	PANZA	0	0.000	0.032	0.188	0.812	0.188
PANZNER	PANZBNW	0	0.000	0.884	0.011	0.929	0.011
PANZNER	PANZBSW	2	0.005	0.856	0.006	0.927	0.006
PANZNER	PANZC	0	0.000	0.370	0.007	0.873	0.007
PANZNER	PANZEMa	1	0.004	0.782	0.000	0.922	0.004
PANZNER	PANZEMd	0	0.000	0.843	0.051	0.935	0.051
PANZNER	rPNZAma	0	0.000	0.078	0.236	0.757	0.236
PANZNER	rPNZBma	0	0.000	0.015	0.000	0.985	0.000
PANZNER	rPNZBmd	0	0.000	0.932	0.001	0.979	0.001
PANZNER	rPNZCma	0	0.000	0.470	0.000	0.905	0.000
PANZNER	rPNZEma	1	0.002	0.953	0.000	0.977	0.002
PANZNER	rPNZEmd	0	0.000	0.915	0.015	0.970	0.015
SANDY RIDGE	SANDRD1	2	0.006	0.900	0.000	1.000	0.006
SANDY RIDGE	SANDRD2	3	0.256	0.745	0.252	0.748	0.256
SANDY RIDGE	SANDRD3	3	0.031	0.916	0.028	0.968	0.059
SANDY RIDGE	SANDRD3S	3	0.491	0.508	0.491	0.508	0.492
SANDY RIDGE	rSR1Af	2	0.811	0.038	0.816	0.051	0.816
SANDY RIDGE	rSR1Ama	2	0.428	0.422	0.428	0.463	0.428
SANDY RIDGE	rSR2Ama	2	0.532	0.396	0.532	0.398	0.532
SANDY RIDGE	rSR3Ama	3	0.038	0.813	0.039	0.930	0.046
SANDY RIDGE	rSR3Amd	3	0.225	0.923	0.034	0.964	0.251
SLATE RUN	SLATRNC	0	0.000	0.302	0.013	0.988	0.013
SLATE RUN	SLATRNNW	1	0.237	0.450	0.240	0.760	0.240
SLATE RUN	SLATRNSW	2	0.292	0.513	0.321	0.679	0.345
SLATE RUN	rSRCma	2	0.121	0.552	0.149	0.834	0.150
SLATE RUN	rSRNWma	2	0.112	0.383	0.113	0.862	0.115
SLATE RUN	rSRSEma	2	0.117	0.810	0.017	0.951	0.061
SLATE RUN	rSRSWma	1	0.350	0.348	0.371	0.561	0.371
TRUMBULL CR	TRUMB5	0	0.000	0.280	0.017	0.328	0.017
TRUMBULL CR	TRUMB7F	0	0.000	0.005	0.000	0.010	0.000
TRUMBULL CR	TRUMB7M	1	0.001	0.029	0.000	0.127	0.001
TRUMBULL CR	rTR5Bma	0	0.000	0.805	0.000	0.903	0.000
TRUMBULL CR	rTR7Ema	1	0.002	0.591	0.000	0.729	0.002
TRUMBULL CR	rTR7Ff	1	0.000	0.384	0.001	0.586	0.001
TRUMBULL CR	rTR7Fma	0	0.000	0.765	0.000	0.931	0.000
WHITE STAR	WHSTARN	0	0.000	0.095	0.000	0.125	0.000
WHITE STAR	WHSTARS1	1	0.067	0.553	0.001	0.640	0.069
WHITE STAR	WHSTARS2	2	0.001	0.193	0.011	0.510	0.012
WHITE STAR	rWSNf	0	0.000	0.355	0.000	0.531	0.000
WHITE STAR	rWSNma	0	0.000	0.756	0.178	0.822	0.178
WHITE STAR	rWSSf	0	0.000	0.361	0.010	0.554	0.010
WHITE STAR	rWSSma	1	0.014	0.860	0.026	0.915	0.041
WHITE STAR	rWSSsh	0	0.000	0.430	0.037	0.644	0.037

Table 12. Summary of basic vegetation establishment derived from focused and aggregated random plots in Table 11.

	no. of plots	% of all plots
Table 1 spp.		
no. of plots with no Table 1 spp.	34	33.7%
no. of plots with <10% Table 1 spp.	73	72.2%
no. of plots with <5% Table 1 spp.	69	68.3%
nonnative species		
no. of plots with no nonnative spp.	24	23.8%
no. of plots with <10% nonnative spp.	71	70.3%
no. of plots with <5% nonnative spp.	65	64.4%
adventive species		
no. of plots with no adventive spp.	12	11.9%
no. of plots with < 10% adventive spp.	60	59.4%
no. of plots with < 5% adventive spp.	48	47.5%
Perennial native hydrophytes		
no. of plots with 75% or greater	36	23.8%

Table 13. Summary of VIBI scores for Ohio Mitigation Banks. F = focused plot, AR = aggregated random plot, TALU class = tiered aquatic life use classes from Mack (2004b), VIBI quartiles = quadrisected VIBI score distribution (0-24 = poor, 25-49 = fair, 50-74 = good, 75-100 = excellent). LQWLH = limited quality wetland habitat, RWLH = restorable wetland habitat, WLH = wetland habitat.

site	subarea	site code	description	plot type	FN	TALU class	VIBI quartiles	VIBI	VIBI-E	VIBI-SH	VIBI-F
3 EAGLES	East Forest	3EAGLEF	enhanced forest	F	S	LQWLH	poor	16	23	23	16
3 EAGLES	East Forest	r3EEFf	enhanced forest	AR		WLH	fair	43	64	30	43
3 EAGLES	East Forest	r3EEFma	converting forest	AR		LQWLH	poor	20	20	13	10
3 EAGLES	Northeast Marsh	3EAGLNEM	marsh	F	2	LQWLH	poor	24	24	20	10
3 EAGLES	Northeast Marsh	r3ENMma	marsh	AR	2	RWLH	fair	26	26	20	10
3 EAGLES	Northeast Marsh	r3ENMmd	wet meadow	AR	2	LQWLH	poor	16	16	3	10
3 EAGLES	West Meadow	3EAGLWMw	marsh	F	2	LQWLH	poor	19	19	14	10
3 EAGLES	West Meadow	r3EWMma	marsh	AR	2	LQWLH	poor	7	7	6	13
3 EAGLES	West Meadow	r3EWMmd	wet meadow	AR	2	LQWLH	poor	13	20	3	10
BIG ISLAND	Area A	BGAEAST	wet meadow/young 2nd growth	F		RWLH	fair	36	36	25	13
BIG ISLAND	Area A	BGAWEST	wet meadow/young 2nd growth	F		RWLH	fair	47	47	23	13
BIG ISLAND	Area A	rBGAf	young 2nd growth	AR		RWLH	good	50	50	34	29
BIG ISLAND	Area A	rBGAma	marsh	AR	2	RWLH	fair	32	32	22	16
BIG ISLAND	Area A	rBGAmd	wet meadow	AR	2	RWLH	fair	39	39	9	13
BIG ISLAND	Area B	BGB	marsh	F	2	RWLH	fair	36	36	40	23
BIG ISLAND	Area B	rBGBf	young 2nd growth	AR		LQWLH	poor	13	13	6	0
BIG ISLAND	Area B	rBGBma	marsh	AR	2	RWLH	fair	37	47	19	16
BIG ISLAND	Area B	rBGBmd	wet meadow	AR	2	RWLH	fair	42	42	23	13
BIG ISLAND	Area C	BGC	wet meadow	F	2	WLH	good	71	71	44	20
BIG ISLAND	Area C	rBGCma	marsh	AR	2	WLH	good	61	61	41	22
BIG ISLAND	Area C	rBGCmd	wet meadow	AR		WLH	good	64	64	43	35
BIG ISLAND	Area D	BGD	marsh	F	2	RWLH	good	50	50	26	10
BIG ISLAND	Area D	rBGDf	young 2nd growth	AR		RWLH	fair	40	40	23	33
BIG ISLAND	Area D	rBGDma	marsh	AR	2	RWLH	fair	26	26	16	13
BIG ISLAND	Area D	rBGDmd	wet meadow	AR	2	RWLH	fair	43	43	9	30
CHERRY VALLEY	Area 1	CVA1Ma	marsh	F	2	RWLH	good	57	57	30	19
CHERRY VALLEY	Area 1	CVA1Md	wet meadow	F	2	LQWLH	fair	26	26	13	16
CHERRY VALLEY	Area 1	rC1Vma	marsh	AR	2	RWLH	fair	43	43	26	19
CHERRY VALLEY	Area 1	rC1Vmd	wet meadow	AR	2	RWLH	fair	36	36	23	13
CHERRY VALLEY	Area 3	CVA3	marsh	F	2	WLH	good	67	67	37	30
CHERRY VALLEY	Area 3	rC3Vma	marsh	AR	2	RWLH	good	58	58	41	23
CHERRY VALLEY	Area 3	rC3Vmd	wet meadow	AR	2	LQWLH	poor	23	23	17	13
CHERRY VALLEY	Area 3	rC3Vsh	shrub swamp	AR		LQWLH	fair	26	39	26	20

Table 13. Summary of VIBI scores for Ohio Mitigation Banks. F = focused plot, AR = aggregated random plot, TALU class = tiered aquatic life use classes from Mack (2004b), VIBI quartiles = quadrisected VIBI score distribution (0-24 = poor, 25-49 = fair, 50-74 = good, 75-100 = excellent). LQWLH = limited quality wetland habitat, RWLH = restorable wetland habitat, WLH = wetland habitat.

CHIPPEWA	none	CHIPNRTH	enhanced wet meadow	F	2	LQWLH	poor	3	3	3	10
CHIPPEWA	none	CHIPSOTH	enhanced wet meadow	F	1	RWLH	fair	39	46	33	23
CHIPPEWA	none	rCHIPma	marsh	AR	1,2	LQWLH	poor	20	30	10	20
CHIPPEWA	none	rCHIPmd	wet meadow	AR	2	LQWLH	poor	13	13	3	10
GR LOWLANDS	Area A-D	GRAD	marsh	F	1	RWLH	fair	30	30	10	17
GR LOWLANDS	Area A-D	rGRADf	dead forest	AR		RWLH	fair	33	43	23	27
GR LOWLANDS	Area A-D	rGRADma	marsh	AR	1,2	RWLH	fair	41	41	23	16
GR LOWLANDS	Area A-D	rGRADmd	wet meadow	AR	2	LQWLH	poor	17	17	7	20
GR LOWLANDS	Area B-C	GRBC	marsh	F	1	RWLH	fair	49	49	26	24
GR LOWLANDS	Area B-C	rGRBCf	dying forest	AR		RWLH	fair	30	40	20	30
GR LOWLANDS	Area B-C	rGRBCma	marsh	AR	1,2	RWLH	fair	40	40	23	20
GR LOWLANDS	Area B-C	rGRBCmd	wet meadow	AR	2	RWLH	fair	39	39	20	3
GR LOWLANDS	Area F	GRF	enhanced forest	F		WLH	good	54	53	61	54
GR LOWLANDS	Area F	rGRFf	enhanced forest	AR		RWLH	fair	47	67	60	47
GR LOWLANDS	Area F	rGRFma	converting forest	AR	2	RWLH	fair	27	70	40	23
HEBRON	Large Cell	HEBLC	marsh	F		RWLH	fair	43	43	27	16
HEBRON	Large Cell	rHBLma	marsh	AR	2	LQWLH	poor	22	22	6	10
HEBRON	Large Cell	rHBLmd	wet meadow	AR	2	RWLH	fair	33	33	24	13
HEBRON	Small Cell	HEBSC	marsh	F	2	RWLH	fair	39	39	23	10
HEBRON	Small Cell	rHBSma	marsh	AR	2	RWLH	fair	26	26	10	13
HEBRON	Small Cell	rHBSmd	wet meadow	AR	2	LQWLH	poor	24	24	0	13
LITTLE SCIOTO	Area 3 (South)	LS3	marsh	F	2	RWLH	fair	32	35	16	10
LITTLE SCIOTO	Northeast	LS1NE	marsh	F	2	RWLH	fair	36	39	20	20
LITTLE SCIOTO	Northeast	rLSNEma	marsh	AR	1,2	RWLH	fair	29	36	16	20
LITTLE SCIOTO	Northwest	LS2NW	marsh	F	2	RWLH	fair	30	30	10	10
LITTLE SCIOTO	Northwest	rLSNWma	marsh	AR	1,2	RWLH	fair	36	36	13	10
PANZNER	Field A	PANZA	early wet meadow	F	2	LQWLH	poor	19	19	6	10
PANZNER	Field A	rPNZAma	early wet meadow	AR	2	RWLH	fair	30	30	26	10
PANZNER	Field B	rPNZBma	marsh	AR	1,2	LQWLH	poor	20	30	10	20
PANZNER	Field B	rPNZBmd	wet meadow	AR	2	WLH	good	68	68	44	28
PANZNER	Field B	rPNZCma	marsh	AR	2	RWLH	fair	36	46	26	10
PANZNER	Field B NW	PANZBNW	wet meadow	F	2	WLH	good	67	67	43	25
PANZNER	Field B SW	PANZBSW	wet meadow	F	2	RWLH	good	50	50	43	29
PANZNER	Field C	PANZC	marsh	F	2	RWLH	fair	40	40	23	16
PANZNER	Field E	PANZEMa	marsh	F	2	WLH	good	67	67	50	29

Table 13. Summary of VIBI scores for Ohio Mitigation Banks. F = focused plot, AR = aggregated random plot, TALU class = tiered aquatic life use classes from Mack (2004b), VIBI quartiles = quadrisected VIBI score distribution (0-24 = poor, 25-49 = fair, 50-74 = good, 75-100 = excellent). LQWLH = limited quality wetland habitat, RWLH = restorable wetland habitat, WLH = wetland habitat.

PANZNER	Field E	PANZEMd	wet meadow	F	2	WLH	good	69	69	41	37
PANZNER	Field E	rPNZEma	marsh	AR	2	RWLH	good	58	58	47	23
PANZNER	Field E	rPNZEmd	wet meadow	AR	2	RWLH	good	57	57	40	26
SANDY RIDGE	Area 1	SANDRD1	marsh	F	2	RWLH	fair	35	35	26	13
SANDY RIDGE	Area 1	rSR1Af	dead forest	AR	2	LQWLH	poor	13	23	6	13
SANDY RIDGE	Area 1	rSR1Ama	marsh	AR	2	LQWLH	fair	26	36	16	14
SANDY RIDGE	Area 2	SANDRD2	marsh	F	1,2	RWLH	fair	27	34	3	17
SANDY RIDGE	Area 2	rSR2Ama	marsh	AR	2	LQWLH	poor	22	32	6	10
SANDY RIDGE	Area 3	SANDRD3	wet meadow	F	2	RWLH	fair	33	33	26	13
SANDY RIDGE	Area 3	rSR3Ama	marsh	AR	2	RWLH	good	50	50	36	20
SANDY RIDGE	Area 3	rSR3Amd	wet meadow	AR	2	RWLH	fair	37	37	23	13
SANDY RIDGE	Area 3 south	SANDRD3S	marsh	F	2	RWLH	fair	27	27	13	17
SLATE RUN	Center	SLATRNC	marsh	F	1,2	RWLH	fair	42	42	31	16
SLATE RUN	Center	rSRCma	marsh	AR	2	RWLH	fair	34	34	27	10
SLATE RUN	Northwest	SLATRNNW	marsh	F	1,2	LQWLH	poor	23	23	10	10
SLATE RUN	Northwest	rSRNWma	marsh	AR	2	RWLH	fair	33	33	23	10
SLATE RUN	Southeast	SLATRNSE	marsh	F	2	LQWLH	poor	16	16	13	10
SLATE RUN	Southeast	rSRSEma	marsh	AR	2	LQWLH	poor	16	16	16	10
SLATE RUN	Southwest	SLATRNSW	marsh	F	1,2	LQWLH	poor	23	23	23	10
SLATE RUN	Southwest	rSRSWma	marsh	AR	2	RWLH	fair	33	33	19	13
TRUMBULL CR	Berm 5	TRUMB5	marsh	F	1,2	WLH	good	60	67	50	36
TRUMBULL CR	Berm 5	rTR5Bma	marsh	AR	2	RWLH	fair	30	30	10	17
TRUMBULL CR	Berm 7E	TRUMB7M	marsh	F	1,2	RWLH	fair	46	56	30	23
TRUMBULL CR	Berm 7E	rTR7Ema	marsh	AR	1,2	RWLH	fair	49	59	23	30
TRUMBULL CR	Berm 7F	TRUMB7F	dead forest	F	1,2	LQWLH	poor	20	26	20	20
TRUMBULL CR	Berm 7F	rTR7Ff	enhanced forest	AR		WLH	good	71	60	63	71
TRUMBULL CR	Berm 7F	rTR7Fma	marsh	AR	1,2	RWLH	fair	46	49	23	30
WHITE STAR	North	WHSTARN	enhanced forest	F		RWLH	fair	29	36	20	19
WHITE STAR	North	rWSNf	enhanced forest	AR		RWLH	fair	39	47	33	39
WHITE STAR	North	rWSNma	marsh	AR	2	RWLH	fair	33	33	6	13
WHITE STAR	South	rWSSf	enhanced forest	AR		RWLH	fair	48	57	43	48
WHITE STAR	South	rWSSma	marsh	AR	2	RWLH	good	50	50	23	16
WHITE STAR	South	rWSSsh	shrub swamp	AR		RWLH	good	50	53	50	56
WHITE STAR	South 1	WHSTARS1	marsh	F	2	RWLH	fair	29	29	13	10
WHITE STAR	South 2	WHSTARS2	enhanced forest	F		RWLH	fair	47	42	25	43

Footnotes

1. %unvegetated metric substituted for biomass metric since average biomass <100 g/m2
2. small tree and canopy IV metric scored as "0" since no woody stems >1m present.

Table 14. Metric scores for focused and aggregated random bank plots. Refer to Tables 2 and 10 for description of site codes.

site code	carex	dicot	shrub	hydro-phyte	SVP	shade	A/P	FQAI	%tolerant	%sensitive	%inv gram	%bryophyte	%hydro-phyte	small tree	subcanopy IV	canopy IV	biomass	%AN	avg %unveg	%unveg
3EAGLEF	1	30	1	27	0	9	0.364	14.3	0.809	0.001	0.317	0.000	0.266	0.389	0.000	0.188	*	0.320	0.019	0.338
r3EEFf	1	39	0	27	0	22	0.182	20.3	0.289	0.054	0.006	0.000	0.343	0.298	0.000	0.177	109	0.251	0.172	0.423
r3EEFma	0	19	0	14	0	6	0.636	11.3	0.823	0.011	0.149	0.000	0.404	0.500	0.000	0.750	1199	0.422	0.000	0.422
3EAGLNEM	1	23	0	25	0	4	0.609	11.7	0.895	0.001	0.627	0.000	0.002	0.000	0.000	0.000	378	0.112	0.009	0.121
r3ENMma	0	15	1	21	0	1	0.647	10.1	0.570	0.000	0.171	0.000	0.001	0.000	0.000	0.361	215	0.149	0.165	0.314
r3ENMmd	0	12	0	9	0	0	0.667	8.3	0.728	0.016	0.000	0.000	0.000	0.000	0.000	0.361	678	0.241	0.000	0.241
3EAGLWMw	0	15	0	17	0	0	0.600	9.0	0.670	0.017	0.280	0.000	0.000	0.000	0.000	0.000	165	0.298	0.025	0.323
r3EWMma	0	10	0	10	0	2	0.500	5.1	0.902	0.000	0.335	0.000	0.033	0.000	0.000	0.000	351	0.220	0.000	0.220
r3EWMmd	0	12	0	7	0	0	1.125	3.6	0.958	0.000	0.033	0.000	0.000	0.000	0.000	0.000	71	0.346	0.015	0.361
BGAEAST	3	12	2	22	0	1	0.118	12.6	0.744	0.024	0.512	0.000	0.142	0.129	0.000	0.201	224	0.024	0.563	0.586
BGAWEST	3	22	1	24	0	5	0.286	13.3	0.566	0.000	0.000	0.000	0.063	0.000	0.000	0.222	297	0.047	0.025	0.072
rBGAf	3	17	1	25	0	4	0.182	14.4	0.434	0.000	0.108	0.056	0.051	0.060	0.000	0.186	48	0.083	0.051	0.134
rBGAma	3	14	2	23	0	2	0.250	12.6	0.669	0.000	0.197	0.003	0.024	0.000	0.000	0.183	526	0.039	0.056	0.095
rBGAmd	2	7	0	11	0	3	0.167	9.6	0.734	0.029	0.000	0.000	0.090	0.000	0.000	0.694	147	0.156	0.000	0.156
BGB	3	15	2	29	0	2	0.130	16.7	0.639	0.023	0.570	0.057	0.030	0.000	0.000	0.222	527	0.035	0.040	0.075
rBGBf	0	7	1	10	0	1	0.800	8.9	0.696	0.031	0.027	0.000	0.000	0.324	0.000	0.263	*	0.018	0.075	0.093
rBGBma	2	13	1	22	0	2	0.278	11.7	0.304	0.017	0.113	0.000	0.024	0.053	0.000	0.287	72	0.061	0.683	0.744
rBGBmd	3	13	3	17	0	3	0.000	11.5	0.820	0.000	0.025	0.000	0.112	0.000	0.000	0.250	485	*	0.020	*
BGC	5	26	3	24	0	7	0.125	16.7	0.464	0.000	0.000	0.000	0.268	0.000	0.000	0.000	297	0.053	0.013	0.065
rBGCma	4	22	2	26	0	8	0.156	14.8	0.528	0.009	0.008	0.009	0.072	0.000	0.054	0.270	309	0.198	0.002	0.200
rBGCmd	3	37	4	32	0	9	0.190	17.0	0.618	0.010	0.007	0.026	0.080	0.000	0.047	0.118	308	0.271	0.001	0.271
BGD	2	19	1	24	0	1	0.167	10.8	0.611	0.034	0.068	0.000	0.000	0.000	*	*	305.88	0.011	0.040	0.051
rBGDf	1	13	1	16	0	2	0.250	12.2	0.121	0.012	0.039	0.039	0.013	0.000	0.000	0.186	413	0.052	0.012	0.064
rBGDma	3	9	1	17	0	2	0.235	11.7	0.578	0.001	0.305	0.028	0.083	0.135	0.000	0.806	258	0.029	0.198	0.227
rBGDmd	3	6	1	11	0	2	0.000	10.7	0.395	0.000	0.000	0.000	0.452	0.000	0.000	0.145	294	*	0.000	*
CVA1Ma	4	11	1	28	0	2	0.421	15.1	0.346	0.059	0.004	0.001	0.001	0.000	0.000	0.722	187	0.379	0.150	0.529
CVA1Md	3	9	0	16	0	1	0.182	7.0	0.930	0.000	0.021	0.011	0.030	0.000	0.000	0.000	1041	0.015	0.000	0.015
rC1Vma	3	22	2	31	0	4	0.265	14.3	0.657	0.008	0.053	0.000	0.045	0.000	0.000	0.194	451	0.213	0.026	0.239
rC1Vmd	3	16	1	23	0	4	0.233	11.4	0.716	0.001	0.017	0.000	0.073	0.000	0.000	0.000	712	0.166	0.000	0.166
CVA3	4	13	1	31	0	3	0.391	16.0	0.138	0.121	0.017	0.000	0.001	0.000	0.000	0.000	150	0.504	0.000	0.504
rC3Vma	4	18	1	29	0	4	0.393	14.5	0.521	0.192	0.053	0.000	0.017	0.000	0.000	0.000	224	0.241	0.280	0.521
rC3Vmd	3	19	1	20	0	5	0.233	8.2	0.879	0.000	0.212	0.000	0.088	0.000	0.000	0.000	1228	0.043	0.000	0.043
rC3Vsh	2	10	2	15	1	6	0.200	9.9	0.727	0.000	0.025	0.000	0.072	0.134	0.076	0.233	105	0.151	0.075	0.226
CHIPNRTH	0	10	0	3	0	2	0.429	5.7	1.000	0.000	0.940	0.000	0.003	0.000	0.000	0.000	916	0.010	0.000	0.010
CHIPSOTH	2	8	4	15	0	2	1.500	11.2	0.068	0.029	0.054	0.001	0.003	0.058	0.030	0.299	38	0.228	0.135	0.363
rCHIPma	0	1	0	5	0	0	1.500	7.2	0.027	0.013	0.027	0.000	0.000	0.000	0.000	0.000	0	0.300	0.900	1.200
rCHIPmd	0	13	0	9	0	3	0.313	7.6	0.943	0.002	0.853	0.003	0.005	0.000	0.000	0.489	742	0.038	0.013	0.051

Table 14. Metric scores for focused and aggregated random bank plots. Refer to Tables 2 and 10 for description of site codes.

site code	carex	dicot	shrub	hydro-phyte	SVP	shade	A/P	FQAI	%tolerant	%sensitive	%inv gram	%bryophyte	%hydro-phyte	small tree	subcanopy IV	canopy IV	biomass	%AN	avg %unveg	%unveg
GRAD	0	0	0	8	0	0	1.000	6.4	0.047	0.020	0.004	0.000	0.000	0.111	0.000	0.889	190	0.444	0.450	0.894
rGRADf	0	1	0	4	0	0	3.000	10.0	0.000	0.507	0.000	0.000	0.000	0.127	0.000	0.000	0	0.580	0.500	1.080
rGRADma	3	10	0	22	0	1	0.588	9.8	0.329	0.120	0.026	0.000	0.001	0.000	0.000	0.000	272	0.567	0.311	0.878
rGRADmd	0	1	0	8	0	0	3.500	6.3	0.440	0.129	0.302	0.000	0.000	0.000	0.000	0.000	245	0.336	0.175	0.511
GRBC	3	7	0	23	0	2	0.471	13.4	0.154	0.299	0.018	0.000	0.001	0.000	0.000	0.000	632	0.621	0.000	0.621
rGRBCf	0	1	1	7	0	0	1.000	7.9	0.050	0.303	0.000	0.000	0.000	0.008	0.000	0.310	0	0.589	0.375	0.964
rGRBCma	3	6	0	20	0	3	0.600	12.7	0.364	0.175	0.082	0.000	0.007	0.000	0.000	0.000	376	0.565	0.185	0.750
rGRBCmd	4	13	2	16	0	4	0.158	9.6	0.911	0.000	0.000	0.000	0.046	0.400	0.000	0.589	581	0.023	0.000	0.023
GRF	2	20	3	20	4	15	0.385	21.9	0.047	0.014	0.000	0.005	0.042	0.106	0.092	0.212	*	0.093	0.216	0.309
rGRFf	3	22	4	21	2	13	0.357	22.8	0.190	0.181	0.000	0.026	0.125	0.112	0.029	0.215	*	0.224	0.056	0.279
rGRFma	5	13	0	22	0	6	0.200	15.5	0.427	0.259	0.002	0.000	0.176	0.500	0.000	0.189	0	0.302	0.025	0.327
HEBLC	1	21	2	32	0	5	0.200	17.2	0.746	0.026	0.690	0.000	0.015	0.152	0.000	0.193	626	0.011	0.000	0.011
rHBLma	0	6	1	13	0	0	0.100	10.3	0.492	0.017	0.444	0.000	0.000	0.000	0.000	0.392	730	0.017	0.275	0.292
rHBLmd	0	15	3	16	0	1	0.100	13.3	0.810	0.014	0.694	0.000	0.001	0.101	0.000	0.186	392	0.000	0.000	0.000
HEBSC	2	12	4	19	0	0	0.308	11.0	0.736	0.028	0.378	0.000	0.000	0.000	0.000	0.000	138	0.446	0.259	0.705
rHBSma	0	11	1	16	0	0	1.286	9.4	0.307	0.002	0.246	0.000	0.000	0.000	0.000	0.722	174	0.535	0.281	0.817
rHBSmd	1	8	0	8	0	1	0.200	4.5	0.962	0.000	0.038	0.000	0.038	0.000	0.000	0.000	220	0.097	0.000	0.097
LS3	2	12	0	17	0	3	0.053	10.2	0.812	0.000	0.178	0.000	0.010	0.000	0.000	0.000	7	0.034	0.225	0.259
LS1NE	0	10	0	18	0	1	0.375	13.6	0.067	0.008	0.004	0.000	0.007	0.000	0.000	0.000	12	0.035	0.165	0.200
rLSNEma	0	8	0	18	0	0	0.615	13.2	0.125	0.028	0.031	0.000	0.000	0.000	0.000	0.000	43	0.069	0.371	0.440
LS2NW	0	8	0	17	0	0	0.294	10.7	0.455	0.000	0.139	0.000	0.000	0.000	0.000	0.000	409	0.176	0.045	0.221
rLSNWma	0	11	1	19	0	1	0.227	11.4	0.462	0.000	0.037	0.000	0.000	0.000	0.000	0.000	135	0.320	0.079	0.399
PANZA	0	12	0	11	0	0	2.500	6.6	0.774	0.000	0.000	0.000	0.000	0.000	0.000	0.000	623	0.922	0.000	0.922
rPNZAma	0	24	0	30	0	2	0.955	12.8	0.698	0.023	0.005	0.000	0.008	0.000	0.000	0.694	676	0.828	0.000	0.828
rPNZBma	0	1	0	2	0	0	1.000	3.5	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.970	0.975	1.945
rPNZBmd	4	20	4	24	1	5	0.160	15.0	0.403	0.037	0.006	0.006	0.051	0.000	0.000	0.171	366	0.024	0.000	0.024
rPNZCma	2	14	3	27	0	1	0.600	12.6	0.535	0.019	0.003	0.000	0.001	0.000	0.000	0.347	47	0.418	0.106	0.524
PANZBNW	5	19	2	22	1	6	0.154	15.9	0.392	0.058	0.012	0.002	0.078	0.000	0.000	0.300	719	0.007	0.000	0.007
PANZBSW	3	17	1	28	1	4	0.286	18.8	0.561	0.151	0.095	0.012	0.039	0.000	*	0.000	727	0.033	0.013	0.046
PANZC	0	14	2	28	0	0	0.750	15.0	0.397	0.004	0.000	0.000	0.000	0.000	0.000	0.280	646	0.510	0.012	0.522
PANZEMa	6	12	2	30	0	4	0.167	16.7	0.564	0.105	0.014	0.070	0.041	0.000	0.000	0.000	320	0.140	0.010	0.150
PANZEMd	4	25	1	33	0	5	0.270	19.9	0.312	0.129	0.000	0.000	0.108	0.000	0.000	0.168	320	0.052	0.000	0.052
rPNZEma	4	14	3	29	0	0	0.300	18.6	0.611	0.203	0.031	0.023	0.000	0.000	0.000	0.000	701	0.025	0.000	0.025
rPNZEmd	4	11	1	22	0	2	0.167	15.2	0.453	0.438	0.015	0.015	0.002	0.000	0.000	0.000	911	0.032	0.000	0.032
SANDRD1	2	15	0	30	0	1	0.478	14.0	0.772	0.047	0.007	0.000	0.001	0.000	0.000	0.000	582	0.100	0.008	0.108
rSR1Af	0	8	2	6	0	3	1.200	6.0	0.821	0.000	0.000	0.000	0.000	0.000	0.036	0.000	10	0.813	0.088	0.902
rSR1Ama	0	6	0	13	0	0	0.667	12.0	0.662	0.188	0.000	0.000	0.000	0.190	0.000	0.807	0	0.466	0.092	0.558
SANDRD2	1	5	1	14	0	1	0.250	6.8	0.275	0.000	0.060	0.000	0.000	0.000	0.000	0.000	0	0.200	0.150	0.350

Table 14. Metric scores for focused and aggregated random bank plots. Refer to Tables 2 and 10 for description of site codes.

site code	carex	dicot	shrub	hydro-phyte	SVP	shade	A/P	FQAI	%tolerant	%sensitive	%inv gram	%bryophyte	%hydro-phyte	small tree	subcanopy IV	canopy IV	biomass	%AN	avg %unveg	%unveg
rSR2Ama	0	4	1	13	0	0	0.400	10.8	0.541	0.008	0.004	0.000	0.000	0.074	0.000	0.833	0	0.529	0.052	0.581
SANDRD3	2	16	1	25	1	1	0.350	12.2	0.794	0.000	0.073	0.000	0.001	0.000	0.000	0.000	431	0.055	0.016	0.071
rSR3Ama	2	16	1	27	1	2	0.304	13.4	0.536	0.228	0.069	0.000	0.002	0.000	0.000	0.000	430	0.124	0.036	0.160
rSR3Amd	2	21	1	23	0	5	0.250	11.7	0.619	0.000	0.244	0.000	0.012	0.000	0.000	0.000	430	0.064	0.000	0.064
SANDRD3S	0	5	0	10	0	1	0.167	7.5	0.699	0.300	0.579	0.000	0.000	0.000	0.000	0.000	202	0.001	0.009	0.010
SLATRNC	4	22	1	29	0	4	0.579	14.5	0.661	0.000	0.075	0.000	0.022	0.000	0.000	0.236	248	0.601	0.030	0.631
rSRCma	4	16	1	30	0	1	0.524	13.9	0.810	0.001	0.130	0.000	0.004	0.000	0.000	0.694	248	0.386	0.014	0.401
SLATRNNW	0	12	1	16	0	1	0.467	9.0	0.826	0.001	0.050	0.000	0.003	0.000	0.000	0.570	248	0.543	0.075	0.618
rSRNWma	2	17	1	27	0	2	0.417	11.8	0.804	0.004	0.123	0.000	0.006	0.000	0.000	0.334	248	0.576	0.118	0.694
SLATRNSE	1	14	0	17	0	1	0.667	9.6	0.912	0.012	0.560	0.000	0.000	0.000	0.000	0.000	748	0.183	0.000	0.000
rSRSEma	3	10	1	24	0	0	0.333	9.8	0.807	0.007	0.471	0.000	0.000	0.000	0.000	0.270	748	0.141	0.022	0.163
SLATRNSW	3	16	1	22	0	2	0.524	10.5	0.838	0.000	0.405	0.000	0.007	0.000	0.000	0.000	248	0.448	0.178	0.626
rSRSWma	3	14	0	21	0	1	0.318	13.0	0.836	0.017	0.193	0.000	0.012	0.000	0.000	0.229	248	0.534	0.054	0.588
TRUMB5	5	14	4	26	0	3	0.217	14.1	0.209	0.063	0.005	0.000	0.021	0.000	0.135	0.567	47	0.052	0.275	0.327
rTR5Bma	0	3	1	7	0	1	0.500	7.8	0.694	0.208	0.000	0.000	0.000	0.000	0.000	0.361	0	0.097	0.035	0.132
TRUMB7M	2	7	0	20	0	0	0.188	13.9	0.013	0.105	0.001	0.000	0.000	0.000	0.000	0.000	0	0.099	0.488	0.586
rTR7Ema	0	9	2	18	0	1	0.154	13.0	0.175	0.448	0.002	0.000	0.014	0.065	0.000	0.694	0	0.123	0.487	0.610
TRUMB7F	0	15	1	8	0	3	1.000	11.5	0.004	0.000	0.000	0.000	0.002	0.127	0.000	0.187	*	0.002	0.463	0.464
rTR7Ff	3	25	1	18	3	19	0.107	23.0	0.198	0.137	0.000	0.028	0.380	0.000	0.177	0.216	*	0.008	0.302	0.310
rTR7Fma	2	8	1	15	0	2	0.400	14.0	0.228	0.365	0.000	0.000	0.069	0.063	0.000	0.000	0	0.145	0.070	0.215
WHSTARN	1	11	0	5	0	6	0.000	11.1	0.083	0.001	0.000	0.000	0.106	0.282	0.071	0.317	*	0.000	0.000	0.000
rWSNf	1	26	2	10	0	13	0.000	16.9	0.269	0.016	0.000	0.020	0.254	0.000	0.063	0.188	*	0.000	0.281	0.000
rWSNma	2	11	1	5	0	5	0.091	9.0	0.949	0.000	0.000	0.000	0.137	0.042	0.000	0.211	*	0.015	0.000	0.015
rWSSf	2	27	1	10	0	13	0.111	17.0	0.245	0.184	0.000	0.000	0.163	0.211	0.126	0.161	*	0.000	0.320	0.320
rWSSma	3	19	1	21	0	4	0.179	10.9	0.513	0.000	0.016	0.000	0.034	0.025	0.000	0.205	*	0.043	0.073	0.115
rWSSsh	4	37	1	15	1	18	0.077	18.7	0.413	0.026	0.000	0.029	0.223	0.106	0.177	0.104	*	0.001	0.328	0.329
WHSTARS1	2	14	1	15	0	2	0.286	9.8	0.536	0.017	0.334	0.000	0.000	0.030	0.000	0.271	144	0.063	0.375	0.438
WHSTARS2	0	14	2	12	0	4	0.000	11.1	0.126	0.000	0.001	0.002	0.300	0.093	0.136	0.192	*	*	0.060	*

Table 15. Applicable Wetland Tiered Aquatic Life Uses (WTALUs) for plots from Ohio mitigation banks (from Mack 2004c). LQWLH = limited quality wetland habitat, RWLH = restorable wetland habitat, WLH = wetland habitat, SWLH = superior wetland habitat. Equivalent antidegradation categories as specified in Ohio Administrative Code Rule 3745-1-54 are indicated in parentheses below the TALU category.

HGM class	HGM subclass	plant community	ecoregions	LQWLH (Category 1)	RWLH (modified Category 2)	WLH (Category 2)	SWLH (Category 3)
Depression	all	Swamp forest, Marsh, Shrub swamp	EOLP	0 - 30	31 - 60	61 - 75	76 - 100
			all other regions	0 - 24	25 - 50	51 - 62	63 - 100
	all	Wet Meadow (incl. prairies and sedge/grass dominated communities that are not slopes)	all regions	0 - 29	30 - 59	60 - 75	76 - 100
Impoundment	all	Swamp Forest, Marsh, Shrub Swamp	EOLP	0 - 26	27 - 52	53 - 66	67 - 100
			all other regions	0 - 24	25 - 47	48 - 63	64 - 100
		Wet Meadow (incl. prairies and sedge/grass dominated communities that are not slopes)	all regions	0 - 29	30 - 59	60 - 75	76 - 100
Riverine	Mainstem	Swamp Forest, Marsh, Shrub Swamp	EOLP	0 - 29	30 - 56	57 - 73	74 - 100
			all other regions	0 - 20	21 - 41	42 - 52	53 - 100
	Headwater or Mainstem	Wet Meadow (incl. prairies and sedge/grass dominated communities that are not slopes)	all regions	0 - 29	30 - 59	60 - 75	76 - 100
Slope	all	Wet meadow (fen), tall shrub fen, forest seep	all regions	0 - 29	30 - 59	60 - 75	76 - 100

Table 16. Mean (standard deviation) of metric values for 1st , 2nd, and 3rd ORAM tertiles of natural reference wetland plots, bank plots, and individual mitigation site plots. 1st tertile = 0 to 33 (low quality), 2nd tertile = 34-65 (good quality), 3rd tertile = >65 (high quality). Means without shared letters are significantly different (p <0.05). Refer to Tables 1 and 2 for a description of the metrics. There were not forested individual mitigation wetlands and no comparison between bank performance on VIBI-F metrics could be made.

metric	1st	2nd	3rd	bank	mitigation
carex	0.8(0.9)a	2.3(1.7)a	3.8(2.4)b	2.0(1.7)a	2.0(1.5)a
dicot	8.7(5.4)a	19.7(8.7)b	25.4(7.9)c	13.2(6.6)a	12.4(5.5)a
shrub	1.1(1.2)a	3.1(2.6)b	5.7(3.1)c	1.1(1.1)a	1.1(1.3)a
hydrophyte	10.3(6.1)a	24.0(9.1)b	30.3(10.4)c	19.2(7.8)d	20.0(6.5)bd
SVP	0.5(1.3)a	0.7(1.0)a	2.3(1.8)b	0.6(1.2)a	na
shade	6.9(4.4)a	14.5(3.2)b	20.2(7.2)c	7.8(7.1)a	na
A/P	0.37(0.36)ac	0.29(0.24)ac	0.16(0.11)a	0.47(0.51)bc	0.41(0.24)ac
FQAI	9.6(4.2)a	17.2(4.9)b	24.1(6.1)c	12.1(4.0)a	10.4(2.4)a
%tolerant	0.61(0.30)a	0.42(0.28)b	0.16(0.15)c	0.52(0.28)ab	0.70(0.22)a
%sensitive	0.08(0.21)a	0.24(0.25)b	0.41(0.22)c	0.06(0.11)a	0.08(0.25)ab
%invasive graminoids	0.60(0.29)a	0.20(0.25)b	0.01(0.02)c	0.14(0.21)b	0.16(0.19)bc
%bryophyte	0.012(0.023)a	0.014(0.034)a	0.081(0.106)b	0.011(0.017)a	na
small tree	0.245(0.198)a	0.197(0.099)ab	0.106(0.060)b	0.142(0.124)ab	na
subcanopy IV	0.04(0.07)a	0.05(0.06)a	0.12(0.09)b	0.05(0.06)a	na
canopy IV	0.29(0.18)	0.23(0.20)	0.19(0.07)	0.20(0.07)	na
biomass	835(514)a	478(315)b	431(282)b	345(294)b	270(227)b
%unvegetated	0.19(0.24)ab	0.25(0.19)ab	0.19(0.23)b	0.36(0.33)ac	0.47(0.30)ac

Table 17. Relative Abundance of Amphibian Species at Mitigation Bank Subareas.

Bank Subarea	Hybrid Sal.	Small-mouth Sal.	Tiger Sal.	Toads	Gray Treefrog	Red Spotted Newt	Spring Peeper	Chorus Frog	Bullfrog	Green Frog	Leopard Frog
3EAGLEF		0.135								0.405	0.459
3EAGLEFN				0.992					0.001	0.006	0.001
3EAGLEW				0.664					0.009		0.327
BGA		0.067		0.133			0.133	0.333	0.333		
BGB1				0.509			0.173			0.004	0.314
BGB2		0.008		0.363			0.242	0.202			0.185
BGD				0.693	0.024		0.110				0.173
CHIPNRTH				0.715			0.217	0.006	0.018	0.045	
CHIPSOTH1							0.012		0.179	0.810	
CHIPSOTH2				0.020			0.030		0.210	0.740	
CV1A-North							0.002		0.006	0.990	0.002
CV1A-South					0.003				0.017	0.947	0.034
CV3A									0.016	0.984	
GRAD									0.014	0.905	0.081
GRBC				0.488			0.066		0.006	0.343	0.096
GRF										0.994	0.006
HEBLC										0.615	0.385
HEBSC				0.017			0.017		0.517	0.400	0.050
LS1NE									0.889		0.111
LS2NW									0.511	0.044	0.444
LS3							0.010		0.020	0.020	0.949
PANZA				0.294			0.032			0.044	0.630
PANZB							0.036		0.143	0.808	0.013
PANZC				0.025					0.083	0.875	0.017
SANDRD1									0.563	0.438	
SANDRD2									0.667	0.333	
SANDRD3					0.036					0.893	0.071
SRSC				0.004	0.039		0.008	0.004		0.043	0.902
SRSE			0.027	0.009	0.027		0.486	0.063		0.009	0.378
TRUMB5				0.603	0.008	0.003	0.016		0.027	0.225	0.119
TRUMB7E				0.484	0.016	0.006	0.018		0.024	0.214	0.238
TRUMB7F					0.010	0.005	0.010		0.062	0.867	0.046
WHSTARN	0.0048			0.786			0.017	0.095	0.007	0.007	0.083
WHSTARSE				0.975			0.001			0.003	0.022
WHSTARSF		0.034					0.069	0.172		0.172	0.552
Tot. Rel. Ab.	0.0001	0.0070	0.0008	0.2221	0.0046	0.0004	0.0487	0.0250	0.1234	0.3767	0.1912

Table 18. Stems per hectare of woody species by type. wetland = FACW, OBL tree spp., mesic = FAC tree species, willow tree = *Salix* spp. that are "trees", upland = FACU, UPL tree spp., dead = standing dead trees, sub mesic = subcanopy FAC, FACU, UPL small tree or shrub forest spp., sub wet = subcanopy FACW or OBL small tree or shrub forest spp., subcan full = subcanopy small tree or shrub wetland species that grow in full sun, adventive = nonnative spp. Refer to Table 2 for site codes.

site	subarea	wetland	mesic	willow tree	upland	dead	sub mesic	sub wet	subcan full	adventive
3 Eagles	3EAGLEF	10	370	0	30	300	0	0	0	0
3 Eagles	r3EEFf	100	815	0	63	163	0	0	0	38
3 Eagles	r3EEFma	0	0	0	0	200	0	0	0	0
3 Eagles	r3EEFuf	0	700	0	0	300	0	0	0	0
3 Eagles	r3ENMma	0	0	25	0	0	0	0	25	0
3 Eagles	r3ENMmd	0	200	0	0	0	0	0	0	0
3 Eagles	r3ENMof	0	350	0	0	0	0	0	0	0
Big Island	BGAEAST	940	330	140	0	20	0	0	200	0
Big Island	BGAWEST	825	225	0	0	0	0	0	0	0
Big Island	BGB	1600	0	25	0	0	0	0	0	0
Big Island	rBGAf	2720	400	0	0	0	0	0	520	0
Big Island	rBGAma	675	175	125	0	0	0	0	100	0
Big Island	rBGAmd	300	0	0	0	0	0	0	0	0
Big Island	rBGBf	1500	0	0	0	600	0	0	1300	0
Big Island	rBGBma	267	17	0	0	33	0	0	0	0
Big Island	rBGBmd	150	150	0	0	0	0	0	0	0
Big Island	rBGBpd	0	0	0	0	160	0	0	0	0
Big Island	rBGCma	766	333	0	33	0	0	0	0	0
Big Island	rBGCmd	57	114	0	28	14	0	0	100	0
Big Island	rBGDf	3266	33	33	0	0	0	0	133	0
Big Island	rBGDma	740	0	0	0	0	0	0	0	0
Big Island	rBGDmd	100	100	0	0	0	0	0	3200	0
Cherry V.	CV1AMa	40	0	0	0	0	0	0	0	0
Cherry V.	CVA3	0	0	0	0	0	0	0	50	0
Cherry V.	rC1Vma	0	33	67	0	0	0	0	66	33
Cherry V.	rC1Vmd	0	0	0	0	0	0	0	67	244
Cherry V.	rC3Vma	0	0	0	0	0	0	0	133	0
Cherry V.	rC3Vmd	0	0	0	0	0	0	0	100	0
Cherry V.	rC3Vsh	800	0	0	0	1000	0	400	4500	0
Chippewa	CHIPSOTH	60	0	0	0	1130	0	20	320	10
Chippewa	rCHIPmd	0	0	88	0	0	0	0	50	50
GR Lowl.	GRAD	0	0	0	0	2070	0	0	0	0
GR Lowl.	GRF	1660	830	0	0	1150	0	100	40	0
GR Lowl.	rGRADf	0	0	0	0	2950	0	0	0	0
GR Lowl.	rGRBCf	0	0	0	0	2400	0	0	550	0
GR Lowl.	rGRBCmd	150	0	0	0	0	0	0	100	0
GR Lowl.	rGRFf	1314	564	0	38	1750	0	13	0	13
GR Lowl.	rGRFma	900	0	0	50	50	0	0	0	0
Hebron	HEBLC	280	10	10	0	0	0	60	100	0
Hebron	HEBSC	0	0	0	0	0	0	100	25	0
Hebron	rHBLma	350	0	0	0	0	0	0	25	0
Hebron	rHBLmd	600	351	250	0	0	0	117	484	17
Hebron	rHBSma	0	0	0	0	50	0	0	0	0
Panzner	PANZBNW	0	170	0	0	0	0	10	240	0
Panzner	PANZBSW	0	0	0	0	0	0	0	10	0
Panzner	PANZC	0	0	280	0	30	0	0	70	0
Panzner	PANZEMd	0	40	0	0	0	0	0	150	0
Panzner	rPNZAma	0	0	50	0	0	0	0	0	0
Panzner	rPNZBmd	0	1800	500	0	0	0	0	2166	0
Panzner	rPNZCma	0	175	450	0	0	0	25	125	0
Sandy R.	rSR1Af	0	0	0	0	2200	0	67	267	100
Sandy R.	rSR1Apd	0	0	0	0	2700	0	0	0	0
Sandy R.	rSR2Ama	0	0	0	0	0	0	25	0	0
Sandy R.	rSR3Amd	125	0	0	0	0	0	0	0	0
Sandy R.	rSRCma	78	333	889	0	0	0	0	55	0
Sandy R.	rSRNWma	0	10	1100	0	0	0	0	100	0
Sandy R.	rSRSEma	200	533	533	0	0	0	0	66	0
Sandy R.	rSRSWma	0	0	38	0	0	0	38	0	25
Slate Run	SLATRNC	0	100	1800	0	0	0	0	0	175
Slate Run	SLATRNNW	0	0	0	0	0	0	25	0	50

Table 18. Stems per hectare of woody species by type. wetland = FACW, OBL tree spp., mesic = FAC tree species, willow tree = *Salix* spp. that are "trees", upland = FACU, UPL tree spp., dead = standing dead trees, sub mesic = subcanopy FAC, FACU, UPL small tree or shrub forest spp., sub wet = subcanopy FACW or OBL small tree or shrub forest spp., subcan full = subcanopy small tree or shrub wetland species that grow in full sun, adventive = nonnative spp. Refer to Table 2 for site codes.

Trumbull	rTR5Bma	0	0	0	0	200	0	0	200	0
Trumbull	rTR5Bof	0	0	0	0	0	0	500	700	650
Trumbull	rTR5Bpd	0	0	0	0	600	0	0	0	0
Trumbull	rTR7Ema	0	0	0	0	150	0	0	0	0
Trumbull	rTR7Epd	0	0	38	0	488	0	25	38	0
Trumbull	rTR7Ff	1017	984	0	150	1183	0	417	0	17
Trumbull	rTR7Fpd	0	0	0	0	800	0	0	0	0
Trumbull	rTR7Fuf	3100	300	0	500	500	0	300	0	0
Trumbull	TRUMB5	0	0	0	0	410	0	160	80	0
Trumbull	TRUMB7F	420	190	0	40	2570	0	0	10	0
Wh. Star	rWSNf	317	867	0	783	217	0	0	350	0
Wh. Star	rWSNma	0	133	0	0	0	0	0	50	67
Wh. Star	rWSNuf	650	400	0	1000	250	0	0	1050	200
Wh. Star	rWSNuth	1000	100	0	1450	50	0	0	550	300
Wh. Star	rWSSf	350	225	0	650	300	0	0	225	100
Wh. Star	rWSSma	1300	200	0	0	0	0	0	400	0
Wh. Star	rWSSsh	680	240	0	2080	20	0	20	1260	40
Wh. Star	rWSSuf	899	634	0	899	133	233	333	0	0
Wh. Star	rWSSuth	409	355	0	1046	25	20	76	548	98
Wh. Star	WHSTARN	1240	1470	0	310	370	0	0	90	0
Wh. Star	WHSTARS1	50	50	0	0	0	0	0	230	0
Wh. Star	WHSTARS2	1780	460	0	3000	420	0	0	1400	580

Table 19. Stand table for focused and aggregated random plots with woody species >1m. Refer to Table 2 for site codes. f = wetland forest, ma = marsh, md = wet meadow, sh = shrub swamp, uf = upland forest, uth = upland thicket.

site	species	spec code	frequency	rel freq	density	rel den	dominance	rel dom	IV
3EAGLEF	Acer negundo	mesic	8	0.667	320	0.444	8.417	0.397	0.503
3EAGLEF	Aesculus glabra	mesic	2	0.167	20	0.028	0.167	0.008	0.067
3EAGLEF	Craetagus sp.	upland	2	0.167	30	0.042	0.025	0.001	0.070
3EAGLEF	Fraxinus pennsylvanica	wetland	1	0.083	10	0.014	0.044	0.002	0.033
3EAGLEF	Populus deltoides	mesic	1	0.083	10	0.014	0.000	0.000	0.032
3EAGLEF	Standing dead	dead	9	0.750	300	0.417	12.075	0.570	0.579
3EAGLEF	Ulmus rubra	mesic	2	0.167	20	0.028	0.409	0.019	0.071
BGAEAST	Cornus amomum	sub full	1	0.083	130	0.080	0.003	0.000	0.055
BGAEAST	Fraxinus pennsylvanica	wetland	6	0.500	890	0.546	1.757	0.304	0.450
BGAEAST	Populus deltoides	mesic	4	0.333	290	0.178	3.498	0.605	0.372
BGAEAST	Quercus palustris	wetland	2	0.167	50	0.031	0.188	0.033	0.077
BGAEAST	Rosa palustris	sub full	1	0.083	70	0.043	0.001	0.000	0.042
BGAEAST	Salix nigra	willow tree	4	0.333	140	0.086	0.215	0.037	0.152
BGAEAST	Standing dead	dead	2	0.167	20	0.012	0.014	0.002	0.060
BGAEAST	Ulmus rubra	mesic	3	0.250	40	0.025	0.102	0.018	0.097
BGAWEST	Fraxinus pennslyvanica	wetland	3	0.250	800	0.762	0.148	0.772	0.595
BGAWEST	Populus deltoides	mesic	2	0.167	150	0.143	0.025	0.131	0.147
BGAWEST	Quercus palustris	wetland	1	0.083	25	0.024	0.006	0.031	0.046
BGAWEST	Ulmus rubra	mesic	2	0.167	75	0.071	0.013	0.065	0.101
BGB	Acer saccharinum	wetland	2	0.167	50	0.031	0.007	0.005	0.068
BGB	Fraxinus pennsylvanica	wetland	4	0.333	1525	0.938	1.260	0.973	0.748
BGB	Quercus palustris	wetland	1	0.083	25	0.015	0.028	0.021	0.040
BGB	Salix nigra	willow tree	1	0.083	25	0.015	0.001	0.000	0.033
CHIPSOTH	Acer saccharinum	wetland	3	0.250	30	0.019	0.407	0.068	0.113
CHIPSOTH	Cephalanthus occidentalis	sub wet	1	0.083	10	0.006	0.000	0.000	0.030
CHIPSOTH	Fraxinus pennsylvanica	wetland	2	0.167	30	0.019	0.643	0.108	0.098
CHIPSOTH	Rhamnus frangula	adventive	1	0.083	10	0.006	0.000	0.000	0.030
CHIPSOTH	Spiraea alba	sub full	1	0.083	320	0.208	0.006	0.001	0.097
CHIPSOTH	Standing dead	dead	6	0.500	1130	0.734	4.896	0.822	0.685
CHIPSOTH	Viburnum recognitum	sub wet	1	0.083	10	0.006	0.000	0.000	0.030
CV1AMa	Fraxinus pennsylvanica	wetland	2	0.167	40	1.000	0.003	1.000	0.722
CVA3	Cornus amomum	sub full	1	0.083	50	1.000	0.001	1.000	0.694
GRAD	Standing dead	dead	8	0.667	2070	1.000	6.493	1.000	0.889
GRF	Acer rubrum	wetland	7	0.583	1030	0.272	2.714	0.110	0.322
GRF	Carya ovata	mesic	1	0.083	10	0.003	0.000	0.000	0.029
GRF	Fagus grandifolia	mesic	1	0.083	10	0.003	0.000	0.000	0.029
GRF	Fraxinus pennsylvanica	wetland	1	0.083	10	0.003	0.000	0.000	0.029
GRF	Lindera benzoin	sub wet	1	0.083	10	0.003	0.000	0.000	0.029
GRF	Nyssa sylvatica	wetland	2	0.167	70	0.019	0.006	0.000	0.062
GRF	Quercus bicolor	wetland	10	0.833	370	0.098	9.285	0.376	0.436
GRF	Quercus palustris	wetland	9	0.750	180	0.048	5.997	0.243	0.347
GRF	Rosa palustris	sub full	2	0.167	40	0.011	0.001	0.000	0.059
GRF	Standing dead	dead	8	0.667	1150	0.304	3.959	0.160	0.377
GRF	Ulmus rubra	mesic	6	0.500	810	0.214	2.721	0.110	0.275
GRF	Viburnum recognitum	sub wet	2	0.167	90	0.024	0.002	0.000	0.064
HEBLC	Acer saccharinum	wetland	1	0.083	40	0.087	0.044	0.033	0.068
HEBLC	Cephalanthus occidentalis	sub wet	1	0.083	60	0.130	0.001	0.001	0.072
HEBLC	Cornus amomum	sub full	1	0.083	100	0.217	0.002	0.001	0.101
HEBLC	Fraxinus pennsylvanica	wetland	5	0.417	240	0.522	1.127	0.840	0.593
HEBLC	Salix nigra	willow tree	1	0.083	10	0.022	0.123	0.092	0.066

Table 19. Stand table for focused and aggregated random plots with woody species >1m. Refer to Table 2 for site codes. f = wetland forest, ma = marsh, md = wet meadow, sh = shrub swamp, uf = upland forest, uth = upland thicket.

site	species	spec code	frequency	rel freq	density	rel den	dominance	rel dom	IV
HEBLC	Ulmus rubra	mesic	1	0.083	10	0.022	0.044	0.033	0.046
HEBSC	Cephalanthus occidentalis	sub wet	1	0.083	100	0.800	0.002	0.800	0.561
HEBSC	Rosa palustris	sub full	1	0.083	25	0.200	0.001	0.200	0.161
PANZBNW	Cephalanthus occidentalis	sub wet	1	0.083	10	0.024	0.000	0.008	0.039
PANZBNW	Populus deltoides	mesic	2	0.167	170	0.405	0.008	0.327	0.300
PANZBNW	Salix discolor	willow shrub	3	0.250	200	0.476	0.015	0.631	0.453
PANZBNW	Salix sp.	willow shrub	1	0.083	40	0.095	0.001	0.033	0.071
PANZBSW	Salix sp.	willow shrub	1	0.083	10	1.000	0.000	1.000	0.694
PANZC	Salix discolor	willow shrub	1	0.083	20	0.053	0.005	0.232	0.123
PANZC	Salix nigra	willow tree	2	0.167	280	0.737	0.012	0.585	0.496
PANZC	Salix sp.	willow shrub	2	0.167	50	0.132	0.003	0.154	0.151
PANZC	Standing dead	dead	1	0.083	30	0.079	0.001	0.028	0.064
PANZEMd	Populus deltoides	mesic	1	0.083	40	0.211	0.001	0.211	0.168
PANZEMd	Salix eriocephala	willow shrub	1	0.083	150	0.789	0.003	0.789	0.554
r3EEFf	Acer negundo	mesic	8	0.667	363	0.309	4.949	0.263	0.413
r3EEFf	Aesculus glabra	mesic	5	0.417	238	0.202	1.094	0.058	0.226
r3EEFf	Celtis occidentalis	mesic	6	0.500	113	0.096	3.601	0.192	0.262
r3EEFf	Crataegus sp.	upland	3	0.250	63	0.053	0.250	0.013	0.106
r3EEFf	Fraxinus pennlyvanica	wetland	2	0.167	100	0.085	0.005	0.000	0.084
r3EEFf	Juglans nigra	mesic	2	0.167	13	0.011	0.301	0.016	0.064
r3EEFf	Platanus occidentalis	mesic	4	0.333	63	0.053	0.541	0.029	0.138
r3EEFf	Quercus bicolor	wetland	1	0.083	0	0.000	0.000	0.000	0.028
r3EEFf	Rosa multiflora	adventive	1	0.083	38	0.032	0.001	0.000	0.038
r3EEFf	Standing dead	dead	7	0.583	163	0.138	7.597	0.404	0.375
r3EEFf	Ulmus rubra	mesic	2	0.167	25	0.021	0.454	0.024	0.071
r3EEFma	Standing dead	dead	3	0.250	200	1.000	4.418	1.000	0.750
r3EEFuf	Acer negundo	mesic	1	0.083	100	0.100	11.040	0.307	0.163
r3EEFuf	Aesculus glabra	mesic	2	0.167	200	0.200	1.337	0.037	0.135
r3EEFuf	Celtis occidentalis	mesic	2	0.167	100	0.100	11.040	0.307	0.191
r3EEFuf	Gleditsia triacanthos	mesic	1	0.083	100	0.100	5.940	0.165	0.116
r3EEFuf	Juglans nigra	mesic	2	0.167	200	0.200	2.515	0.070	0.146
r3EEFuf	Standing dead	dead	3	0.250	300	0.300	4.111	0.114	0.221
r3ENMma	Salix amygdaloides	willow tree	1	0.083	25	0.500	0.001	0.500	0.361
r3ENMma	Salix eriocephala	willow shrub	1	0.083	25	0.500	0.001	0.500	0.361
r3ENMmd	Platanus occidentalis	mesic	1	0.083	100	0.500	0.002	0.500	0.361
r3ENMmd	Populus deltoides	mesic	1	0.083	100	0.500	0.002	0.500	0.361
r3ENMof	Platanus occidentalis	mesic	1	0.083	350	1.000	0.084	1.000	0.694
rBGAf	Acer negundo	mesic	1	0.083	20	0.005	0.000	0.000	0.030
rBGAf	Acer saccarhinum	wetland	0	0.000	0	0.000	0.000	0.000	0.000
rBGAf	Cornus amomum	sub full	2	0.167	480	0.132	0.009	0.001	0.100
rBGAf	Fraxinus pennlyvanica	wetland	6	0.500	2520	0.692	4.593	0.411	0.535
rBGAf	Populus deltoides	mesic	5	0.417	260	0.071	6.212	0.556	0.348
rBGAf	Quercus palustris	wetland	4	0.333	200	0.055	0.249	0.022	0.137
rBGAf	Rosa setigera	sub full	1	0.083	40	0.011	0.001	0.000	0.032
rBGAf	Ulmus rubra	mesic	2	0.167	120	0.033	0.098	0.009	0.070
rBGAma	Cornus amomum	sub full	1	0.083	100	0.093	0.002	0.003	0.060
rBGAma	Fraxinus pennlyvanica	wetland	4	0.333	675	0.628	0.489	0.678	0.546
rBGAma	Populus deltoides	mesic	2	0.167	150	0.140	0.101	0.140	0.149
rBGAma	Salix amygdaloides	willow tree	1	0.083	25	0.023	0.111	0.153	0.087
rBGAma	Salix nigra	willow tree	2	0.167	100	0.093	0.013	0.018	0.093

Table 19. Stand table for focused and aggregated random plots with woody species >1m. Refer to Table 2 for site codes. f = wetland forest, ma = marsh, md = wet meadow, sh = shrub swamp, uf = upland forest, uth = upland thicket.

site	species	spec code	frequency	rel freq	density	rel den	dominance	rel dom	IV
rBGAma	Ulmus rubra	mesic	1	0.083	25	0.023	0.006	0.008	0.038
rBGAmd	Fraxinus pennlyvanica	wetland	1	0.083	300	1.000	0.331	1.000	0.694
rBGBf	Cornus amomum	sub full	1	0.083	1300	0.382	0.026	0.001	0.156
rBGBf	Fraxinus pennlyvanica	wetland	7	0.583	1500	0.441	14.843	0.692	0.572
rBGBf	Standing dead	dead	2	0.167	600	0.176	6.577	0.307	0.217
rBGBf	Ulmus rubra	mesic	0	0.000	0	0.000	0.000	0.000	0.000
rBGBma	Fraxinus pennlyvanica	wetland	4	0.333	267	0.841	0.148	0.346	0.507
rBGBma	Populus deltoides	mesic	1	0.083	17	0.053	0.000	0.001	0.046
rBGBma	Standing dead	dead	2	0.167	33	0.105	0.278	0.653	0.308
rBGBmd	Populus deltoides	mesic	1	0.083	50	0.167	0.001	0.167	0.139
rBGBmd	Quercus palustris	wetland	1	0.083	150	0.500	0.003	0.500	0.361
rBGBmd	Ulmus rubra	mesic	1	0.083	100	0.333	0.002	0.333	0.250
rBGBpd	Standing dead	dead	3	0.250	160	1.000	2.277	1.000	0.750
rBGCma	Acer saccarhinum	wetland	1	0.083	33	0.004	0.001	0.000	0.029
rBGCma	Fraxinus pennlyvanica	wetland	2	0.167	733	0.667	0.088	0.523	0.452
rBGCma	Ulmus rubra	mesic	3	0.250	333	0.303	0.072	0.429	0.327
rBGCma	Viburnum prunifolium	upland	1	0.083	33	0.030	0.008	0.048	0.054
rBGCmd	Cornus amomum	sub full	2	0.167	57	0.182	0.001	0.045	0.131
rBGCmd	Cornus sericea	sub full	1	0.083	43	0.136	0.001	0.034	0.084
rBGCmd	Crataegus sp.	upland	1	0.083	14	0.046	0.000	0.011	0.047
rBGCmd	Fraxinus pennlyvanica	wetland	1	0.083	14	0.046	0.000	0.011	0.047
rBGCmd	Gleditsia triacanthos	mesic	1	0.083	14	0.046	0.000	0.011	0.047
rBGCmd	Quercus palustris	wetland	1	0.083	43	0.136	0.010	0.411	0.210
rBGCmd	Standing dead	dead	1	0.083	14	0.046	0.000	0.011	0.047
rBGCmd	Ulmus rubra	mesic	2	0.167	100	0.318	0.011	0.455	0.314
rBGCmd	Viburnum prunifolium	upland	1	0.083	14	0.046	0.000	0.011	0.047
rBGDf	Acer saccarhinum	wetland	3	0.250	200	0.058	0.127	0.049	0.119
rBGDf	Cornus amomum	sub full	1	0.083	100	0.029	0.002	0.001	0.038
rBGDf	Fraxinus pennlyvanica	wetland	4	0.333	3033	0.875	2.159	0.836	0.681
rBGDf	Populus deltoides	mesic	1	0.083	33	0.010	0.147	0.057	0.050
rBGDf	Quercus palustris	wetland	1	0.083	33	0.010	0.001	0.000	0.031
rBGDf	Rosa setigera	sub full	1	0.083	33	0.010	0.001	0.000	0.031
rBGDf	Salix nigra	willow tree	1	0.083	33	0.010	0.147	0.057	0.050
rBGDma	Fraxinus pennlyvanica	wetland	5	0.417	740	1.000	2.337	1.000	0.806
rBGDmd	Fraxinus pennlyvanica	wetland	1	0.083	100	0.029	0.110	0.630	0.248
rBGDmd	Salix discolor	willow shrub	1	0.083	3200	0.941	0.063	0.359	0.461
rBGDmd	Ulmus rubra	mesic	1	0.083	100	0.029	0.002	0.011	0.041
rC1Vma	Cornus amomum	sub full	1	0.083	33	0.167	0.001	0.167	0.139
rC1Vma	Salix eriocephala	willow shrub	1	0.083	33	0.167	0.001	0.167	0.139
rC1Vma	Salix humilis	adventive	1	0.083	33	0.167	0.001	0.167	0.139
rC1Vma	Salix nigra	willow tree	1	0.083	67	0.333	0.001	0.333	0.250
rC1Vma	Ulmus rubra	mesic	1	0.083	33	0.167	0.001	0.167	0.139
rC1Vmd	Cornus amomum	sub full	1	0.083	67	0.214	0.001	0.214	0.171
rC1Vmd	Salix fragilis	adventive	2	0.167	244	0.786	0.005	0.786	0.580
rC3Vma	Cornus amomum	sub full	1	0.083	133	1.003	0.003	1.000	0.695
rC3Vmd	Cornus amomum	sub full	1	0.083	100	1.000	0.002	1.000	0.694
rC3Vsh	Acer saccarhinum	wetland	4	0.333	700	0.104	9.043	0.431	0.290
rC3Vsh	Cornus amomum	sub full	3	0.250	3800	0.567	0.119	0.006	0.274
rC3Vsh	Fraxinus pennlyvanica	wetland	1	0.083	100	0.015	0.442	0.021	0.040
rC3Vsh	Spiraea alba	sub full	1	0.083	700	0.104	0.014	0.001	0.063

Table 19. Stand table for focused and aggregated random plots with woody species >1m. Refer to Table 2 for site codes. f = wetland forest, ma = marsh, md = wet meadow, sh = shrub swamp, uf = upland forest, uth = upland thicket.

site	species	spec code	frequency	rel freq	density	rel den	dominance	rel dom	IV
rC3Vsh	Standing dead	dead	5	0.417	1000	0.149	11.338	0.541	0.369
rC3Vsh	Viburnum recognitum	sub wet	2	0.167	400	0.060	0.008	0.000	0.076
rCHIPmd	Rosa multiflora	adventive	2	0.167	50	0.266	0.001	0.082	0.172
rCHIPmd	Rubus allegheniensis	sub full	1	0.083	50	0.266	0.001	0.082	0.144
rCHIPmd	Salix nigra	willow tree	2	0.167	88	0.465	0.010	0.836	0.489
rGRADf	Standing dead	dead	10	0.833	2950	0.500	31.348	0.892	0.742
rGRBCf	Spiraea alba	sub full	1	0.083	550	0.093	0.011	0.000	0.059
rGRBCf	Standing dead	dead	5	0.417	2400	0.407	3.791	0.108	0.310
rGRBCmd	Cornus amomum	sub full	1	0.083	100	0.400	0.002	0.000	0.161
rGRBCmd	Quercus palustris	wetland	2	0.167	150	0.600	3.977	1.000	0.589
rGRFf	Acer rubrum	wetland	8	0.667	813	0.220	5.667	0.206	0.364
rGRFf	Carya ovata	mesic	1	0.083	13	0.003	0.000	0.000	0.029
rGRFf	Fagus grandifolia	mesic	3	0.250	88	0.024	0.048	0.002	0.092
rGRFf	Lindera benzoin	sub wet	0	0.000	0	0.000	0.000	0.000	0.000
rGRFf	Nyssa sylvatica	wetland	4	0.333	113	0.031	1.064	0.039	0.134
rGRFf	Prunus serotina	upland	2	0.167	38	0.010	0.310	0.011	0.063
rGRFf	Pyrus malus	adventive	1	0.083	13	0.003	0.301	0.011	0.033
rGRFf	Quercus bicolor	wetland	7	0.583	125	0.034	3.947	0.143	0.254
rGRFf	Quercus palustris	wetland	10	0.833	263	0.071	7.467	0.271	0.392
rGRFf	Standing dead	dead	6	0.500	1750	0.475	7.132	0.259	0.411
rGRFf	Ulmus rubra	mesic	5	0.417	463	0.125	1.577	0.057	0.200
rGRFf	Viburnum recognitum	sub wet	1	0.083	13	0.003	0.000	0.000	0.029
rGRFma	Acer rubrum	wetland	6	0.500	800	0.800	18.837	0.694	0.665
rGRFma	Fraxinus pennlyvanica	wetland	1	0.083	50	0.050	0.001	0.000	0.045
rGRFma	Populus tremuloides	upland	1	0.083	50	0.050	2.970	0.109	0.081
rGRFma	Quercus bicolor	wetland	1	0.083	50	0.050	1.203	0.044	0.059
rGRFma	Standing dead	dead	1	0.083	50	0.050	4.150	0.153	0.095
rHBLma	Cornus amomum	sub full	1	0.083	25	0.067	0.001	0.001	0.050
rHBLma	Fraxinus pennlyvanica	wetland	5	0.417	350	0.933	0.401	0.999	0.783
rHBLmd	Acer negundo	mesic	1	0.083	17	0.009	0.004	0.001	0.031
rHBLmd	Cephalanthus occidentalis	sub wet	1	0.083	117	0.064	0.002	0.000	0.049
rHBLmd	Cornus amomum	sub full	4	0.333	467	0.257	0.300	0.057	0.216
rHBLmd	Fraxinus pennlyvanica	wetland	5	0.417	533	0.294	1.527	0.288	0.333
rHBLmd	Gleditsia triacanthos	mesic	1	0.083	17	0.009	0.000	0.000	0.031
rHBLmd	Populus deltoides	mesic	7	0.583	317	0.174	1.555	0.293	0.350
rHBLmd	Quercus palustris	wetland	2	0.167	67	0.037	0.184	0.035	0.079
rHBLmd	Rosa multiflora	adventive	1	0.083	17	0.009	0.000	0.000	0.031
rHBLmd	Rosa palustris	sub full	1	0.083	17	0.009	0.000	0.000	0.031
rHBLmd	Salix nigra	willow tree	5	0.417	250	0.138	1.730	0.326	0.294
rHBSma	Standing dead	dead	2	0.167	50	1.000	3.560	1.000	0.722
rPNZAma	Salix amygdaloides	willow tree	1	0.083	50	1.000	0.001	1.000	0.694
rPNZBmd	Populus deltoides	mesic	1	0.083	1800	0.403	0.035	0.268	0.251
rPNZBmd	Salix discolor	willow shrub	2	0.167	933	0.209	0.040	0.306	0.227
rPNZBmd	Salix eriocephala	willow shrub	2	0.167	1000	0.224	0.034	0.261	0.217
rPNZBmd	Salix exigua	willow shrub	2	0.167	200	0.045	0.011	0.086	0.099
rPNZBmd	Salix nigra	willow tree	1	0.083	500	0.112	0.010	0.074	0.090
rPNZBmd	Spiraea alba	sub full	1	0.083	33	0.007	0.001	0.005	0.032
rPNZCma	Cephalanthus occidentalis	sub wet	1	0.083	25	0.032	0.001	0.010	0.042
rPNZCma	Populus deltoides	mesic	2	0.167	175	0.226	0.015	0.300	0.231
rPNZCma	Salix eriocephala	willow shrub	1	0.083	100	0.129	0.002	0.041	0.084

Table 19. Stand table for focused and aggregated random plots with woody species >1m. Refer to Table 2 for site codes. f = wetland forest, ma = marsh, md = wet meadow, sh = shrub swamp, uf = upland forest, uth = upland thicket.

site	species	spec code	frequency	rel freq	density	rel den	dominance	rel dom	IV
rPNZCma	Salix exigua	willow shrub	1	0.083	25	0.032	0.001	0.010	0.042
rPNZCma	Salix nigra	willow tree	2	0.167	450	0.581	0.031	0.640	0.462
rSR1Af	Rhamnus frangula	adventive	2	0.167	100	0.038	0.002	0.000	0.068
rSR1Af	Rosa setigera	sub full	1	0.083	67	0.025	0.001	0.000	0.036
rSR1Af	Salix discolor	willow shrub	3	0.250	200	0.076	1.035	0.082	0.136
rSR1Af	Standing dead	dead	8	0.667	2200	0.836	11.658	0.918	0.807
rSR1Af	Viburnum recognitum	sub wet	1	0.083	67	0.025	0.001	0.000	0.036
rSR1Apd	Standing dead	dead	6	0.500	2700	1.000	3.835	1.000	0.833
rSR2Ama	Cephalanthus occidentalis	sub wet	1	0.083	25	1.000	0.001	1.000	0.694
rSR3Amd	Acer saccarhinum	wetland	1	0.083	125	1.000	0.003	1.000	0.694
rSRCma	Fraxinus pennlyvanica	wetland	1	0.083	56	0.041	0.001	0.006	0.043
rSRCma	Gleditsia triacanthos	mesic	2	0.167	22	0.016	0.003	0.015	0.066
rSRCma	Populus deltoides	mesic	3	0.250	311	0.229	0.023	0.117	0.199
rSRCma	Quercus palustris	wetland	1	0.083	22	0.016	0.000	0.002	0.034
rSRCma	Salix eriocephala	willow shrub	3	0.250	44	0.033	0.018	0.091	0.125
rSRCma	Salix exigua	willow shrub	1	0.083	11	0.008	0.000	0.001	0.031
rSRCma	Salix nigra	willow tree	4	0.333	889	0.656	0.151	0.769	0.586
rSRNWma	Gleditsia triacanthos	mesic	1	0.083	10	0.008	0.000	0.008	0.033
rSRNWma	Salix eriocephala	willow shrub	1	0.083	100	0.083	0.002	0.083	0.083
rSRNWma	Salix nigra	willow tree	1	0.083	1100	0.909	0.022	0.909	0.634
rSRSEma	Populus deltoides	mesic	1	0.083	533	0.400	0.011	0.188	0.224
rSRSEma	Quercus palustris	wetland	2	0.167	200	0.150	0.019	0.335	0.217
rSRSEma	Salix eriocephala	willow shrub	1	0.083	33	0.025	0.001	0.012	0.040
rSRSEma	Salix exigua	willow shrub	1	0.083	33	0.025	0.001	0.012	0.040
rSRSEma	Salix nigra	willow tree	3	0.250	533	0.400	0.025	0.453	0.368
rSRSWma	Cephalanthus occidentalis	sub wet	1	0.083	38	0.375	0.001	0.028	0.162
rSRSWma	Salix amygdaloides	willow tree	2	0.167	25	0.250	0.017	0.633	0.350
rSRSWma	Salix fragilis	adventive	1	0.083	25	0.250	0.006	0.226	0.187
rSRSWma	Salix nigra	willow tree	1	0.083	13	0.125	0.003	0.113	0.107
rTR5Bma	Spiraea tomentosa	sub full	1	0.083	200	0.500	0.004	0.500	0.361
rTR5Bma	Standing dead	dead	1	0.083	200	0.500	0.004	0.500	0.361
rTR5Bof	Cornus amomum	sub full	1	0.083	500	0.270	0.010	0.270	0.208
rTR5Bof	Cornus racemosa	sub full	1	0.083	200	0.108	0.004	0.108	0.100
rTR5Bof	Physocarpus opulifolius	sub wet	2	0.167	250	0.135	0.005	0.135	0.146
rTR5Bof	Rosa multiflora	adventive	1	0.083	650	0.351	0.013	0.351	0.262
rTR5Bof	Viburnum recognitum	sub wet	1	0.083	250	0.135	0.005	0.135	0.118
rTR5Bpd	Standing dead	dead	1	0.083	600	1.000	0.012	1.000	0.694
rTR7Ema	Standing dead	dead	1	0.083	150	1.000	0.003	1.000	0.694
rTR7Epd	Cornus amomum	sub full	1	0.083	13	0.002	0.000	0.083	0.056
rTR7Epd	Salix nigra	willow tree	1	0.083	38	0.065	0.009	0.006	0.052
rTR7Epd	Salix sericea	willow shrub	1	0.083	25	0.043	0.001	0.000	0.042
rTR7Epd	Standing dead	dead	6	0.500	488	0.848	1.507	0.993	0.780
rTR7Epd	Viburnum recognitum	sub wet	1	0.083	25	0.043	0.001	0.000	0.042
rTR7Ff	Acer rubrum	wetland	5	0.417	100	0.027	2.544	0.160	0.201
rTR7Ff	Acer saccharum	wetland	4	0.333	200	0.053	0.216	0.014	0.133
rTR7Ff	Fagus grandifolia	mesic	5	0.417	150	0.040	0.579	0.036	0.164
rTR7Ff	Fraxinus pennlyvanica	wetland	7	0.583	717	0.190	4.908	0.308	0.361
rTR7Ff	Hamamelis virginiana	mesic	3	0.250	367	0.097	0.480	0.030	0.126
rTR7Ff	Lindera benzoin	sub wet	2	0.167	150	0.040	0.007	0.000	0.069
rTR7Ff	Liriodendron tulipifera	upland	5	0.417	117	0.031	0.686	0.043	0.164

Table 19. Stand table for focused and aggregated random plots with woody species >1m. Refer to Table 2 for site codes. f = wetland forest, ma = marsh, md = wet meadow, sh = shrub swamp, uf = upland forest, uth = upland thicket.

site	species	spec code	frequency	rel freq	density	rel den	dominance	rel dom	IV
rTR7Ff	Populus tremuloides	upland	2	0.167	33	0.009	0.605	0.038	0.071
rTR7Ff	Rhamnus frangula	adventive	1	0.083	17	0.004	0.000	0.000	0.029
rTR7Ff	Standing dead	dead	7	0.583	1183	0.314	3.812	0.239	0.379
rTR7Ff	Ulmus rubra	mesic	6	0.500	467	0.124	2.078	0.131	0.252
rTR7Ff	Viburnum recognitum	sub wet	2	0.167	267	0.071	0.009	0.001	0.079
rTR7Fpd	Standing dead	dead	5	0.417	800	1.000	8.271	1.000	0.806
rTR7Fuf	Acer saccharum	wetland	7	0.583	3000	0.638	28.883	0.706	0.643
rTR7Fuf	Carya cordiformis	mesic	1	0.083	100	0.021	0.024	0.001	0.035
rTR7Fuf	Fagus grandifolia	mesic	2	0.167	200	0.043	0.135	0.003	0.071
rTR7Fuf	Fraxinus pennlyvanica	wetland	1	0.083	100	0.021	0.024	0.001	0.035
rTR7Fuf	Lindera benzoin	sub wet	1	0.083	300	0.064	0.006	0.000	0.049
rTR7Fuf	Liriodendron tulipifera	upland	3	0.250	500	0.106	7.706	0.188	0.182
rTR7Fuf	Standing dead	dead	4	0.333	500	0.106	4.114	0.101	0.180
rWSNf	Acer saccarhinum	wetland	1	0.083	17	0.007	0.205	0.014	0.035
rWSNf	Cornus amomum	sub full	3	0.250	250	0.099	1.406	0.097	0.149
rWSNf	Cornus racemosa	sub full	3	0.250	67	0.026	0.019	0.001	0.093
rWSNf	Crataegus sp.	upland	1	0.083	33	0.013	0.008	0.001	0.032
rWSNf	Fraxinus pennlyvanica	wetland	9	0.750	233	0.092	4.312	0.298	0.380
rWSNf	Morus rubra	mesic	1	0.083	17	0.007	0.018	0.001	0.030
rWSNf	Quercus bicolor	wetland	3	0.250	67	0.026	0.315	0.022	0.099
rWSNf	Quercus rubra	mesic	6	0.500	117	0.046	3.789	0.262	0.269
rWSNf	Rosa setigera	sub full	1	0.083	33	0.013	0.001	0.000	0.032
rWSNf	Standing dead	dead	5	0.417	217	0.086	1.372	0.095	0.199
rWSNf	Ulmus rubra	mesic	5	0.417	733	0.290	3.004	0.208	0.305
rWSNf	Viburnum prunifolium	upland	0	0.000	0	0.000	0.000	0.000	0.000
rWSNf	Zanthoxylum americanum	upland	1	0.083	750	0.296	0.015	0.001	0.127
rWSNma	Cornus racemosa	sub full	1	0.083	50	0.200	0.001	0.006	0.096
rWSNma	Pyrus malus	adventive	3	0.250	67	0.267	0.166	0.979	0.499
rWSNma	Tilia americana	mesic	1	0.083	133	0.533	0.003	0.015	0.211
rWSNuf	Cornus racemosa	sub full	2	0.167	950	0.268	0.019	0.001	0.145
rWSNuf	Crataegus sp.	upland	2	0.167	150	0.042	0.497	0.025	0.078
rWSNuf	Fraxinus pennlyvanica	wetland	4	0.333	500	0.141	3.951	0.195	0.223
rWSNuf	Pyrus malus	adventive	3	0.250	200	0.056	0.343	0.017	0.108
rWSNuf	Quercus bicolor	wetland	3	0.250	150	0.042	5.013	0.248	0.180
rWSNuf	Sambucus canadensis	sub full	1	0.083	100	0.028	0.002	0.000	0.037
rWSNuf	Standing dead	dead	2	0.167	250	0.070	8.963	0.443	0.227
rWSNuf	Ulmus rubra	mesic	3	0.250	400	0.113	1.393	0.069	0.144
rWSNuf	Viburnum prunifolium	upland	1	0.083	100	0.028	0.002	0.000	0.037
rWSNuf	Zanthoxylum americanum	upland	2	0.167	750	0.211	0.037	0.002	0.127
rWSNuth	Acer saccarhinum	wetland	3	0.250	300	0.087	3.681	0.172	0.170
rWSNuth	Carya ovata	mesic	2	0.167	100	0.029	0.669	0.031	0.076
rWSNuth	Cornus racemosa	sub full	4	0.333	550	0.159	0.264	0.012	0.168
rWSNuth	Fraxinus pennlyvanica	wetland	7	0.583	500	0.145	11.977	0.558	0.429
rWSNuth	Pyrus malus	adventive	2	0.167	300	0.087	0.908	0.042	0.099
rWSNuth	Quercus bicolor	wetland	3	0.250	200	0.058	3.467	0.162	0.157
rWSNuth	Standing dead	dead	1	0.083	50	0.014	0.221	0.010	0.036
rWSNuth	Zanthoxylum americanum	upland	4	0.333	1450	0.420	0.270	0.013	0.255
rWSSf	Berberis thunbergii	adventive	2	0.167	50	0.027	0.001	0.000	0.065
rWSSf	Carya ovata	mesic	1	0.083	50	0.027	0.221	0.023	0.045
rWSSf	Cornus amomum	sub full	2	0.167	150	0.081	0.009	0.001	0.083

Table 19. Stand table for focused and aggregated random plots with woody species >1m. Refer to Table 2 for site codes. f = wetland forest, ma = marsh, md = wet meadow, sh = shrub swamp, uf = upland forest, uth = upland thicket.

site	species	spec code	frequency	rel freq	density	rel den	dominance	rel dom	IV
rWSSf	Cornus racemosa	sub full	2	0.167	75	0.041	0.002	0.000	0.069
rWSSf	Crataegus sp.	upland	1	0.083	25	0.014	0.028	0.003	0.033
rWSSf	Fraxinus pennlyvanica	wetland	6	0.500	350	0.189	4.066	0.430	0.373
rWSSf	Pyrus malus	adventive	1	0.083	50	0.027	0.055	0.006	0.039
rWSSf	Quercus macrocarpa	mesic	1	0.083	25	0.014	0.111	0.012	0.036
rWSSf	Standing dead	dead	4	0.333	300	0.162	3.978	0.420	0.305
rWSSf	Ulmus rubra	mesic	4	0.333	150	0.081	0.966	0.102	0.172
rWSSf	Viburnum prunifolium	upland	3	0.250	100	0.054	0.008	0.001	0.102
rWSSf	Zanthoxylum americanum	upland	2	0.167	525	0.284	0.021	0.002	0.151
rWSSma	Acer saccarhinum	wetland	1	0.083	100	0.053	1.227	0.177	0.105
rWSSma	Cornus amomum	sub full	2	0.167	400	0.211	0.008	0.001	0.126
rWSSma	Fraxinus pennlyvanica	wetland	5	0.417	1200	0.632	4.012	0.580	0.543
rWSSma	Standing dead	dead	0	0.000	0	0.000	0.000	0.000	0.000
rWSSma	Ulmus rubra	mesic	2	0.167	200	0.105	1.669	0.241	0.171
rWSSsh	Acer saccarhinum	wetland	1	0.083	20	0.004	0.088	0.017	0.035
rWSSsh	Cornus amomum	sub full	3	0.250	1260	0.265	0.046	0.009	0.175
rWSSsh	Crataegus sp.	upland	2	0.167	80	0.017	0.511	0.097	0.094
rWSSsh	Fraxinus pennlyvanica	wetland	5	0.417	660	0.139	1.543	0.293	0.283
rWSSsh	Ligustrum vulgare	adventive	1	0.083	20	0.004	0.000	0.000	0.029
rWSSsh	Platanus occidentalis	mesic	1	0.083	20	0.004	0.795	0.151	0.080
rWSSsh	Pyrus malus	adventive	1	0.083	20	0.004	0.000	0.000	0.029
rWSSsh	Quercus sp.	mesic	1	0.083	20	0.004	0.088	0.017	0.035
rWSSsh	Standing dead	dead	1	0.083	20	0.004	0.088	0.017	0.035
rWSSsh	Ulmus rubra	mesic	4	0.333	200	0.042	0.675	0.128	0.168
rWSSsh	Viburnum lentago	sub wet	1	0.083	20	0.004	0.000	0.000	0.029
rWSSsh	Viburnum prunifolium	upland	4	0.333	1480	0.311	0.248	0.047	0.231
rWSSsh	Zanthoxylum americanum	upland	1	0.083	520	0.109	0.010	0.002	0.065
rWSSuf	Acer saccharum	wetland	2	0.167	133	0.043	0.368	0.031	0.080
rWSSuf	Carpinus caroliniana	sub mesic	3	0.250	233	0.074	0.503	0.042	0.122
rWSSuf	Carya cordiformis	mesic	1	0.083	33	0.011	0.147	0.012	0.035
rWSSuf	Carya ovata	mesic	3	0.250	200	0.064	1.006	0.084	0.133
rWSSuf	Crataegus sp.	upland	2	0.167	67	0.021	0.184	0.015	0.068
rWSSuf	Fraxinus nigra	wetland	1	0.083	33	0.011	0.037	0.003	0.032
rWSSuf	Fraxinus pennlyvanica	wetland	2	0.167	700	0.223	2.780	0.232	0.207
rWSSuf	Fraxinus quadrangulata	upland	1	0.083	33	0.011	0.001	0.000	0.031
rWSSuf	Lindera benzoin	sub wet	1	0.083	133	0.043	0.003	0.000	0.042
rWSSuf	Platanus occidentalis	mesic	1	0.083	0	0.000	0.000	0.000	0.028
rWSSuf	Prunus serotina	upland	0	0.000	0	0.000	0.000	0.000	0.000
rWSSuf	Prunus virginiana	upland	1	0.083	33	0.011	0.008	0.001	0.032
rWSSuf	Quercus bicolor	wetland	1	0.083	33	0.011	0.409	0.034	0.043
rWSSuf	Quercus muhlenbergii	upland	1	0.083	33	0.011	0.409	0.034	0.043
rWSSuf	Quercus rubra	mesic	2	0.167	67	0.021	0.038	0.003	0.064
rWSSuf	Standing dead	dead	3	0.250	133	0.043	3.861	0.322	0.205
rWSSuf	Staphylea trifolia	mesic	1	0.083	100	0.032	0.002	0.000	0.039
rWSSuf	Tilia americana	mesic	1	0.083	67	0.021	0.295	0.025	0.043
rWSSuf	Ulmus rubra	mesic	3	0.250	167	0.053	1.113	0.093	0.132
rWSSuf	Viburnum lentago	sub wet	2	0.167	200	0.064	0.805	0.067	0.099
rWSSuf	Viburnum prunifolium	upland	3	0.250	733	0.234	0.029	0.002	0.162
rWSSuth	Acer saccharum	wetland	1	0.083	13	0.006	0.055	0.008	0.032
rWSSuth	Berberis thunbergii	adventive	1	0.083	60	0.013	0.001	0.000	0.032

Table 19. Stand table for focused and aggregated random plots with woody species >1m. Refer to Table 2 for site codes. f = wetland forest, ma = marsh, md = wet meadow, sh = shrub swamp, uf = upland forest, uth = upland thicket.

site	species	spec code	frequency	rel freq	density	rel den	dominance	rel dom	IV
rWSSuth	Carpinus caroliniana	sub mesic	1	0.083	20	0.004	0.005	0.001	0.030
rWSSuth	Carya ovata	mesic	3	0.250	58	0.022	0.696	0.104	0.125
rWSSuth	Cercis canadensis	upland	2	0.167	38	0.017	0.061	0.009	0.064
rWSSuth	Cornus amomum	sub full	1	0.083	13	0.006	0.000	0.000	0.030
rWSSuth	Cornus racemosa	sub full	3	0.250	535	0.234	0.011	0.002	0.162
rWSSuth	Fraxinus pennlyvanica	wetland	6	0.500	238	0.110	0.999	0.143	0.251
rWSSuth	Juglans nigra	mesic	1	0.083	13	0.006	0.055	0.008	0.032
rWSSuth	Ligustrum vulgare	adventive	1	0.083	38	0.017	0.001	0.000	0.034
rWSSuth	Lindera benzoin	sub wet	1	0.083	63	0.029	0.001	0.000	0.038
rWSSuth	Physocarpus opulifolius	sub wet	1	0.083	13	0.006	0.000	0.000	0.030
rWSSuth	Platanus occidentalis	mesic	1	0.083	13	0.006	0.055	0.008	0.032
rWSSuth	Prunus virginiana	upland	1	0.083	13	0.006	0.014	0.002	0.030
rWSSuth	Quercus bicolor	wetland	7	0.583	158	0.043	1.553	0.239	0.288
rWSSuth	Quercus muhlenbergii	upland	1	0.083	20	0.004	0.245	0.047	0.045
rWSSuth	Quercus rubra	mesic	1	0.083	13	0.006	0.055	0.008	0.032
rWSSuth	Rhus glabra	upland	1	0.083	75	0.035	0.002	0.000	0.040
rWSSuth	Standing dead	dead	2	0.167	25	0.012	0.798	0.114	0.098
rWSSuth	Tilia americana	mesic	7	0.584	220	0.072	3.154	0.474	0.376
rWSSuth	Ulmus rubra	mesic	3	0.250	38	0.017	0.359	0.051	0.106
rWSSuth	Viburnum prunifolium	upland	3	0.250	450	0.209	0.012	0.002	0.154
rWSSuth	Zanthoxylum americanum	upland	2	0.167	450	0.209	0.009	0.001	0.126
SLATRNC	Gleditsia triacanthos	mesic	1	0.083	25	0.012	0.006	0.007	0.034
SLATRNC	Populus deltoides	mesic	2	0.167	75	0.036	0.013	0.014	0.072
SLATRNC	Salix fragilis	adventive	2	0.167	175	0.084	0.150	0.170	0.140
SLATRNC	Salix nigra	willow tree	5	0.417	1800	0.867	0.713	0.809	0.698
SLATRNNW	Cephalanthus occidentalis	sub wet	1	0.083	25	0.333	0.001	0.039	0.152
SLATRNNW	Salix fragilis	adventive	1	0.083	50	0.667	0.012	0.961	0.570
TRUMB5	Cornus amomum	sub full	2	0.167	70	0.108	0.001	0.053	0.109
TRUMB5	Physocarpus opulifolius	sub wet	1	0.083	20	0.031	0.000	0.015	0.043
TRUMB5	Spiraea tomentosa	sub full	1	0.083	10	0.015	0.000	0.008	0.035
TRUMB5	Standing dead	dead	3	0.250	410	0.631	0.021	0.819	0.567
TRUMB5	Viburnum recognitum	sub wet	1	0.083	140	0.215	0.003	0.106	0.135
TRUMB7F	Acer rubrum	wetland	1	0.083	10	0.003	0.241	0.010	0.032
TRUMB7F	Acer saccharinum	wetland	8	0.667	400	0.124	7.035	0.287	0.359
TRUMB7F	Carya ovata	mesic	1	0.083	10	0.003	0.044	0.002	0.029
TRUMB7F	Carya sp	mesic	1	0.083	10	0.003	0.241	0.010	0.032
TRUMB7F	Cornus sp.	sub full	1	0.083	10	0.003	0.002	0.000	0.029
TRUMB7F	Fraxinus pennsylvanica	wetland	1	0.083	10	0.003	0.044	0.002	0.029
TRUMB7F	Populus tremuloides	upland	3	0.250	40	0.012	1.158	0.047	0.103
TRUMB7F	Standing dead	dead	9	0.750	2570	0.796	12.548	0.512	0.686
TRUMB7F	Ulmus rubra	mesic	6	0.500	170	0.053	3.204	0.131	0.228
WHSTARN	Acer saccharinum	wetland	3	0.250	40	0.011	0.147	0.004	0.089
WHSTARN	Cornus racemosa	sub full	2	0.167	90	0.026	0.002	0.000	0.064
WHSTARN	Fraxinus pennslyvanica	wetland	8	0.667	1200	0.345	27.622	0.724	0.579
WHSTARN	Standing dead	dead	5	0.417	370	0.106	2.632	0.069	0.197
WHSTARN	Ulmus rubra	mesic	7	0.583	1470	0.422	7.724	0.202	0.403
WHSTARN	Viburnum prunifolium	upland	1	0.083	10	0.003	0.011	0.000	0.029
WHSTARN	Zanthoxylum americanum	upland	3	0.250	300	0.086	0.013	0.000	0.112
WHSTARS1	Cornus amomum	sub full	1	0.083	230	0.697	0.005	0.011	0.264

Table 19. Stand table for focused and aggregated random plots with woody species >1m. Refer to Table 2 for site codes. f = wetland forest, ma = marsh, md = wet meadow, sh = shrub swamp, uf = upland forest, uth = upland thicket.

site	species	spec code	frequency	rel freq	density	rel den	dominance	rel dom	IV
WHSTARS1	Fraxinus pennslyvanica	wetland	2	0.167	50	0.152	0.008	0.018	0.112
WHSTARS1	Populus deltoides	mesic	2	0.167	50	0.152	0.417	0.972	0.430
WHSTARS2	Acer saccharinum	wetland	5	0.417	250	0.033	1.460	0.082	0.177
WHSTARS2	Cornus amomum	sub full	5	0.417	1080	0.141	0.136	0.008	0.189
WHSTARS2	Fraxinus pennsylvanica	wetland	7	0.583	1530	0.200	12.771	0.715	0.500
WHSTARS2	Juniperus virginiana	upland	1	0.083	10	0.001	0.002	0.000	0.028
WHSTARS2	Platanus occidentalis	mesic	1	0.083	10	0.001	0.241	0.013	0.033
WHSTARS2	Pyrus malus	adventive	6	0.500	580	0.076	0.820	0.046	0.207
WHSTARS2	Rosa setigera	sub full	2	0.167	320	0.042	0.006	0.000	0.070
WHSTARS2	Standing dead	dead	6	0.500	420	0.055	1.015	0.057	0.204
WHSTARS2	Ulmus rubra	mesic	6	0.500	450	0.059	1.236	0.069	0.209
WHSTARS2	Viburnum prunifolium	upland	3	0.250	320	0.042	0.078	0.004	0.099
WHSTARS2	Zanthoxylum americanum	upland	2	0.167	2670	0.349	0.099	0.006	0.174

Table 20. Summary of summer water depth measurements in center of random plots at bank subareas.

bank area	mean z (cm)	SE	st dev	median z (cm)	min	max	N
3 Eagles East Forest	13.7	11.9	35.7	0.0	0.0	108.0	9
3 Eagles NE Marsh	12.3	5.3	15.0	5.0	0.0	36.0	8
3 Eagles West Meadow	0.0	0.0	0.0	0.0	0.0	0.0	2
Big Island Area A	14.7	3.1	9.8	17.0	0.0	30.0	10
Big Island Area B	51.5	6.9	30.2	56.0	0.0	100.0	19
Big Island Area C	1.0	0.4	1.3	0.0	0.0	3.0	10
Big Island Area D	11.1	5.6	16.9	4.0	0.0	54.0	9
Cherry Valley Area 1	4.3	2.4	9.3	0.0	0.0	35.5	15
Cherry Valley Area 3	7.7	5.7	15.0	0.0	0.0	41.0	7
Chippewa Central	8.6	6.7	25.8	0.0	0.0	100.0	15
Grand Lowlands A-D	14.8	5.5	17.5	9.8	0.0	48.0	10
Grand Lowlands B-C	6.1	2.6	7.9	0.0	0.0	21.0	9
Grand Lowlands F	15.5	9.3	29.3	1.5	0.0	93.0	10
Hebron Large Cell	17.6	4.6	14.6	9.8	0.0	37.0	10
Hebron Small Cell	34.6	14.4	32.3	39.0	5.0	84.0	5
Little Scioto NE	38.5	6.3	20.1	35.0	12.0	79.0	10
Little Scioto NW	19.2	5.1	16.0	26.5	0.0	37.0	10
Panzner Field A	0.0	0.0	0.0	0.0	0.0	0.0	10
Panzner Field B	20.8	12.9	28.8	0.0	0.0	58.0	5
Panzner Field C	5.6	3.3	6.5	5.3	0.0	12.0	4
Panzner Field E	0.0	0.0	0.0	0.0	0.0	0.0	5
Sandy Ridge Area 1	48.0	7.9	25.1	47.5	23.0	110.0	10
Sandy Ridge Area 2	57.3	6.7	21.3	48.8	36.5	100.0	10
Sandy Ridge Area 3	23.4	9.5	30.1	19.8	0.0	100.0	10
Slate Run Center	24.1	4.6	14.7	19.5	9.0	56.0	10
Slate Run NW	35.2	12.6	39.8	19.0	3.0	126.0	10
Slate Run SE	17.7	5.0	8.7	20.0	8.0	25.0	3
Slate Run SW	45.7	10.7	33.9	40.0	3.0	100.0	10
Trumbull Berm 5	13.5	13.5	19.1	13.5	0.0	27.0	2
Trumbull Berm 7E	64.2	10.5	33.4	67.2	0.0	100.0	10
Trumbull Berm 7F	19.0	11.1	33.2	0.0	0.0	100.0	9
White Star North	2.3	2.3	5.1	0.0	0.0	11.5	5
White Star South	3.6	3.3	9.9	0.0	0.0	30.0	9

Table 21. Hydrological attributes of mitigation banks. Data from 2003-2004 and 2004-2005 except for Big Island Area D (2001-2002). The %time inundated refers to number of readings where water level was above the ground surface. The %time in the root zone refers to number of readings where water level was 0 to -30 cm. Differences in N reflect differences in deployment and retrieval dates, temporary datalogger failures, occasional missed readings due to extremely cold weather, etc. Data from well deployed in 2004 current as of January 21, 2005.

site name	year	N	flashiness index	%time inundated	% time root zone	%time below root zone	Mean depth (cm)	Median depth (cm)	25th percentile	75th percentile
Big Island Area A	2003-2004	947	1.656	56	32	12	-7.0	0.8	-3.6	2.8
Big Island Area B south	2003-2004	605	2.924	79	26	0	6.2	5.3	-0.6	10.7
Big Island Area B southwest	2003-2004	947	1.862	92	8	8	17.8	23.4	12.2	25.7
Big Island Area D	2001-2002	754	1.478	21	21	58	-41.0	-53.7	-74.9	-5.8
Cherrv Valley Area 1 Marsh	2004-2005	400	1.027	69	31	0	0.8	2.0	-1.0	3.8
Cherry Valley Area 1 Meadow	2004-2005	381	2.521	31	40	27	-15.2	-4.8	-36.4	1.0
Cherry Valley Area 3	2004-2005	380	1.376	55	44	1	-1.1	-1.3	-4.1	3.3
Chippewa Central North Well	2004-2005	397	2.914	8	31	61	-31.6	-34.5	-49.2	-18.3
Chippewa Central South Well	2004-2005	378	2.407	7	83	10	-15.5	-16.3	-24.9	-8.4
Grand River Lowlands Area A-D	2004-2005	392	2.159	33	26	41	-21.4	-11.4	-51.0	4.1
Grand River Lowlands Area B-C	2004-2005	396	2.319	38	26	36	-15.7	-16.8	-36.9	3.6
Grand River Lowlands Area F	2004-2005	40.	2.672	42	54	4	-5.7	-1.8	-11.4	2.3
Hebron Large Cell	2003-2004	542	1.437	64	30	6	5.3	8.6	-6.4	21.3
Hebron Small Cell	2003-2004	1005	2.450	58	38	4	-2.6	1.8	-7.1	5.6
Little Scioto NW	2003-2004	900	1.927	51	49	0	2.9	0.5	-4.8	12.7
Little Scioto South	2003-2004	947	1.881	68	24	7	3.3	5.7	-2.9	14.6
Panzner Field A Center	2004-2005	429	2.296	8	54	38	-24.5	-22.6	-37.8	-11.2
Panzner Field A East	2004-2005	430	2.369	3	71	26	-20.3	-17.1	-31.0	-9.2
Panzner Field B West	2004-2005	232	0.739	91*	9	0	2.5	2.8	1.8	3.8
Panzner Field B East	2004-2005	253	1.048	0	100	0	-7.1	-6.6	-8.9	-5.6
Panzner Field C	2004-2005	397	2.239	2	98	0	-16.1	-16.6	-22.7	-10.5
Panzner Field E West	2004-2005	390	2.453	15*	46	39	-24.6	-21.3	-44.7	-3.8
Panzner Field E Center	2004-2005	358	1.646	0	55	45	-29.7	-28.6	-38.9	-19.7
Sandy Ridge Area 1	2003-2004	892	0.776	88	12	0	2.8	3.0	1.3	5.1
Sandy Ridge Area 3	2003-2004	909	1.377	40	48	12	-8.4	-0.8	-5.1	1.4
Slate Run Northwest	2003-2004	970	1.563	41	59	0	-2.7	-1.3	-6.1	1.8
Slate Run Center	2003-2004	998	1.961	68	32	6	-0.5	2.4	-3.2	5.2

Table 23 cont.

site name	year	N	flashiness index	%time inundated	% time root zone	%time below root zone	Mean depth (cm)	Median depth (cm)	25th percentile	75th percentile
Slate Run Southwest	2003-2004	914	1.694	53	25	22	-8.2	0.5	-17.5	4.1
Slate Run Southeast	2003-2004	1005	0.929	37	47	16	-9.8	-1.3	-8.9	1.5
Three Eagles Northeast Marsh	2003-2004	667	1.567	12	88	0	-8.5	-9.7	-11.4	-2.5
Three Eagles West Meadow	2003-2004	541	3.690	7	65	28	-21.6	-21.8	-32.4	-6.8
Three Eagles East Forest	2003-2004	917	1.677	4	73	23	-17.9	-15.5	-28.8	-8.5
Trumbull Creek Berm 5	2004-2005	297	0.808	98	2	0	8.2	8.4	5.3	10.4
Trumbull Creek Berm 7E	2004-2005	379	2.153	16	38	46	-19.6	-26.3	-35.9	-5.0
Trumbull Creek Berm 7F	2004-2005	308	1.955	26	46	28	-16.2	-19.7	-31.8	2.9
White Star North Forest	2004-2005	397	0.484	0	13	87	-36.9	-39.4	-40.4	-38.4
White Star South Forest	2004-2005	389	0.882	4	20	76	-37.5	-45.5	-47.0	-32.2
White Star South Marsh	2004-2005	403	2.530	5	26	69	-38.8	-49.3	-53.8	-27.2

*** Water level above ground surface at these wells is ground water being pushed up well casing above ground surface.**

Table 22. Median (25th - 75th percentiles) soil values for selected parameters from random plots.

site	subarea	%N	pH	%C	%OM	P Bray 1 ppm	P Bray 2 ppm	K ppm	Mg ppm	Ca ppm
3 Eagles	3EEF	0.26 (0.20-0.32)	7.7 (7.4-8.0)	3.1 (2.4-3.5)	4.0 (2.9-5.0)	4 (3.5-7.0)	9 (7-9.0)	116 (84-141)	277 (161-428)	2970 (2952-3110)
3 Eagles	3ENM	0.20 (0.15-0.30)	6.7 (6.3-6.9)	2.1 (1.5-3.1)	3.2 (2.5-4.6)	8 (6.0-23.0)	44 (26-58)	114 (69-154)	342 (274-432)	2162 (1937-3093)
3 Eagles	3EWM	0.26	7.1	2.6	4.0	4	21	140	439	3062
Big Island	BGA	0.22 (0.20-0.23)	6.3 (6.0-6.4)	2.0 (1.9-2.2)	2.9 (2.6-3.0)	5 (4.8-6.3)	33.5 (29-38)	130 (122-154)	396 (333-439)	1948 (1820-2042)
Big Island	BGB	0.24 (0.21-0.26)	6.5 (6.4-6.9)	2.4 (2.1-2.5)	3.0 (2.6-3.3)	5 (4-7)	38 (32-41)	119 (104-122)	372 (319-410)	2153 (1939-2436)
Big Island	BGC	0.24 (0.22-0.30)	6.0 (6.0-6.3)	2.5 (2.2-3.2)	3.2 (3.0-3.8)	4.5 (3.0-5.5)	29 (22-38)	95 (75-112)	323 (238-429)	1840 (1364-2056)
Big Island	BGD	0.20 (0.19-0.22)	6.8 (6.7-6.9)	1.9 (1.85-2.1)	2.9 (2.6-3.2)	6 (4..3-8.5)	34 (31-40)	75 (67-87)	325 (303-376)	1942 (1819-2121)
Cherry Valley	C1V	0.13 (0.12-0.17)	5.8 (5.5-6.2)	1.4 (1.2-1.7)	2.0 (1.8-2.2)	14 (5-18)	42 (14-75)	52 (33-72)	276 (223-316)	1189 (997-1454)
Cherry Valley	C3V	0.17 (0.15-0.21)	6.0 (5.6-6.0)	1.8 (1.5-2.1)	2.5 (2.4-2.8)	11 (5-17)	28 (10-53)	36 (31-54)	214 (197-253)	1025 (990-1099)
Chippewa	CHIP	0.47 (0.38-0.67)	5.6 (5.4-5.9)	5.5 (4.4-8.0)	6.4 (5.6-7.2)	8 (5-12)	24 (16-34)	89 (60-113)	271 (199-344)	1835 (1533-2328)
GR Lowlands	GRAD	0.15 (0.14-0.18)	5.7 (5.4-6.6)	1.5 (1.2-1.7)	1.6 (1.3-1.8)	6.5 (4.8-7.0)	35 (20-47)	70 (60-119)	189 (129-223)	737 (457-900)
GR Lowlands	GRBC	0.20 (0.17-0.23)	5.3 (5.1-6.0)	2.0 (1.7-2.2)	2.1 (1.6-2.9)	11 (7-14)	46 (27-59)	64 (57-119)	173 (115-247)	690 (474-971)
GR Lowlands	GRF	0.16 (0.16-0.20)	5.1 (5.0-5.2)	1.9 (1.6-2.2)	2.1 (1.7-2.3)	3 (2.5-4.5)	10 (6-17)	62 (48-73)	123 (114-182)	346 (269-411)
Hebron	HBL	0.27 (0.24-0.32)	6.4 (6.2-6.7)	3.2 (2.7-3.6)	3.5 (3.1-3.6)	5.5 (4-8)	14 (10-19)	61 (41-92)	401 (371-492)	2074 (1912-2270)
Hebron	HBS	0.20 (0.13-0.23)	6.2 (6.0-6.3)	2.1 (1.5-2.6)	2.5 (2.0-3.0)	6 (2-10)	15 (8-26)	44 (29-103)	242 (217-307)	1423 (1167-1511
Little Scioto	LSNE	0.22 (0.22-0.25)	7.1 (6.9-7.3)	2.5 (2.3-2.9)	2.9 (2.6-3.3)	7 (6-9)	30 (21-36)	89 (69-101)	532 (487-599)	2734 (2550-3118)
Little Scioto	LSNW	0.26 (0.25-0.30)	6.7 (6.4-6.7)	2.7 (2.7-3.3)	3.4 (3.0-3.7)	8 (5-8.3)	33 (22-34)	100 (88-110)	560 (533-614)	3224 (2833-3349)
Panzner	PANZA	2.71 (2.5-2.8)	6.0 (5.7-6.1)	39.2 (37.5-39.8)	16.3 (13.9-17.7)	71.5 (57-83)	157 (116-167)	64 (56-110)	406 (319-463)	3891 (3180-4515)
Panzner	PANZB	2.20	6.0 (5.4-6.1)	41.0	14.7 (10.4-15.5)	10 (1-49)	50 (24-52)	24 (21-38)	249 (162-273)	3026 (2422-4049)
Panzner	PANZC	2.65 (2.5-2.9)	6.2 (6.0-6.2)	42.5 (38.9-44.9)	8.8 (7.7-10.1)	11 (10.3-12.5)	16 (14-16)	27 (16-32)	168 (150-215)	1865 (1561-2254)
Panzner	PANZE	2.12 (1.8-2.6)	5.7 (5.6-5.9)	34.6 (31.2-43.3)	11.4 (8.2-13.1)	17 (11-23)	26 (14-52)	15 (14-37)	238 (169-316)	2478 (1926-2813)
Sandy Ridge	SR1A	0.18 (0.16-0.22)	5.7 (5.6-5.9)	1.6 (1.5-2.0)	1.8 (1.6-2.2)	4 (3.5-5.0)	28 (17-48)	77 (67-92)	148 (134-160)	995 (790-1131)
Sandy Ridge	SR2A	0.15 (0.14-0.17)	5.9 (5.7-6.0)	1.3 (1.2-1.4)	1.5 (1.3-1.6)	3 (2.0-4.8)	31 (23-55)	66 (58-76)	147 (142-160)	964 (920-989)
Sandy Ridge	SR3A	0.16 (0.13-0.17)	5.7 (5.5-6.2)	1.4 (1.1-1.6)	1.7 (1.4-1.8)	2.5 (2-3)	15 (12-17)	69 (65-84)	191 (181-232)	1288 (1110-1373)
Slate Run	SRC	0.11 (0.09-0.15)	6.5 (6.1-7.4)	1.4 (1.1-1.8)	1.4 (1.3-2.2)	7 (4.5-7.5)	16 (11-19)	59 (48-102)	298 (249-372)	1824 (1470-2002)
Slate Run	SRNW	0.10 (0.08-0.17)	6.5 (6.1-7.0)	1.1 (0.95-1.9)	1.3 (1.2-2.4)	5 (3.5-9.0)	11 (9-19)	72 (48-94)	283 (181-299)	1429 (1182-1814)
Slate Run	SRSE	0.12 (0.116-0.14)	6.7 (6.2-6.8)	1.3 (1.2-1.5)	1.6 (1.4-1.7)	5 (4-7)	10 (7-12)	100 (85-107)	288 (233-476)	1549 (1211-1583)
Slate Run	SRSW	0.15 (0.12-0.17)	6.6 (6.4-7.1)	1.7 (1.5-2.0)	2.1 (1.6-2.4)	3.5 (2.0-8.5)	17 (9-22)	99 (89-122)	298 (248-434)	1886 (1442-2188)
Trumbull	TRB5	0.23	6.0	2.4	2.5	3	14	72	133	868
Trumbull	TRB7E	0.16 (0.11-0.19)	5.3 (5.1-5.8)	1.7 (1.3-2.1)	1.7 (1.5-2.3)	6 (1-7)	10 (4-13)	64 (61-68)	149 (96-176)	792 (536-993)
Trumbull	TRB7F	0.22 (0.16-0.23)	4.8 (4.7-5.0)	2.6 (1.9-2.8)	3.0 (2.4-3.2)	4 (2-5)	8 (6-11)	72 (72-96)	101 (87-178)	494 (410-894)
Wh. Star	WSN	0.39 (0.34-0.45)	7.2 (6.6-7.6)	4.9 (4.3-5.6)	6.1 (4.9-7.1)	4 (3-11)	56 (39-88)	53 (48-63)	530 (510-649)	3287 (2955-3320)
Wh. Star	WSS	0.30 (0.23-0.33)	7.4 (7.3-7.6)	4.1 (3.7-4.5)	5.4(4.4-6.2)	5 (4-6)	50 (31-57)	54 (47-81)	565 (438-619)	2628 (2402-3063)

Table 23. Median, 25th and 75th percentile of soil parameters of natural marshes previously studied by Ohio EPA (Fennessy et al. 2004). N=45 samples from 10 sites.

parameter	median	25th	75th
%C	9.30	5.7	19.5
%OM	6.7	5.2	8.7
%N	0.67	0.50	1.38
P Bray 1	19	7.0	17.0
P Bray 2	40	21.5	59.5
K ppm	72	46.5	116.5
Mg ppm	312	231.5	429.5
Ca ppm	1864	1522	2469
pH	5.5	5.0	6.0

Table 24. Summary of overall ecological performance of Ohio mitigation banks.

site	% wetland (meets 3 parameters) low=0 med, high=1	natural hydroperiods yes=1 no=0	%open water low, med=1 high=0	%perennial native hydrophytes low=0 med,high=1	%invasive plant species low=1 high=0	mean VIBI score 40-60 yes=1 no=0	score	overall performance
Big Island	Medium	Yes - A, C, D No - B	Low - A, C, D High - B	High - A, C, D Low - B	Low	Yes	6/6 - A, C, D 1/6 -B	partially successful[1]
Cherry Valley	High	Yes	Low	Medium	Low	Yes	6/6	mostly successful
Chippewa	High	Yes	Low	High	High	No	4/6	not successful[2]
Grand R Lowlands	Medium	No	Medium	Low	Low	No	3/6	partially successful[3]
Hebron	Medium	No	Medium	High	High	No	3/6	partially successful[4]
Little Scioto	Low	Yes - NW, NE No - LS3	High	High	Low	No	3/6	partially successful[5]
Panzner	High	Yes	Low	High	Low	Yes	6/6	mostly successful
Sandy Ridge	Low	No	High	Low - 1, 2 High - 3	High	No	1/6	mostly not successful[6]
Slate Run	Medium	No	Medium	Medium	High	No	3/6	partially successful
Three Eagles	Low	No	Medium	Low	High	No	1/6	mostly not successful
Trumbull Cr	Low	No	High	High	Low	Yes	2/6	mostly not successful
White Star	High	Yes	Low	Medium	Low	Yes	6/6	mostly successful

1. Area B of Big Island is nearly half the bank site and is shallow, unvegetated water except at the margins.
2. Chippewa is an "enhancement" bank that was already wetland. The main performance goal was reduction in cover of reed canary grass and enhancement activities have mostly not resulted in a substantial reduction of reed canary grass cover.
3. The bank does exhibit a significant flood storage service.
4. The bank is well vegetated in areas where permanent shallow inundation is not maintained.

Figure 1. Location of Ohio bank sites.

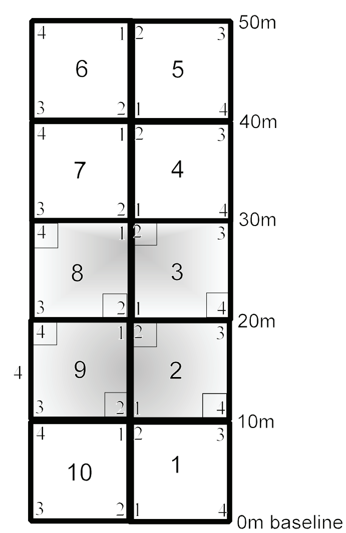

Figure 2. Standard (focused) 20m x 50m (2 x 5) vegetation sample plot. Standard intensive modules (2, 3, 8, 9) are shaded. Standard corners for nested quadrats (2, 4) are indicated by small squares. Modules are number in the direction of movement (down 1-5, back 6-10) along the center line; module corners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

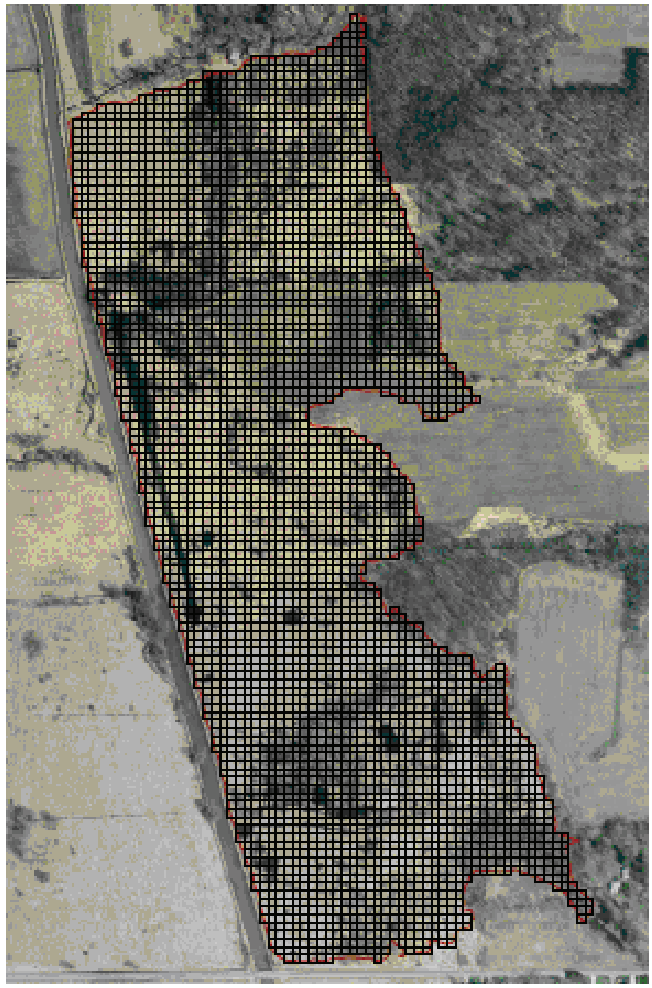

Figure 3. 10m x 10m geospatial grid of wetland restoration Chippewa Central Mitigation Bank.

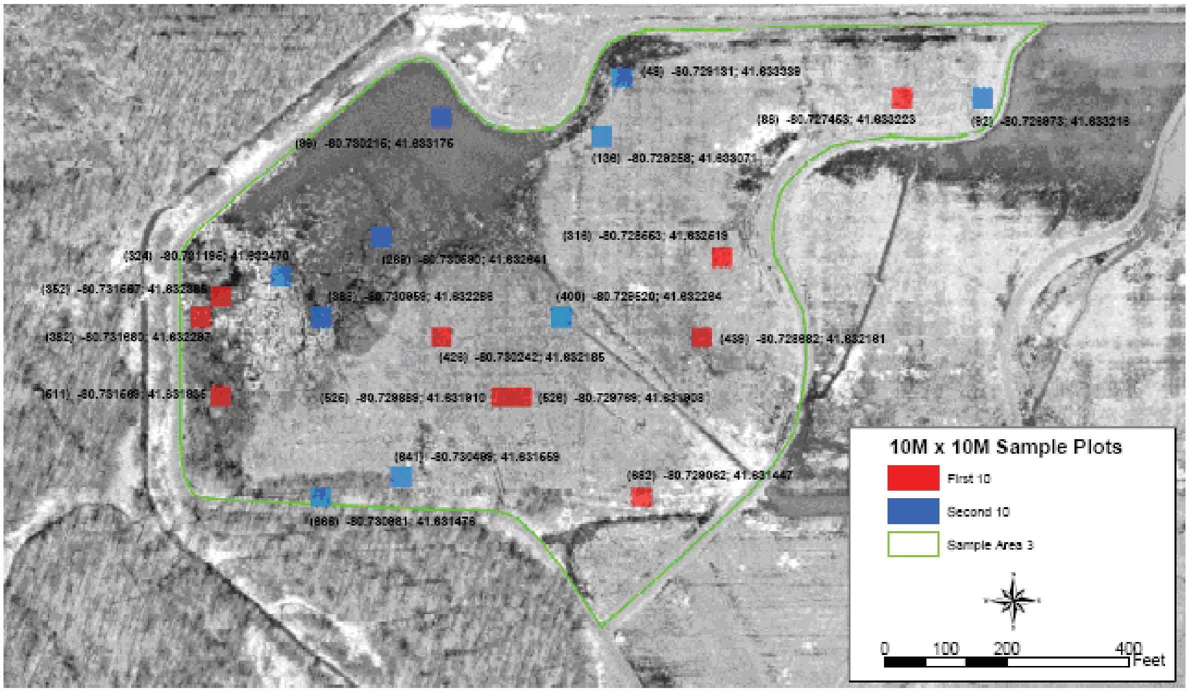

Figure 4. Random Plots at Cherry Valley Bank Area 3.

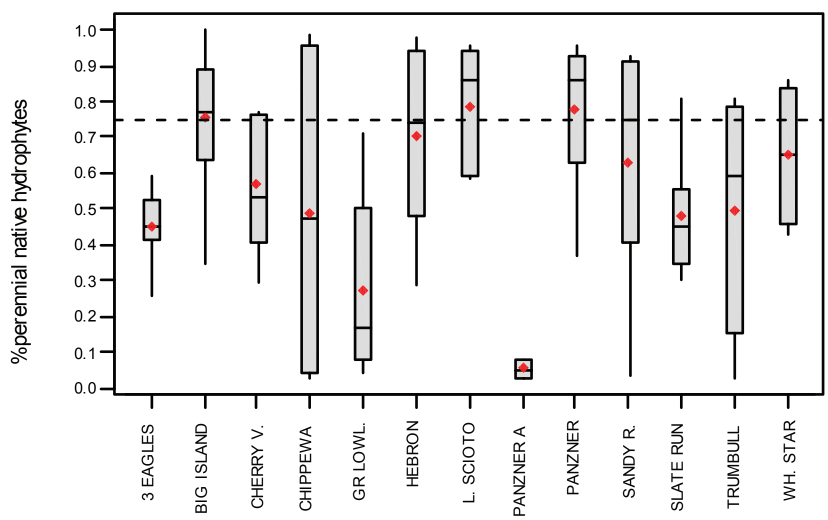

Figure 5. Relative cover of perennial native hydrophytes at Ohio mitigation banks from focused and aggregated random plots. Panzner Field A in year 1 post hydrologic restoration and prior to planting. dot = mean, bar = median, box = 25th and 75th percentiles.

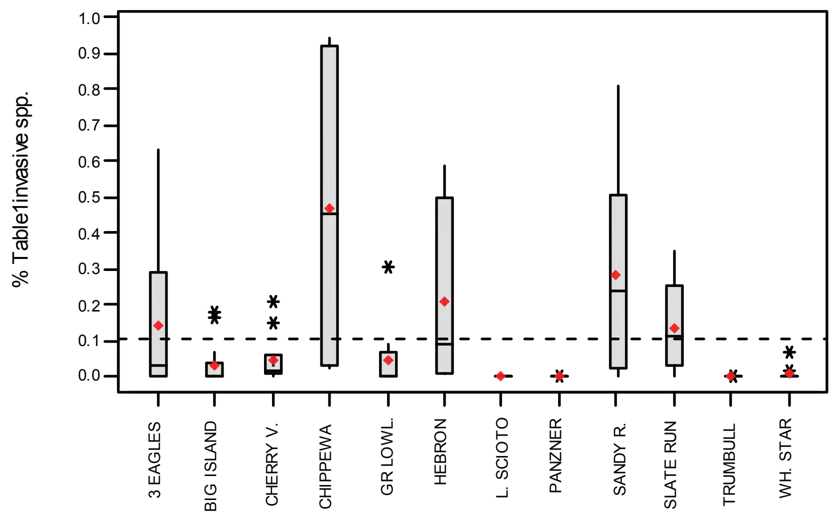

Figure 6. Relative cover of invasive species from Table 1 of ORAM v. 5.0 (*Lythrum salicaria, Myriophyllum spicatum, Najas minor, Phalaris arundinacea, Phragmites, australis, Potamogeton crispus, Ranunculus ficaria, Rhamnus frangula, Typha angustifolia, T.* xglauca) at Ohio mitigation banks from focused and aggregated random plots. dot = mean, bar = median, box = 25th and 75th percentiles.

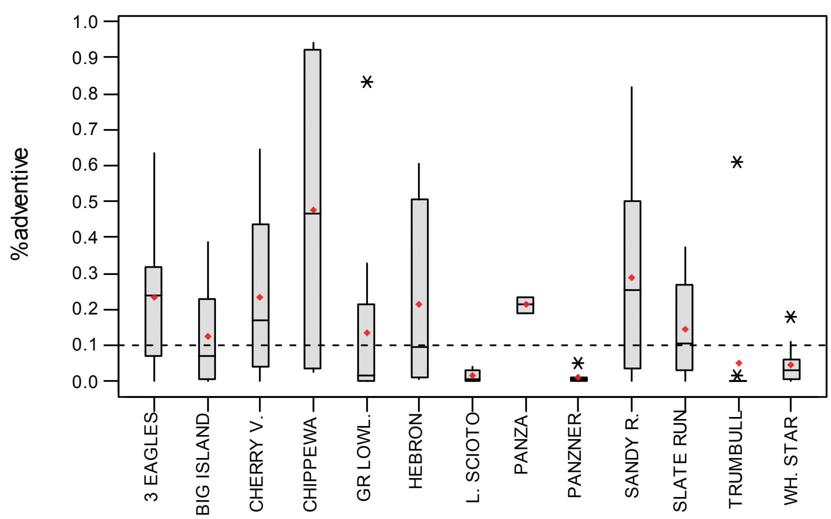

Figure 7. Relative cover of adventive species (nonnative spp., *Phalaris arundinacea, Phragmites, australis*) at Ohio mitigation banks from focused and aggregated random plots. dot = mean, bar = median, box = 25th and 75th percentiles.

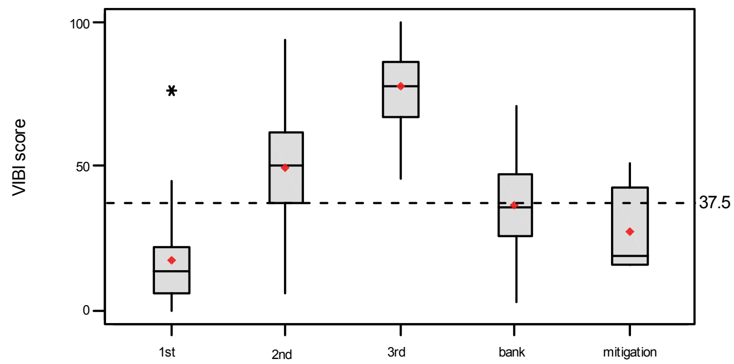

Figure 8. Vegetation IBI scores by Ohio Rapid Assessment Method (ORAM) score tertiles for natural reference wetlands, mitigation banks (bank) and individual mitigation sites (mitigation). 1st tertile = 0 to 33 (low quality), 2nd tertile = 34-65 (good quality), 3rd tertile = >65 (high quality. Scores from mitigation banks not significantly different from individual mitigations but are significantly different from 1st, 2nd and 3rd tertiles (df = 267, F = 100.7, $p < 0.001$). Line = 37.5 which is bottom of 25th percentile of 2nd tertile and would be lowest arguable point of regulatory compliance with requirement that compensatory mitigation be Category 2 or higher in quality under Ohio's Wetland Water Quality Standards (OAC Rule 3745-1-54).

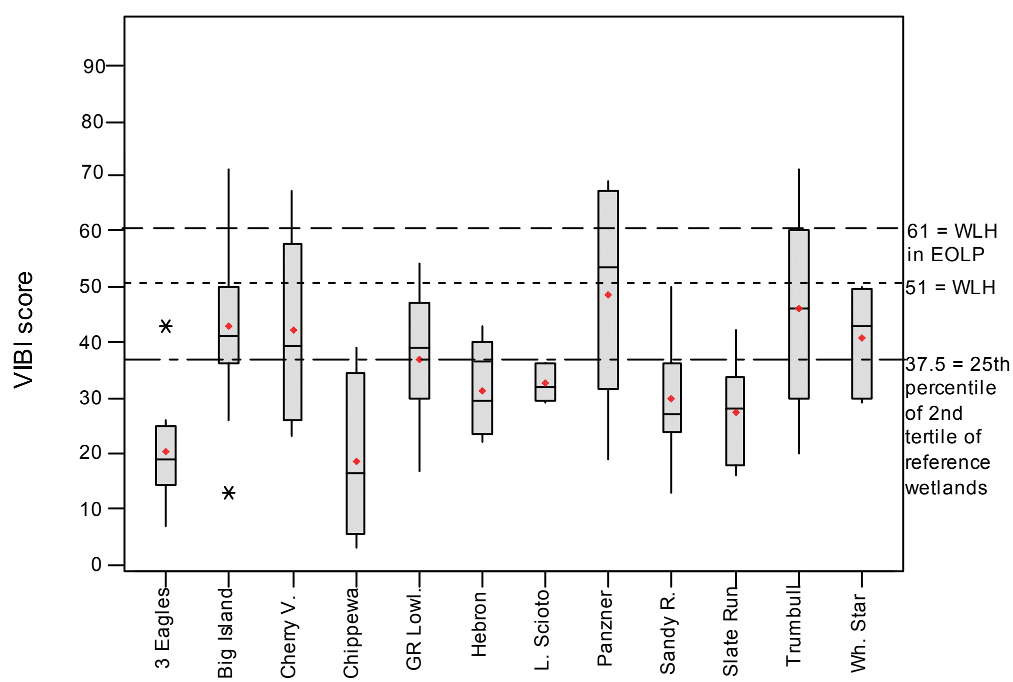

Figure 9. Vegetation IBI scores from focused and aggregated random plots at each bank site. Mean is dot, median is line, box is 25th and 75th percentile. WLH = Wetland Habitat tiered aquatic life use category, EOLP = Erie-Ontario Lake Plains Ecoregion. The threshold for WLH is higher in the EOLP ecoregion.

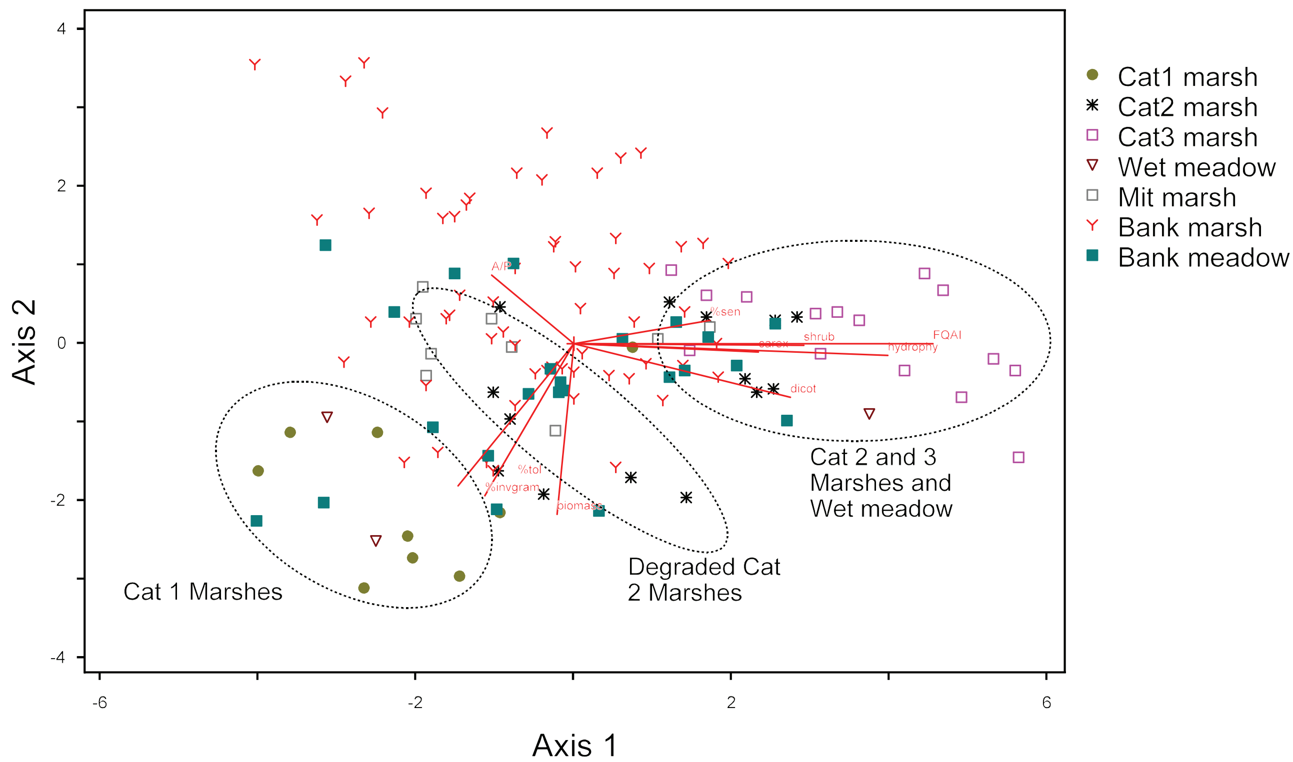

Figure 10. Axes 1 and 2 of Principal Components Analysis of VIBI-E metrics for emergent plots. Percent of variance explained by first three axes is 40.1, 15.6, and 11.8 respectively. Cat1, Cat2, and Cat3 marshes are Category 1, 2, and 3 wetlands, respectively, under Ohio's Wetland Water Quality Standards (OAC Rule 3745-1-54). Fens, Oak Openings Sand Prairies, and Lake Erie coastal marshes excluded from natural reference wetland data set for equivalence of comparisons.

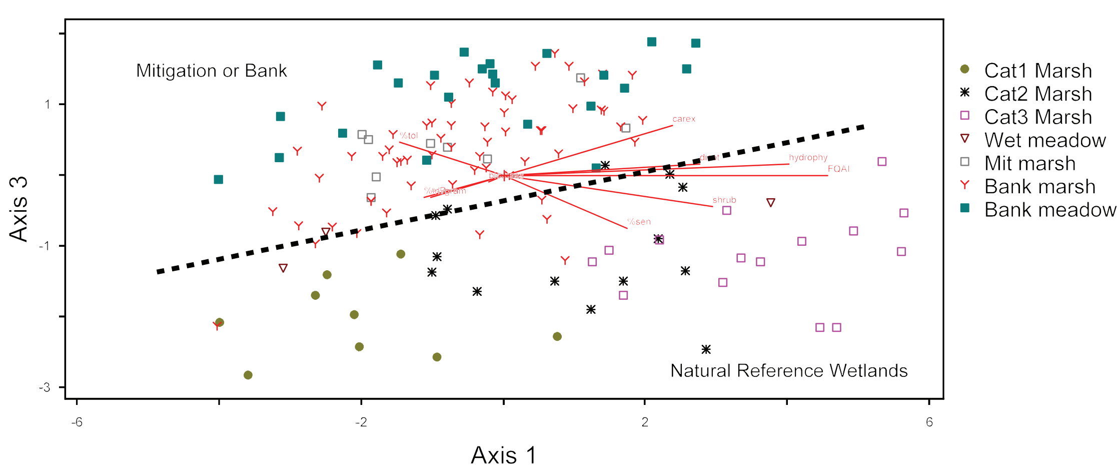

Figure 11. Axes 1 and 3 of Principal Components Analysis of VIBI-E metrics for emergent plots. Percent of variance explained by first three axes is 40.1, 15.6, and 11.8 respectively. Cat1, Cat2, and Cat3 marshes are Category 1, 2, and 3 wetlands, respectively, under Ohio's Wetland Water Quality Standards (OAC Rule 3745-1-54). Fens, Oak Openings Sand Prairies, and Lake Erie coastal marshes excluded from natural reference wetland data set.

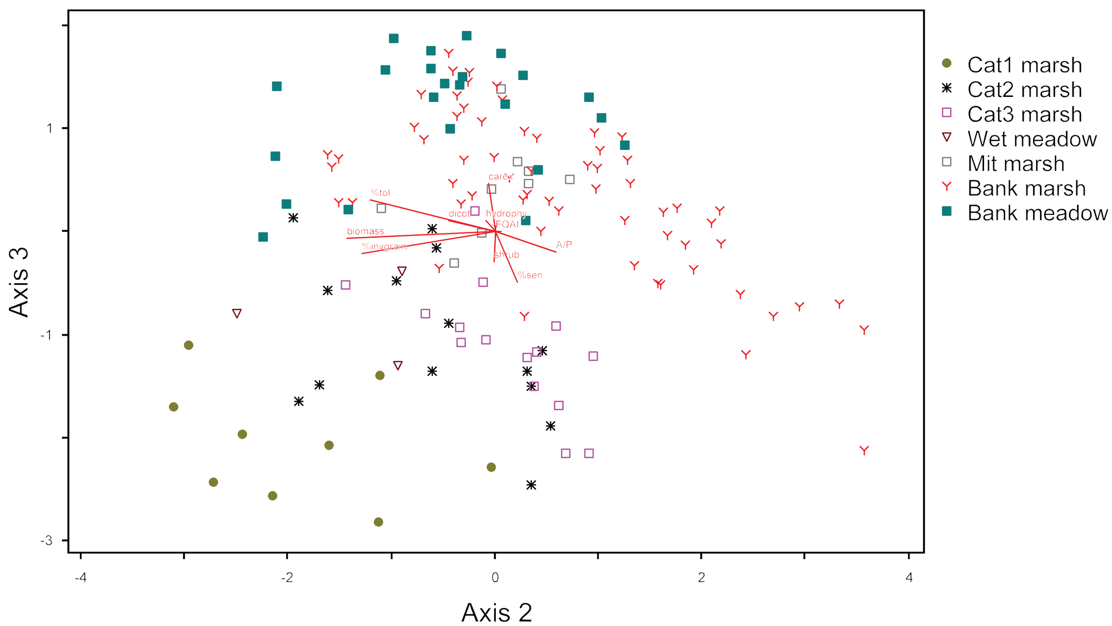

Figure 12. Axes 2 and 3 of Principal Components Analysis of VIBI-E metrics for emergent plots. Percent of variance explained by first three axes is 40.1, 15.6, and 11.8 respectively. Cat1, Cat2, and Cat3 marshes are Category 1, 2, and 3 wetlands, respectively, under Ohio's Wetland Water Quality Standards (OAC Rule 3745-1-54). Fens, Oak Openings Sand Prairies, and Lake Erie coastal marshes excluded from natural reference wetland data set.

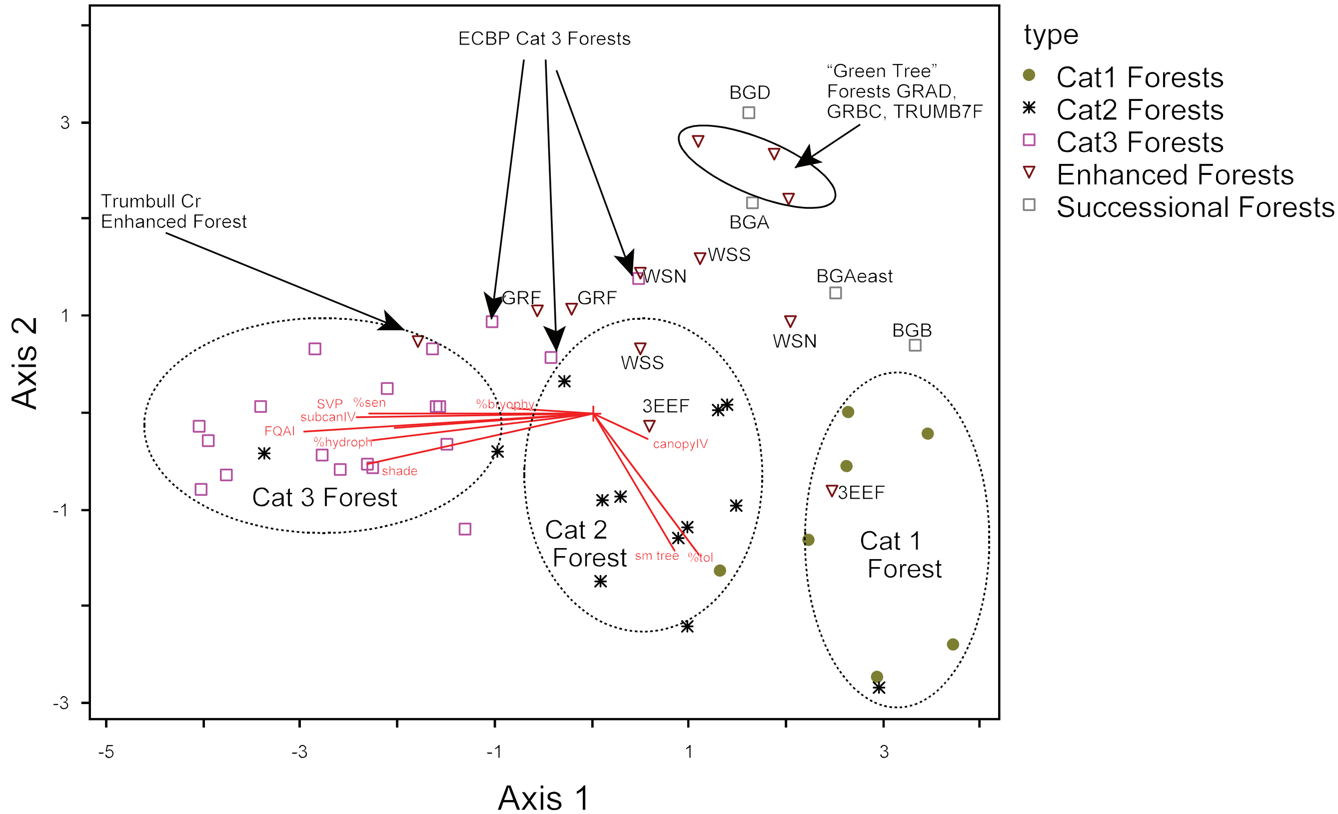

Figure 13. Principal Components Analysis of VIBI-F metrics for forest plots. Percent of variance explained by first three axes is 42.5, 15.5, and 8.8 respectively. Cat1, Cat2, and Cat3 marshes are Category 1, 2, and 3 wetlands, respectively, under Ohio's Wetland Water Quality Standards (OAC Rule 3745-1-54). Bogs and Lake Erie coastal forests excluded from natural reference wetland data set.

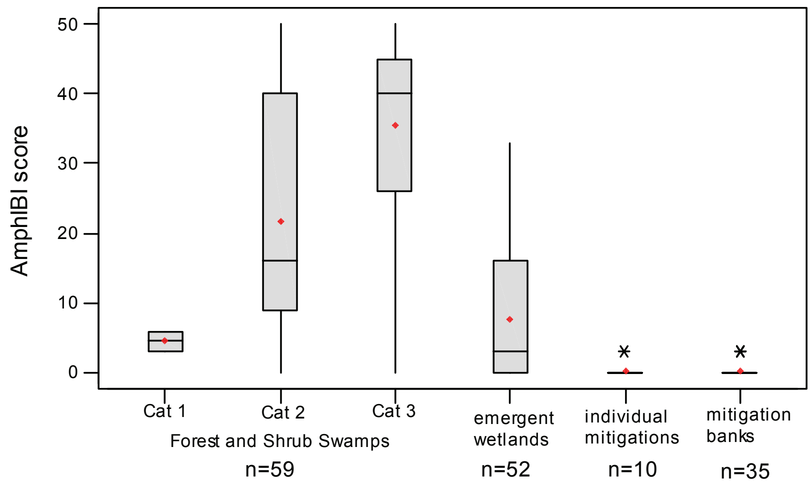

Figure 14. Box plots showing AmphIBI scores and category assignments for natural forested and shrub wetlands, emergent wetlands, and individual and mitigation bank wetlands. Means are indicated by solid circles. Cat 1, Cat 2 and Cat 3 refer to Category 1, 2 or 3 wetlands under OAC Rule 3745-1-54. A line is drawn across the box at the median. The bottom of the box is the first quartile (25%) and the top of the box is the third quartile (75%). All means significantly different (p <0.05) except for Category 1 Forested/Shrub wetlands and Emergent wetlands, and Individual Mitigations and Mitigation Banks.

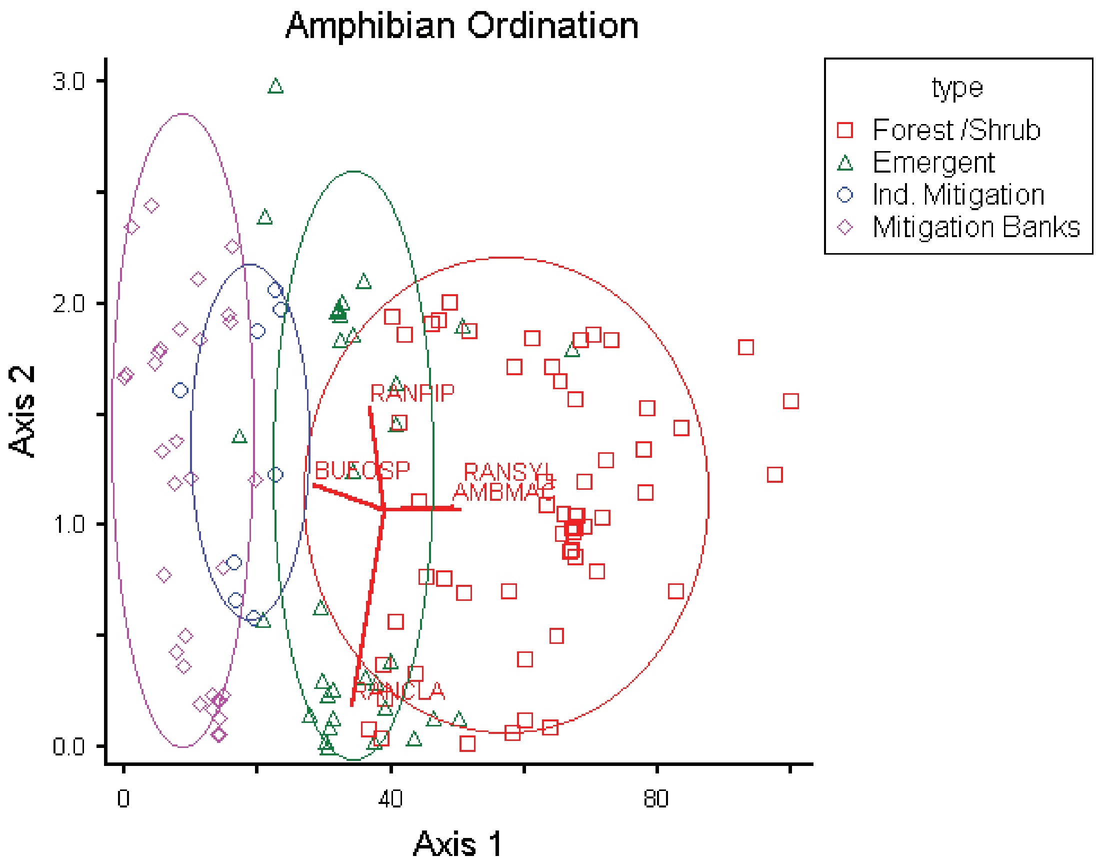

Figure 15. Principal components analysis (PCA) of amphibian community data for natural wetlands, individual mitigation wetlands, and mitigation bank sites. Percent of variance explained by first three axes: Axis 1 (14.4%), Axis 2 (10.4%), Axis 3 (8.9%).

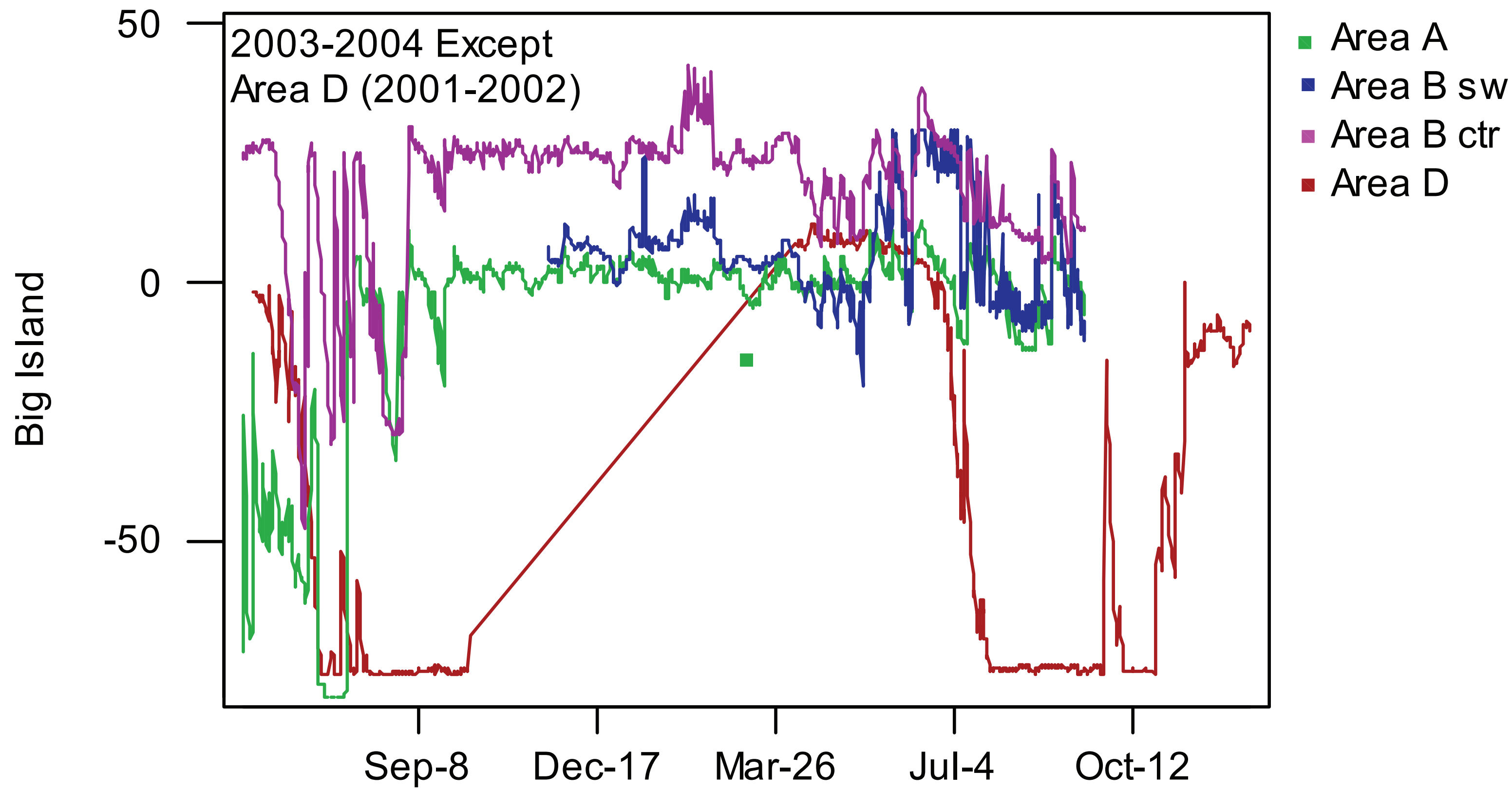

Figure 16. Hydrographs for wells installed in Big Island Areas A, B (south center and southwest), and D. Straight line in Area D well hydrographs reflects lost data due to a defective well. Also, Area D data collected in 2001-2002 but is plotted against the same days of the year as the other hydrographs where data was collected in 2003-2004. The Area D hydrograph is characteristic of the hydrology observed in Area D in 2003-2004 (Mack, personal observation).

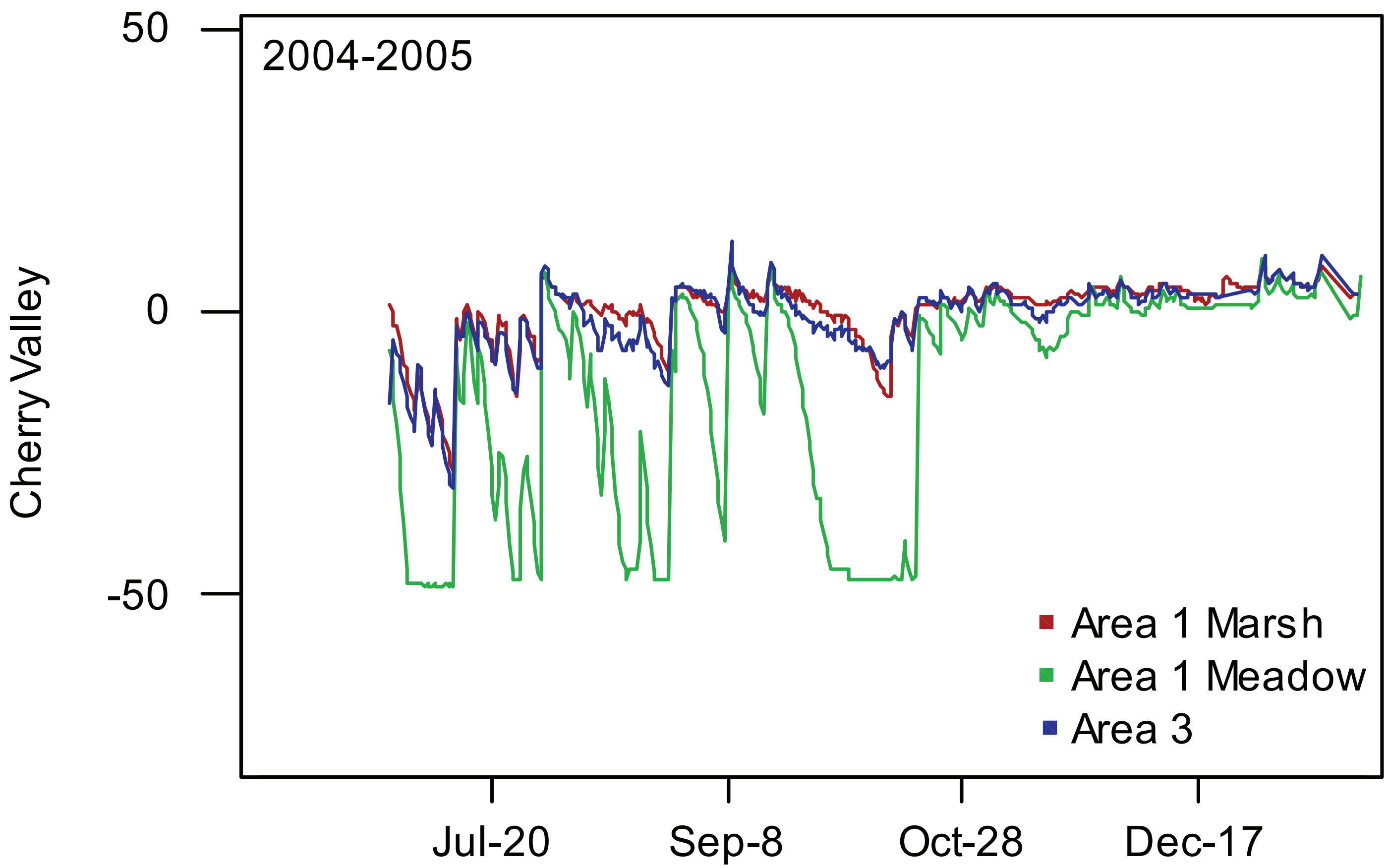

Figure 17. Hydrographs for wells installed in Areas 1 and 3 of Cherry Valley Bank.

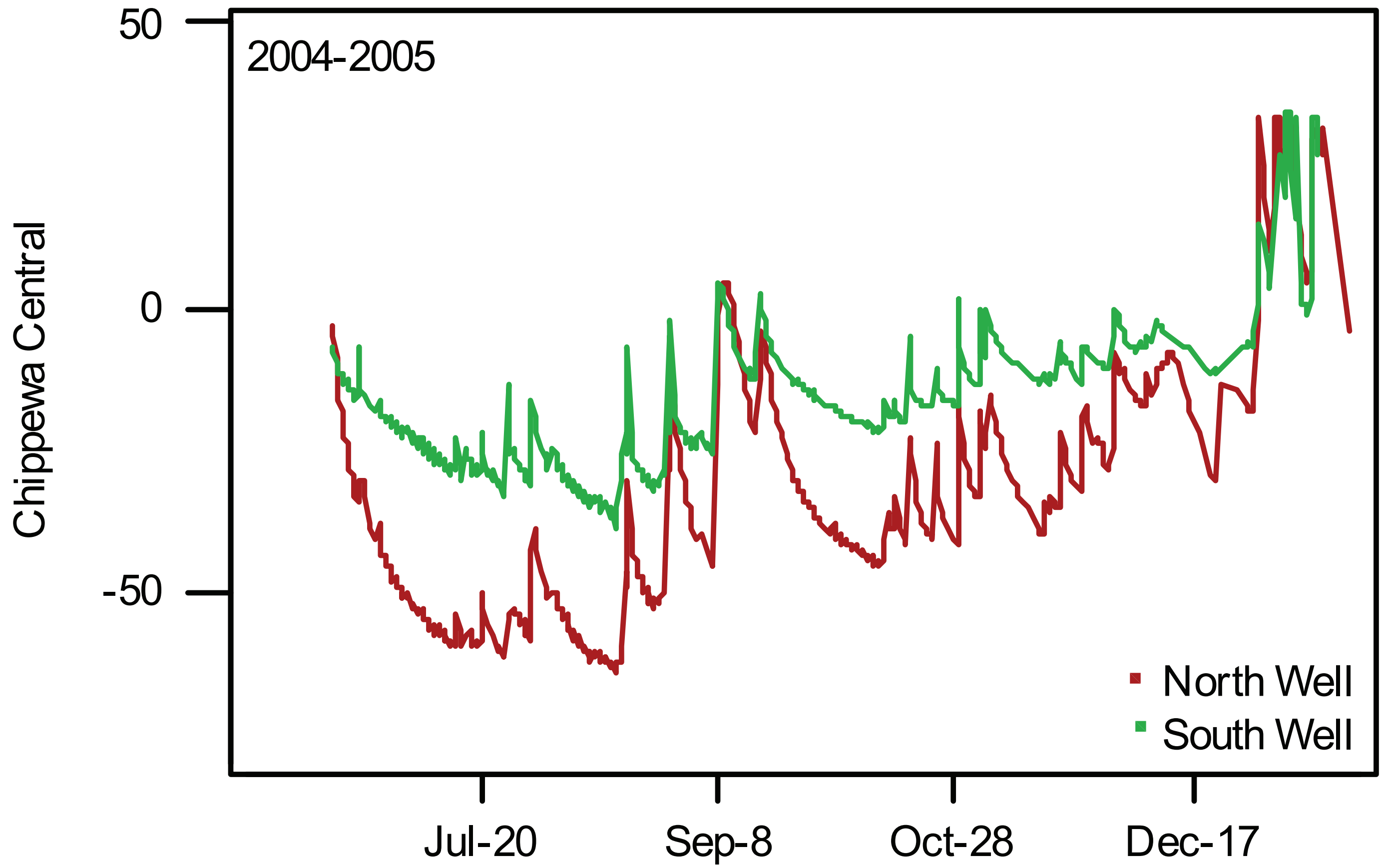

Figure 18. Hydrographs for Chippewa Central bank.

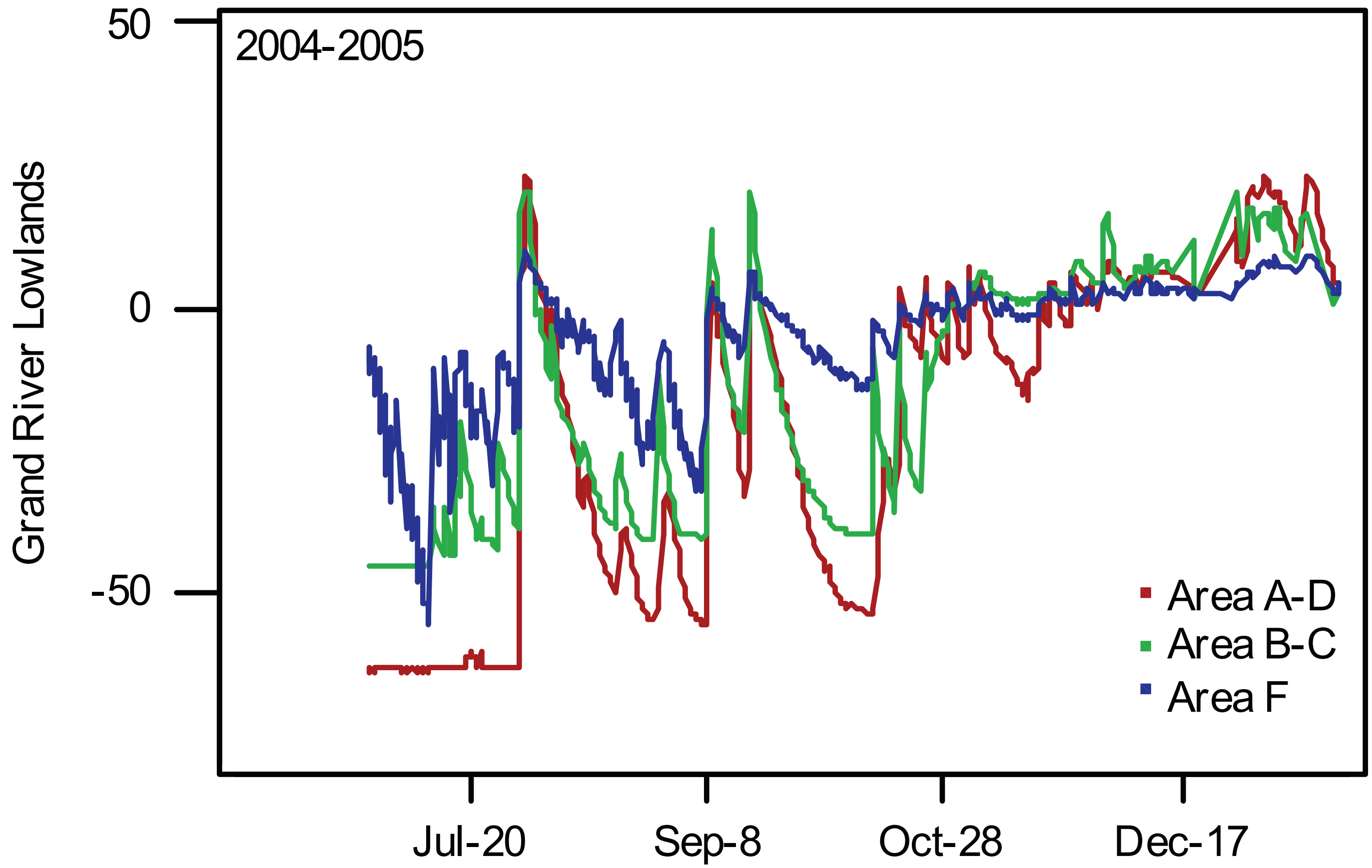

Figure 19. Hydrographs from wells installed in Areas A-D, B-C and F of Grand River Lowlands Bank.

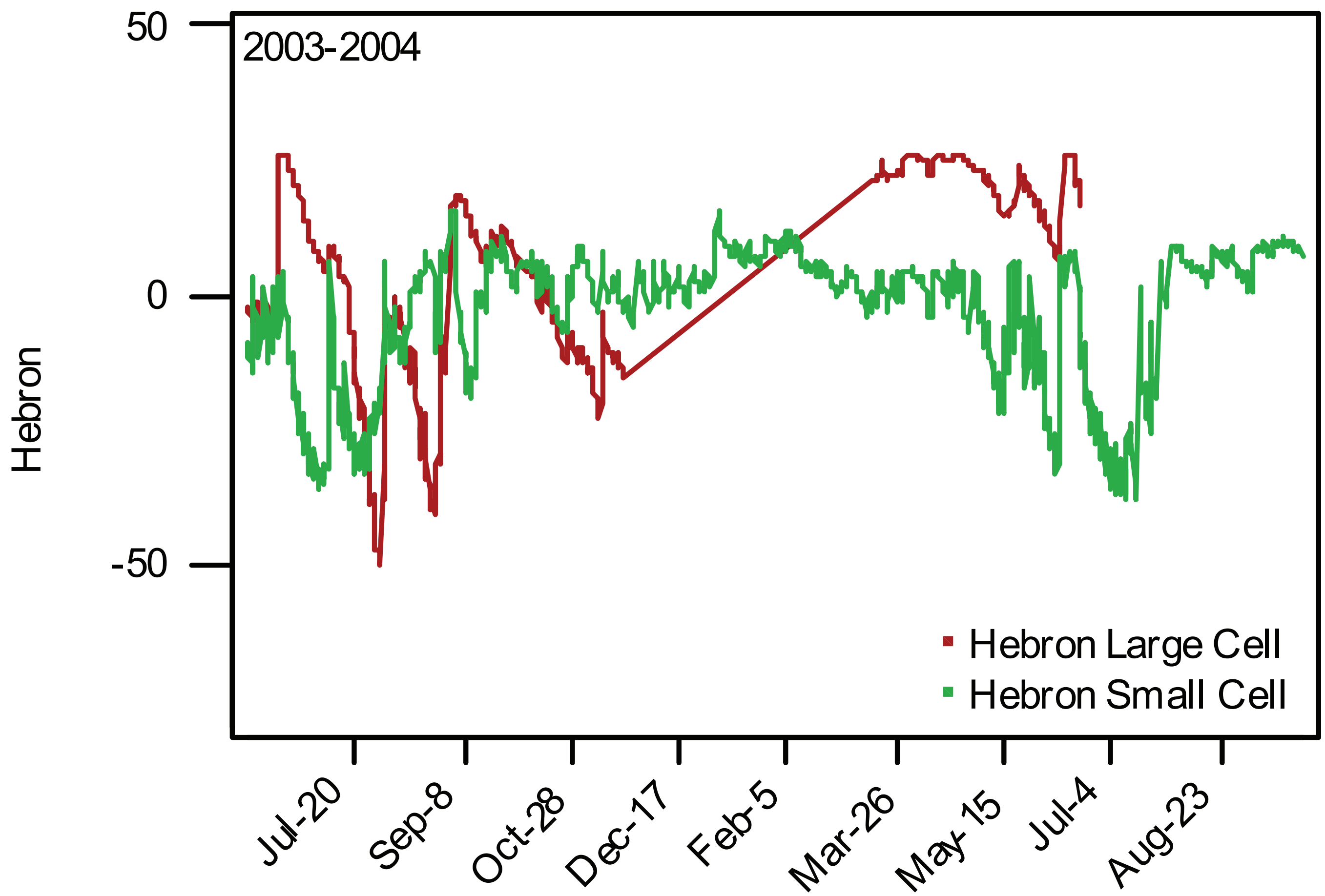

Figure 20. Hydrographs from wells installed at Hebron Bank Large and Small Cells. Straight line at Hebron Large Cell reflects period of well failure.

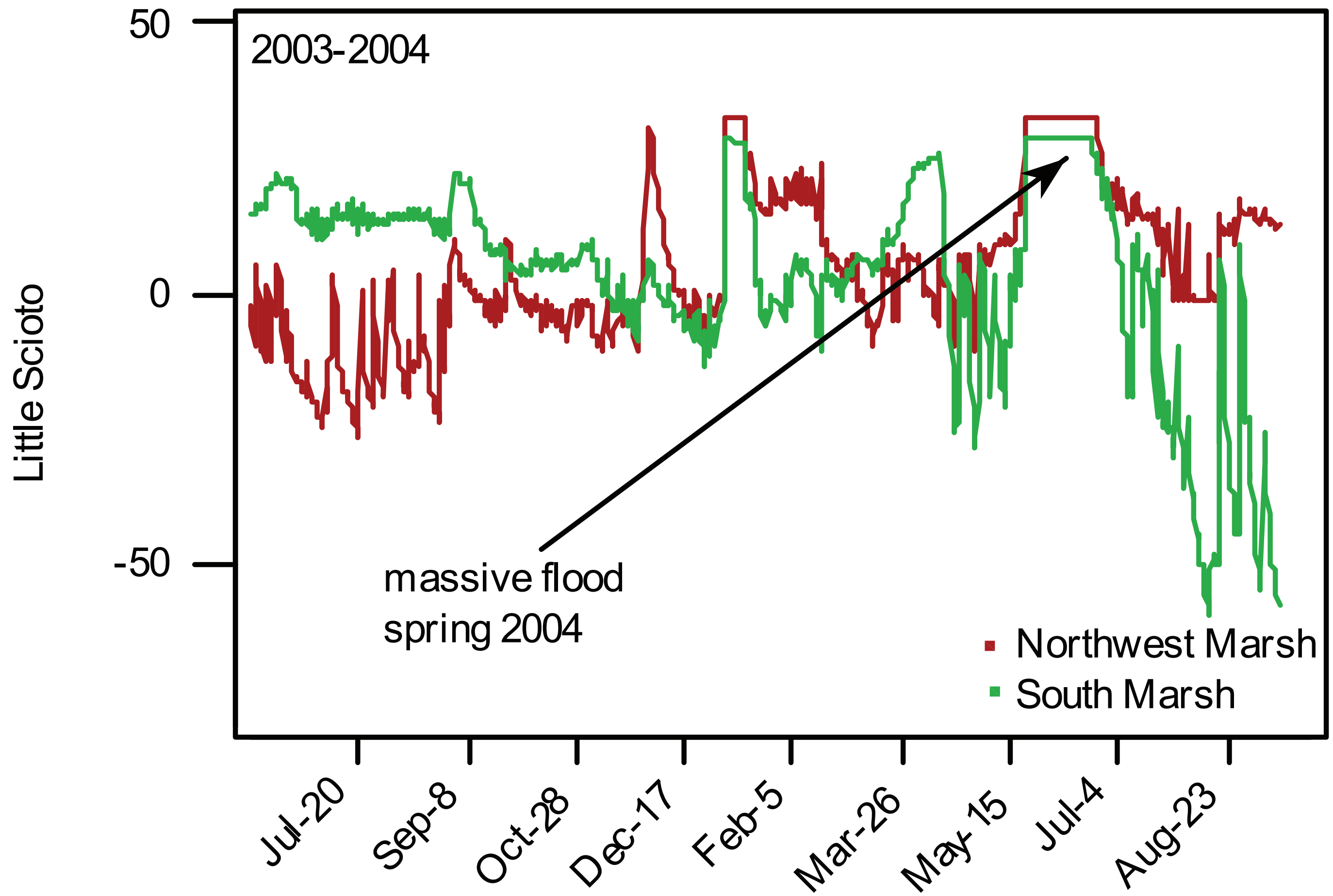

Figure 21. Hydrographs from wells installed at Little Scioto Northwest Marsh (LSNW) and South Marsh (LS3). Note massive flood event in spring 2004 when wells were temporarily submersed.

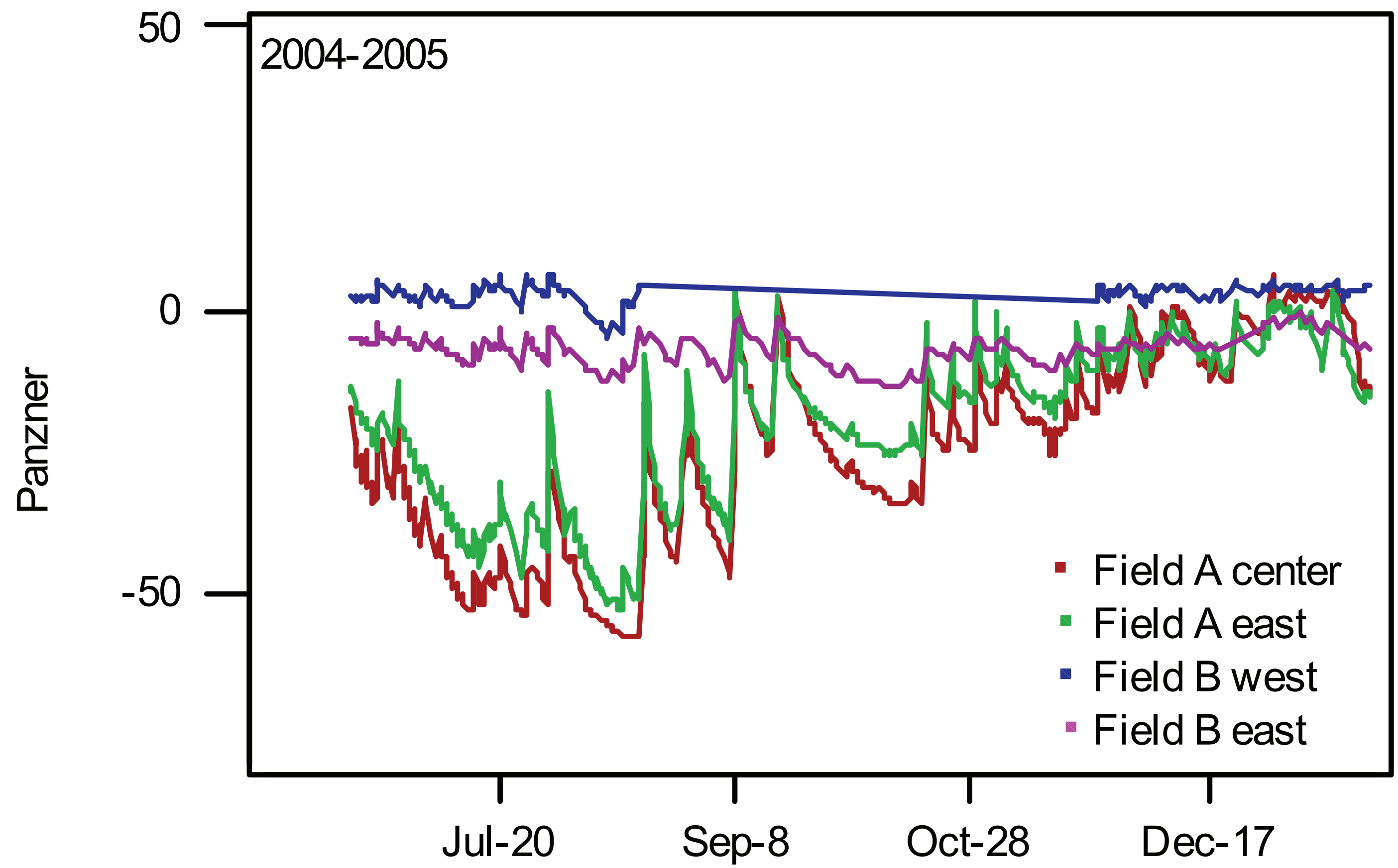

Figure 22. Hydrographs for wells installed at Panzner Bank Fields A (center and east side of field) and Field B (west and east side of field). The straight line for the Field B west well reflects a period of well failure.

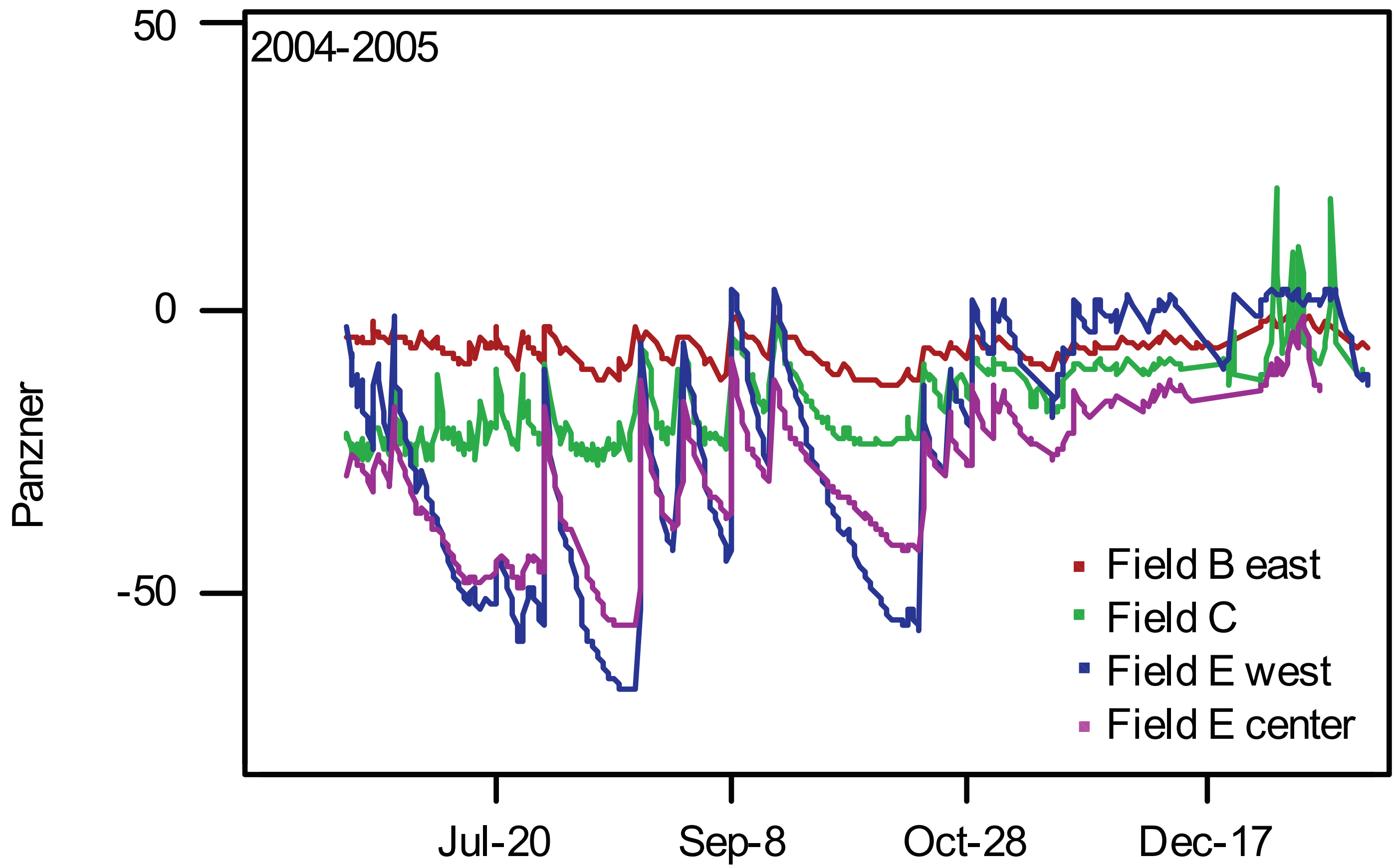

Figure 23. Hydrographs at Panzner Bank Fields B, C, and E (west and center of field).

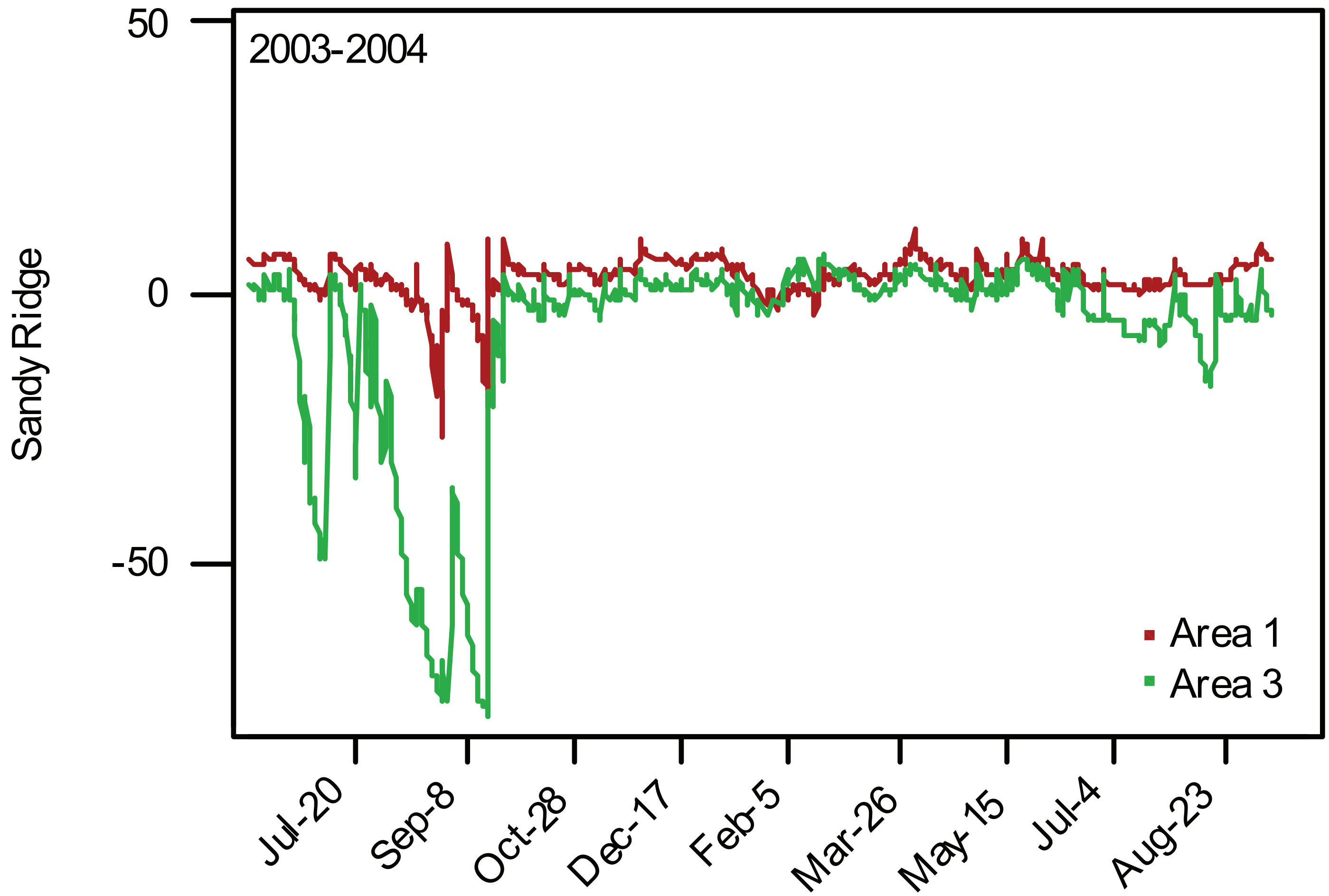

Figure 24. Hydrographs at Sandy Ridge Bank for Areas 1 and 3.

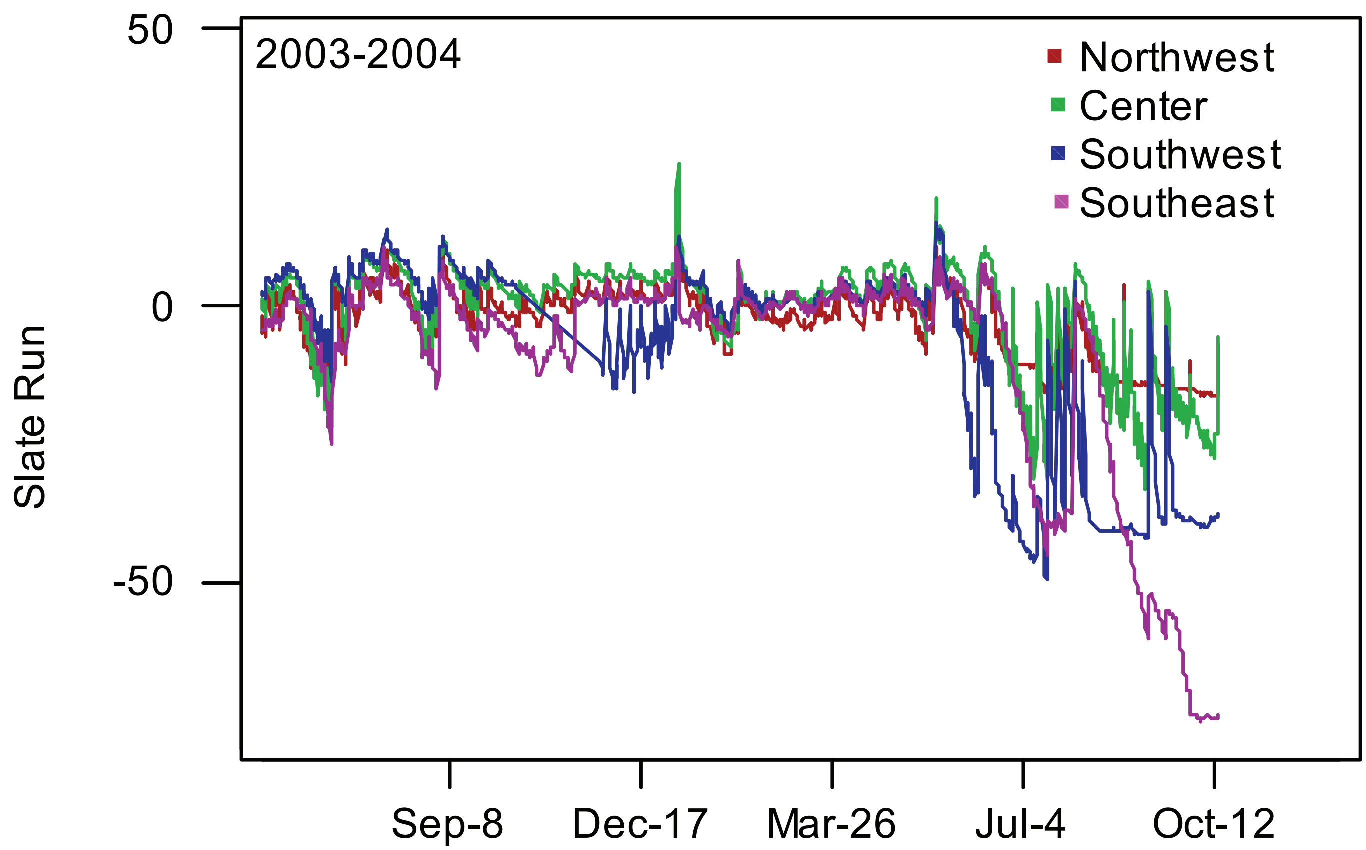

Figure 25. Hydrographs at Slate Run Bank Areas Center, Northwest, Southeast and Southwest.

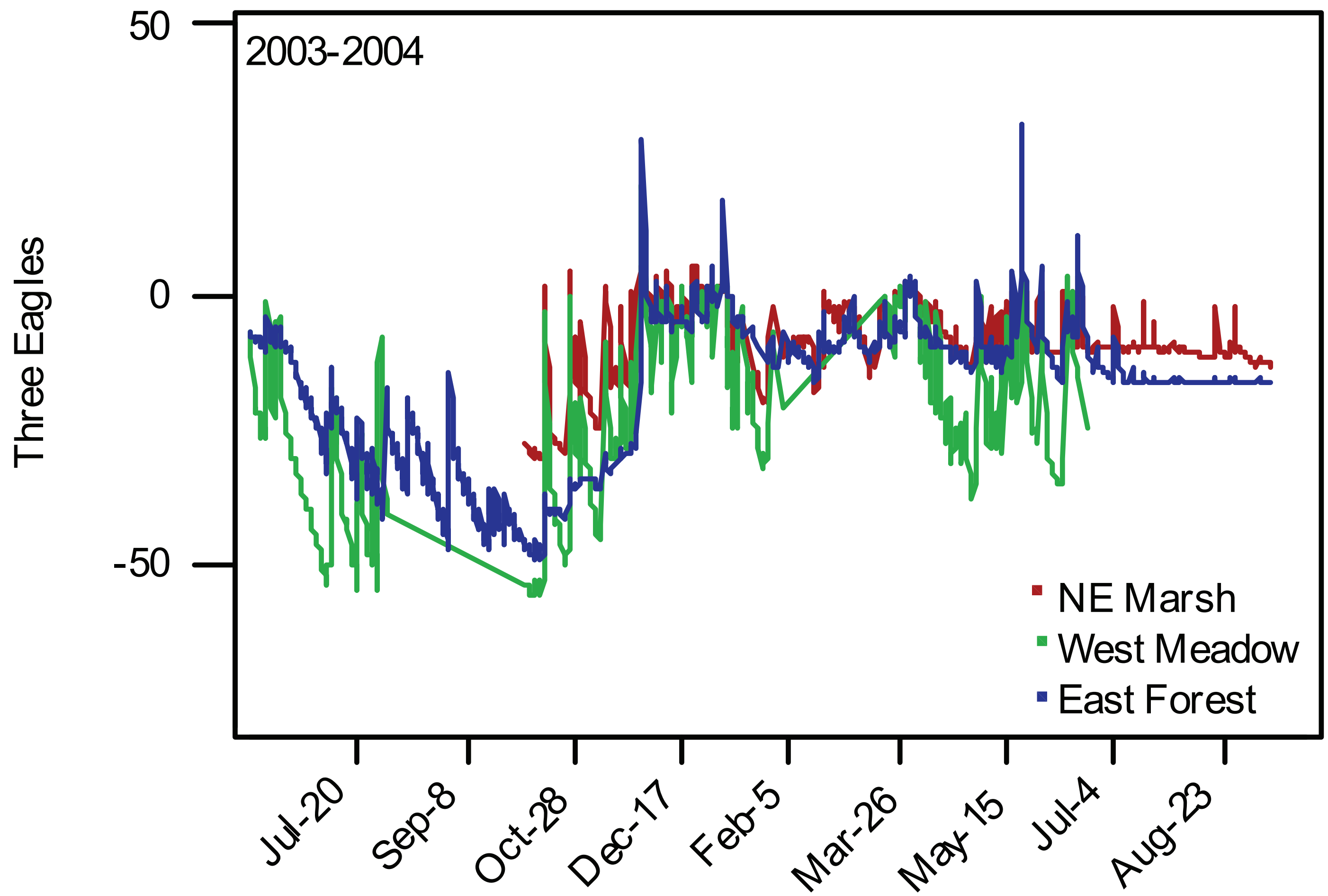

Figure 26. Hydrographs for Three Eagles Bank NE Marsh, West Meadow, and East Forest. Straight lines in West Meadow hydrograph reflect periods of temporary well data logger failure.

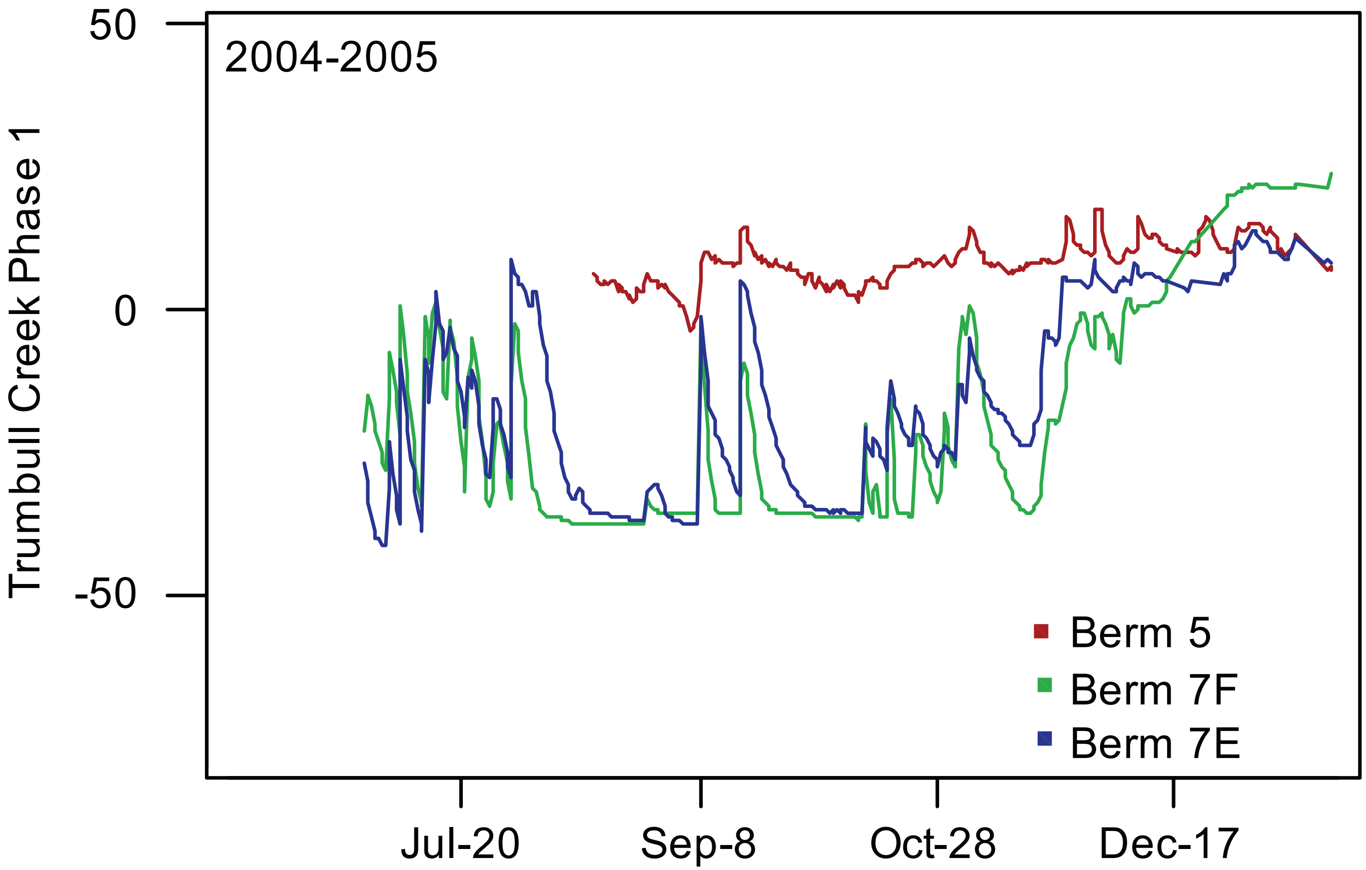

Figure 27. Hydrographs for Trumbull Creek Bank Berm 5 and Berm 7F and 7E.

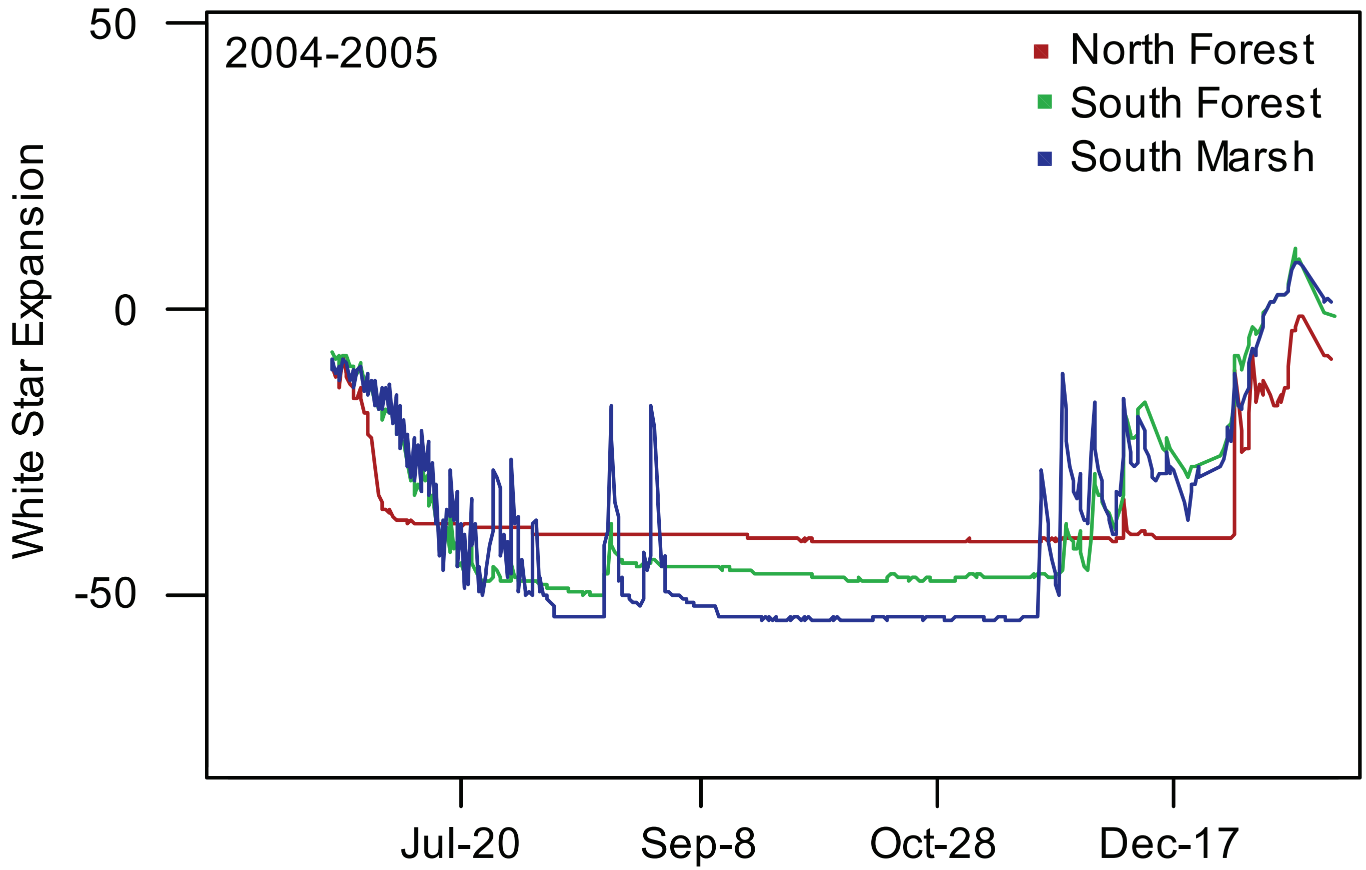

Figure 28. Hydrographs for White Star Expansion North Forest, South Forest, and South Marsh.

APPENDIX A

Because each bank is in many ways unique, a discussion of the results as they pertain to each bank with recommendations follows. Refer to Appendix C for maps of the banks sites.

Big Island

Big Island is a large bank site located west of Marion at the southern end of the former Sandusky Plains prairie region (Mack 2004). It was the second Ohio mitigation bank and was proposed by the Ohio Wetlands Foundation. Since the bank was developed on Big Island Wildlife Area property, the long term manager for the site is the Ohio Department of Natural Resources, Division of Wildlife.

The bank pre-dates establishment of the Mitigation Bank Review Team (MBRT) process under the Federal Bank Guidance. Most of the site was formerly wet prairie but had been drained and was actively farmed. Several ditches flowed south through the bank to the Scioto River. Restoration to develop the bank included breaking tile and constructing a dike with water control structures at the south end of the site. The site can be divided into 6 subareas. Area F was a prexisting second growth mesic and wetland forest. Area B is hydrologically controlled by the large dike. Areas A and F are partially controlled by the Area B dike. Areas C and D are basically depressional in nature and do not have dikes or berms impounding water to maintain their hydrology.

In parts of Area A and D, Big Island is the only Ohio mitigation bank that has successfully initiated secondary forest succession. Young stands of green ash, pin oak, and silver and red maple are common. The site also has successfully restored large areas of sedge meadow (mostly dominated by *Carex vulpinoidea*), marsh, and wet prairie in parts of Area A, C and D. Also embedded in the site are areas of sedge meadow dominated by *Carex hyalinolepis* which volunteered into the site. The entire site was intensively seeded and planted after construction (Kiertscher, Klutter, personal communications). Vegetation IBI scores in many areas were very high with many areas of good quality and approaching excellent quality in the wet prairie community in Area C. On the downside, most of Area B is unvegetated, turbid water. Beavers are plugging the water control structures and water is backing up north into Area A and threatening to kill back the young forest which is developing. On several occasions, water was observed flowing out the emergency outlet structure and eroding the soils in this area and not exiting via the two water control structures.

Despite the strong successes observed in Areas A, C, and D much of Big Island remains non-wetland shallow pond and constitutes a net loss of wetland acreage for impacts mitigated there. A main recommendation for improvement would be fluctuating the water levels using the water control structures in the dike in Area B. This would allow the north end of Area B and all of Area A to dry down in the summer. The south end of Area B will likely be permanently inundated. It could be improved vegetatively and as forage for waterfowl by introducing native floating and submersed aquatic plants. The wet prairie and sedge meadow areas of the site could be enhanced by further introduction of conservative prairie species characteristic of Sandusky Plains wet prairie and prairie sedge meadow (Mack 2004).

Cherry Valley

The Cherry Valley bank is located in east central Ashtabula County in the Grand River Terraces region. Wetland Preservation Limited is the sponsor and the Mount Pleasant Rod and Gun Club is the long term manager. A large finger lake developed in the Grand River valley during the recession of the Wisconsin glaciation and deposited a tight lacustrine clay. Much of the area presettlement was swamp forest and beaver marshes. The Cherry Valley bank is located on former farm fields and consists of a series of sinuous, southwest-northeast trending, low berms dividing the site into three subareas. Water tends to drain northward to an unnamed tributary to Mill Creek and to collect into shallow marsh zones in front of the low berms. The marsh areas grade southward into wet meadow areas. There are no active water control structures. Water exits the berms via shallow ground water seepage and over rock swales in the berms.

All of the marsh areas are relatively small and scattered across the site. There are no large areas of unvegetated open water and the maximum water depth is generally 0.5m and in no place greater than 1m. More open water areas are in many places thickly vegetated with submersed aquatics like

Ceratophyllum dermersum, Elodea canadensis, and *Utricularia gibba*. Wet meadow zones intergrade with upland to very mesic old field especially towards the eastern half of the site. The wet meadow plant community is not as diverse as the marsh communities and could benefit from the introduction of more conservative wet meadow sedges and forbs. A small area of probably preexisting shrub community is located at the northwest corner of Area 3. Other areas of the site would be good candidates for the introduction of alder and buttonbush swamp. Given the climax community of swamp forest in this region, long term successional trends at the site are likely to be swamp forest. Upland or marginal wet meadow areas would benefit from reforestation. Vegetation IBI scores in several locations were in the "high" Category 2 range which is a very positive trend given the young age of the bank in 2004.

Chippewa Central

Chippewa Central is located in Medina County north of the natural glacial lake, Chippewa Lake. Chippewa Central is one of the bank sites that is covered by the North Coast of Park Districts mitigation banking umbrella instrument. Under this instrument eight initial bank sites where authorized and provisions were included for addition of future sites. The park districts that developed and use this instrument are the metro parks for Erie, Lorain, Medina and Sandusky counties.

Chippewa Central is situated on Medina County Metro Park's property and the park district is the long term manager. It is a 100% "enhancement" bank, i.e. the entire bank site was already jurisdictional wetland almost completely dominated by *Phalaris arundinacea*. Chippewa Lake and the wetland complex north of it were likely a large bog/fen complex presettlement. Soil excavation during the installation of the ground water wells revealed muck soils buried by alluvial sediments. The entire area was highly modified, development and septic discharges have occurred around the lake itself and the wetlands to the north were drained and farmed. Chippewa Creek drains this modified wetland complex and was deeply channelized. Portions of the farmland reverted and became dominated by reed canary grass. The Medina County Park District acquired part of this complex. The enhancement consisted of installing a low dike with water control structures along the east side of Chippewa Creek to impound water into the reed canary grass meadows east of the dike and drowned out the reed canary, converting the site to a marsh community. Credits would be released based on the degree this enhancement was successful. Unfortunately, the hydrologic enhancement was not successful in reducing the coverage of reed canary grass except in the southern 1/5 of the site, and there only partly. Where reed canary grass has been killed back, marsh vegetation has not reestablished. There are current plans to introduce plugs and seeds of marsh vegetation and to consider other options for reed canary grass reduction. Long-term, the park district wants to acquire the entire complex and reestablish the natural channel of Chippewa Creek. From a quality perspective, the VIBI scores reflect the continued dominance of reed canary grass at the site. Of note, is the focused plot (Chippewa South) which had a moderately high VIBI score. At the southeast corner of the site, there is a better-quality a dogwood-viburnum-spirea dominated area with young silver maple trees. This community was likely present pre-enhancement but is a positive feature at the site and will hopefully expand.

Grand River Lowlands

The Grand River Lowlands bank is located in the floodplain of the Grand River south-central Ashtabula County a few miles west of Orwell. Wetland Preservation Limited is the sponsor and the Mount Pleasant Rod and Gun Club is the long term manager. The bank consists of four cells, that form a rough square. Two north-south dikes were constructed approximately parallel to the Grand River valley. These dikes were bisected by an interior dike. The bottom-left (SW) corner of the square consists of Area A-D, the bottom-right corner (SE) is Area B-C, the upper left corner (NW) is Area F and the upper right corner (NE) is Area E. Most of areas A-D and B-C were former drained farm fields except for an area of young second growth forest at the north end of Area A-D. Areas E and F were existing pin oak/swamp white oak dominated forest that was considered in the bank plans to be non-wetland do to a lack of hydrology. Existing forest was cleared to construct the dikes around Areas E and F. All of the cells have water control structures. Areas A-D and B-C have series of outlet structures set at different elevations. Areas E and F have single outlet control structures. In addition to reestablishing wetland hydrology at the site, eradication of large areas of reed canary grass in Areas A-D and B-C was a major goal of the bank.

Negatives at this bank include the drowning of large areas of existing forest in Areas A-D, F, E, and B-C. Areas A-D and B-C have a very flashy hydrology which acts as a constant disturbance to the floral and faunal communities; on the positive side, these cells store a considerable amount of water and release it more slowly into the Grand River, and are providing a flood retention ecological service. Reed canary grass remains fairly abundant at the south end of Area A-D and eastern edges of Area B-C. Of positive note was the presence of the less common *Ceratophyllum echinatum* in Area B-C and the colonization of borrow areas for the dikes in Areas E and F by *Utricularia vulgaris*. A very strong fecal odor was noted in Areas A-D and B-C on several occasions during the summer of 2004 and the source of this discharge should be investigated.

From a quality perspective, this bank presents several constraints. Area F was good quality forested wetland in the focused plot. However, species observed were present prior to the hydrologic "enhancement" of this area. In fact, the main effect of the diking was to destroy much of the existing forest and replace it with deep water marsh. Area A-D also had large areas of "dead forest" and open water but there was also a moderately good quality *Juncus effusus* marsh in the northeast corner. Area B-C also had some moderately good wet meadow developing in the NE corner. Unfortunately, considerable areas of unvegetated open water exist.

Hebron

The Hebron bank is the oldest mitigation bank in Ohio and is located at the Hebron Fish Hatchery in Licking County, Ohio. It was established prior to the MBRT process. The bank is located in the Buckeye Lake region. Buckeye Lake was a large bog-wetland complex that was destroyed in the 1820s during the heyday of canal construction by impounding the wetlands and creating Buckeye Lake. Cranberry Bog Nature Preserve is a remnant of this once large complex. The Hebron Fish Hatchery was constructed on hydric soils of this former complex. Two cells (Large and Small) were constructed by excavating shallow pools and constructing low berms near existing swamp forest and the hatchery ponds. This site was also extensively planted (Kiertscher, personal communication). Although initially open and with a surprisingly high plant species diversity (Fennessy and Roehrs 1997), the large pool has become dominated by reed canary grass in many areas and has about half its area in shallow unvegetated open water. The reed canary grass dominated areas of the Large Cell are also reverting to forest with silver maple, green ash, cottonwood, and black willow becoming dominant. The small cell is mostly dominated by *Typha latifolia* and *Scirpus cyperinus* with a about a one-quarter of its area in unvegetated open water. The site is well known to birders and boasts a long species list but some (much?) of this is likely attributable to the existing wetlands that abut the site to the south and east, and to birds attracted to the numerous hatchery ponds.

Little Scioto

Wetland Resource Center LLC's Little Scioto bank is located a few miles northeast of the Big Island bank in the former Sandusky Plains prairie region. Phase 1 of the bank consists of four areas (Northwest, Central, South, and Northeast Areas) located north and south of the Little Scioto river plus existing upland and wetland forest and marsh located along the Little Scioto River that was preserved as part of the bank site. Ohio EPA sampled areas owned by the bank in the Northwest and Central Areas. The two cells that comprise the Northwest Area were sampled (LSNE and LSNW) and one cell in the Central Area (LS3 or LS South). The NE and NW cells are large sinuous areas of hydric soils with small berms and outlet structures at the south end as the get near the Little Scioto River. The south cells are more traditional square diked cells with AgriDrains to the river. Wetland Resource Center is the long term manager of the NE, NW and Central (LS3) cells and the Ohio Department of Natural Resources, Division of Wildlife is the long term manager for the cells to the south and east of the Little Scioto River. Only cells managed by Wetland Resource Center were included in this study.

The NE and NW cells are predominately submersed/floating leaved marshes dominated by *Potamogeton nodosus and Elodea canadensis* and fairly extensive areas of unvegetated open water. Emergent communities develop at the shallower water depths and are dominated by *Typha* spp., *Alisma subcordatum,* and a few other wetland annuals. The south cells (LS3) are basically shallow ponds with little vegetation except at the margins away from the dikes. A very positive feature of the NE and NW cells is the heterogeneous interaction of the wetland and upland areas and the mostly shallow inundation. The bank design basically followed the outline of the hydric soils and eschewed the more typical large square diked cells that maximized the inundated footprint. Unfortunately, little has been done to enhance the upland community back to the mesic prairie and oak savanna typical of this region presettlement. In addition, no attempt has been made to introduce wet prairie and prairie sedge meadow species to the NE and NW cells despite their presence in ditches along the railroad grade north of these cells.[15]

From a quality perspective, VIBI scores were moderately low across the site. Also, a least bittern, *Ixobrychus exilis,* nest was observed in a *Typha angustifolia* stand in the south cell in early summer 2003 (see cover photo). During a large flood event in May-June 2004, the wells at the site were completely submersed and a considerable amount of flood water was stored at the site.

Panzner

The Panzner mitigation bank is located in the former Copley Swamp region just west of Akron in Summit County, Ohio. Panzner & Sons, Incorporated (Steve and Jerry Panzner) is the sponsor of the bank and originally the long term manager was going to be the Revere Land Conservancy. However, that group has merged with a larger northeast Ohio conservation group and the Panzers are currently seeking an alternative long term manager.

The Copley Swamp was a large bog-fen complex located in the Summit Interlobate subregion of the Erie-Ontario Lake Plains ecoregion. Prior to restoration, the Panzner mitigation bank was a truck farm on deep muck soils. The soils were drained by a complex of ditches, drain tiles and pumps. The bank consists of five "fields" (A, B, C, D, and E). Field A had over 6 miles of drain tile and during the growing season, upwards of one million gallons of water were pumped from the tile system each day in order to allow equipment access into the field (Panzner, personal communication). The fields were restored in the following order: B, C and D, E, then A between 2001 and 2004. Farming activities and the excavation of a tributary ditch to Pigeon Creek on the east side of the site had lowered the water table in Fields B, C, D, and E. Muck soils were removed in these fields to lower the ground surface to the water table and the fields were extensively planted with wetland perennials, especially sedge species (Panzner, personal communication). Field A was restored by decommissioning the tile and pump system in the fall of 2003. It was planted in 2005 after sampling for this study. Low, permeable muck berms were constructed along a tributary ditch to Pigeon Creek to exclude floral (e.g. *Lythrum salicaria*) and faunal (e.g. common carp) invasive species from the restoration areas but were not necessary for hydrologic restoration.

Due to a combination of excellent soils (extensive, deep high carbon muck soils), hydrology (abundant ground water upwelling), planting, thoughtful design, and stringent invasive management (virtually 0% invasive plant species), the Panzner bank is the most consistently successful bank assessed in this study. The VIBI scores at several fields were in the high Category 2 range for Fields B and E (with moderate additional introduction of more conservative fen-marsh species, this fields should easily attain Category 3). Of note was the presence of the conservative fen obligate species *Deschampsia cespitosa* which has maintained a presence at the site even during years of active farming (Panzner, personal communication). The rare masked shrew, Sorex cinereus occurs here and some of the only very limited number of sightings of the wood turtle, *Clemmys insculpta* in Ohio have been here. Several areas where marl meadows appear to be redeveloping were noted in Fields B and E.

Sandy Ridge

The Sandy Ridge mitigation bank is located near North Ridgeville, Lorain County within the Sandy Ridge Metro Park and is just east of Elyria. This mitigation bank sponsored by the Ohio Wetlands Foundation was the first in Ohio to go through the procedures outlined in the Federal Bank

[15] This will likely be rectified in 2006 when a vegetation enhancement planting plan will be implemented to improve the quality of the plant community at the site.

Guidance, have a Mitigation Banking Review Team and a signed instrument. Lorain County Metro Parks is the long term manager of the site. The bank instrument was signed in late 1996 and construction of the bank was begun in September 1997 and was competed in September 1998. The bank consists of approximately 44 ha (108 acres), with 27 ha (67 acres) of constructed wetland and another 16.5 ha (41 acres) of wetland enhancement. Prior to construction 22 ha (55 acres) of the bank were determined to be Prior Converted farm fields that were in agricultural production until 1996. There were also 19 ha (46 acres) of existing wetlands on the site and on the north end and some of those were forested. Paddock Ditch which runs along the western border of the property was impounded and large berms were constructed on the east, south and west ends of the project. There is also a berm that runs up the middle of the project site from the north end and then turns west where it grades into a boardwalk that extends to the western berm. The berms serve as walking trails and are large enough to allow passage of vehicles.

The bank is comprised of three hydrologically connected cells, Areas 1,2 and 3 (the hydrology for all three is controlled by a single water control structure). This results in a marked graduation in water depths from shallow emergent wetland in the south part of the site to deep water areas in the north. Large areas of this bank, north of the boardwalk are comprised of unvegetated open water. In these areas the water averages 60-90 cm with deeper pools that exceed 1.5m. The pre-existing forest on the northwest end of the site has been inundated continuously and all trees while still standing have died. Many of the shallower parts of the bank site are dominated by *Juncus effusus*. At the south end of the site there are areas that are a mix of tolerant emergent wetland plants with areas that are dominated by a combination of *Typha latifolia* and *Typha angustifolia*. The bank is a popular site for bird watching and some rare species have been sighted there including sandhill cranes, least bittern, American bittern, black duck, sora, Virginia rail, and northern harrier. Reducing unvegetated open water and increasing emergent vegetation cover would improve overall bird diversity.

Slate Run

The Slate Run Wetland Mitigation Bank is located within Slate Run Metro Park in Pickaway County about 15 miles southeast of Columbus. This bank went through the MBRT process, was sponsored by the Ohio Wetlands Foundation, and Columbus and Franklin County Metro Parks is the long term manager. The bank instrument was signed in March, 1999 and the bank was built later that year. Located within the Till Plains the bank was constructed on 64 ha (158 acres) of land that had been agriculturally row cropped and grazed for the previous 100 years. The area is comprised of a mix of hydric and non-hydric soil series. Thirteen individual areas were developed on the site that range in size from 0.17 to 5.6 ha (0.42 to 13.88 acres).

Construction involved decommissioning the existing tile drainage system, hollowing out of the existing soils to develop depressions and use of the excess soil for development of berms primarily on the west side, but also on parts of the north and south sides. The bank goals were to develop 33 ha (81.5acres) of jurisdictional wetlands and 2.5 ha (6.3 acres) of unvegetated open water. This bank is completely sold out and just ended its five year monitoring period.

Most of the wetlands are pond-like with average depths of 60-90 cm. The parts of the deeper water zones that are vegetated are largely solid beds of the non-native invasive, *Najas minor*. This site could be improved by the eradication of the *Najas minor* beds followed up by planting and seeding of native submersed and floating leaved marsh plants. The existing water levels are much deeper than those proposed in the plan for the site and the most cells would benefit from lower and variable water levels.

Three Eagles

The Three Eagles Wetland Mitigation Bank sponsored by the Ohio Wetlands Foundation is located in northeast Sandusky County about a mile south of the Muddy Creek Bay region of Sandusky Bay. This bank went through the MBRT process and the instrument was signed in December 1999. Construction occurred while the instrument was still in review and was completed in November 1999. The Ohio Department of Natural Resources, Division of Wildlife is the long term manager for the site.

The 64 ha (158 acre) site was row cropped until 1999. Located in the old lake plain, the topography is extremely flat, and soils have a high clay content, and are hydric and non-hydric with hydric inclusions. Green Creek has been relocated and straightened and now runs along the western border of the property. The old Green Creek channel meanders across a large extent of the property and still carrys some flow. The old channel still has a relatively intact, mature forested riparian corridor especially along the southern part of the property. The bank design attempted three main restorations: emergent marsh (NE, NW and East Marshes), enhanced to created wetland forest in the existing forest along the abandoned Green Creek channel (SW, East, and North Forest areas), and wet meadow (West and SE Meadow) (see map in Appendix C). The NE Marsh, West Meadow, and East Forest were monitored because they were large areas representative of the other areas. All of the areas were developed by the construction of berms and water control structures. The berms are highest on the north ends and also run along the east and west sides of the cells. The berm along the eastern side of the site also serves to keep additional water off the adjoining property. Depressions were established within the wetland cells to provide high clay content soil for the berms. The berms for the cells also impound water in many areas of the old Green Creek channel and its forested riparian corridor.

Originally, the banker had projected 48.5 ha (120 acres) of restored, created and enhanced wetlands would develop on the site. A total of 4.6 ha (11.4 acres) of wetland were already present on the site and were proposed to improve in quality through the addition of hydrology and connection to other wetland areas. The bank has not resulted in the amount of wetland acreage predicted. The NE Marsh at the north end of the project is comprised of two large shallow marsh areas. Large parts of these areas are unvegetated open water. The emergent plant communities present in the shallower water zones are dominated by the non-native invasive cattail, *Typha angustifolia*.

The two marsh areas would benefit from active eradication of the *Typha angustifolia*, and a water draw down to allow seeding of a diverse emergent community in the cattail zones and native submersed and floating bed plants in the deep water zones. The West Meadow area has not developed the hydrology to convert a majority of that area into wetland. The East Forest appears to be reverting to marsh as mesic tree species are killed by the increased hydrology.

Trumbull Creek

The Trumbull Creek Wetland Mitigation Bank is located in parts of both Geauga and Ashtabula Counties about 3 miles south of the Lake County line. The entire bank encompasses 187 ha (462 acres) both south and north of State Route 166. Trumbull Creek, a tributary to the Grand River runs through the southern part of the property. The Ohio Wetlands Foundation is the banker and ODNR, Division of Wildlife is the long term manager.

This bank is being built in stages. Originally three phases were proposed but recently the banker has decided to consolidate Phases 2 and 3. A portion of Phase 1, which is the part of the bank monitored for this report, was built in 2001 and has three cells, Berms 5, 6 and 7 (Berms 1-4 are not going to be constructed). The cells were constructed by developing high berms on the east sides that taper back on the north and south sides. The berms are substantial on the down slope side, exceeding 3 m in places, and requiring a dam permit for their construction. The cells, especially Berm 7, are very pond-like in appearance. Some of the forested areas of the site have been inundated by the flood pool and those trees, while still standing, are largely either dead or dying. There are many deep water zones where few or no hydrophytes are growing. Shallower areas, especially in Berm 5 are more heavily vegetated and are developing good quality marsh plant communities.

Long term management improvements for this site would involve lowering and fluctuating the water levels thus allowing for seasonal dry down of large portions of the cells. The drawdown combined with seeding or planting of emergent, submersed and floating bed wetland plants would promote the growth of vegetation in areas that have been continuously inundated with deep water.

Phase 2 of the bank, which now will involve the remainder of the site, is currently under construction and will be substantially different than the first phase. Here the target community will be swamp forest with vernal pools. This community will be established by primarily decommissioning tiles, plugging ditches and developing macrotopographic features. Large numbers of native hardwood hydrophytes of different sizes will be planted throughout the Phase 2 area. Performance standards for Phase 2 include a target VIBI score, at least 75% aerial coverage of native hydrophytes, less than 5% coverage of invasive species, and less than 10% aerial coverage comprised of unvegetated open water for any wetland.

White Star Expansion

The White Star Expansion Area is a wetland mitigation bank that has been added under the umbrella agreement for the North Coast of Park District's mitigation banking instrument. The site is located on property that is a recent extension of the White Star Metro Park in Sandusky County just south of Gibsonburg. Sandusky County Park District is the long term manager of the site. The existing White Star Metro Park is comprised of approximately 323 ha (800 acres) and the Expansion adds approximately 38 ha (95 acres) of which about half to three-quarters was projected to convert into wetland.

This property was largely forested prior to the alteration of the hydrology and other construction that occurred in 2003. Tiles were destroyed and other hydrologic changes were established through berming. The berms which run parallel to the main ditch on the site allow rain events to be captured and retained behind the berms. Agridrains have been installed to allow for management of the water levels if less then berm full is desired.

Forest on the site was dominated by mesic to wetland tree species often with a dense understory of prickly ash (*Zanthoxylum americanum*). The increased hydrology was proposed to drown out the upland species and provide an environment that would be favorable to the development of swamp forest especially species such as green ash, red maple, pin oak, and swamp white oak. The eastern portion of the south cell was used as a borrow area for soils to construct the berms. This deeper water area has been seeded to a mix of wetland emergent plants and is converting to emergent marsh. The 2004 annual report for the site documented 43 acres of wetland conversion that are achieving VIBI scores in either Category 2 (performance goal) or the upper range of Category 1. With an additional growing season or two more wetland should develop and VIBI scores can be expected to increase.

APPENDIX B

Reevaluation of Sandy Ridge Bank 5th Year Monitoring Results

The following is a reanalysis of monitoring Preconstruction and 5th year monitoring data submitted for the Sandy Ridge Mitigation Bank, Lorain County, Ohio. Data for this analysis was found in the following documents: *Preconstruction Monitoring Report Sandy Ridge Wetlands Mitigation Bank, North Ridgeville, Ohio*, October 1997, Prepared for Ohio Wetlands Foundation, Reynoldsburg, Ohio by Davey Resource Group, Kent, Ohio (Preconstruction Report), *Third Year Monitoring Report Sandy Ridge Wetlands Mitigation Bank, North Ridgeville, Ohio*, December 2000, Prepared for Ohio Wetlands Foundation, Lancaster, Ohio by Davey Resource Group, Kent, Ohio (3rd Year Report), and *Fifth Year Monitoring Report Sandy Ridge Wetlands Mitigation Bank, North Ridgeville, Ohio*, December 2002, Prepared for Ohio Wetlands Foundation, Lancaster, Ohio by Davey Resource Group, Kent, Ohio (5th Year Report).

METHODS

Performance goals from the final mitigation plan are listed on pages 3-4 of the 5th Year Report. These goals are summarized in Table B1.

In addition to qualitative floristic and wildlife surveys, the main sampling method used to document performance was the establishment of 4 permanent transects with 18 permanent 1x2m ($2m^2$) quadrats located approximately every 400 feet down the length of the transects (Appendix B-2, 5th Year Report. Seven (7) quadrats were located along Transect 1 in the former upland fields; 5 quadrats were located along Transect 2 in the enhanced or existing wetland areas; 3 quadrats were located along Transect 3 in the existing wetland area; and 3 quadrats were located along Transect 4. Quadrats 8, 9, 10, 11, 17, and 18 were located in the "enhanced wetland area."

Data collected from this sampling design appears to be statistically inadequate to determine compliance with the numeric performance goal Nos. 3 and 4 (Table B1). These goals require a determination of whether there is 80% cover of hydrophytes and <5% cover of invasive plants over the entire acreage of the mitigation bank. To estimate areal cover of these parameters over the entire bank would require the use of randomized sampling design of sufficient number of quadrats (probably 30-50) over the entire site. Technically, the use of permanent transects and quadrats only allows for the estimation of areal cover of the areas within the permanent quadrats unless you assume the permanent quadrat locations are representative of the amount and type of plant communities present at the entire bank site. Based on a review of the photo documentation provided in the 5th Year Report, the quadrats are probably "representative." Since this was the study design selected by the bank, this data was used to determine compliance with these goals. The same problem also occurs with performance goal No. 5 (<25% cover of *Juncus effusus* in the enhanced area) except that the goal itself specifies that compliance with goal shall be determined by using data collected from the permanent quadrats located in the enhanced mitigation area rather than an estimation of *Juncus effusus* cover over the entire enhanced acreage.

RESULTS AND DISCUSSION

Quantitative vegetation data from the Preconstruction and 5th Year Reports was entered into Excel and Minitab v. 12.0 and analyzed. The results are summarized in Tables B2 to B7.

Goal 1. The hydrology criterion appears to have been met as all permanent quadrat points are inundated or saturated for sufficient time to meet the hydrology parameter in the 1987 Delineation Manual.

Goal 2. Only 44% of the permanent quadrat sampling points had the degree of inundation specified in the design plan (Table B7). Depth of inundation is much greater and for longer durations than specified in the design plan. A seasonally to regularly inundated wetland now appears to have basically permanent inundation over a substantial portion of the mitigation bank. This goal has arguably not been met.

Goal 3. Based on cover data from the permanent quadrats, 65.3% of the site is vegetated with hydrophytic plants (FAC, FACW, OBL) as opposed to 40.3% in 1997 and 66.7% in 2000 (Table B3). This is close to the 80% goal; however a large percentage of the 65.3% hydrophyte cover is from *nonnative, annual* hydrophytes. When these are excluded the percent cover of *native, perennial* hydrophytes is no more than 32%. Since the performance goal is 80% cover of *native, perennial* FAC, FACW, or OBL plants, this goal has not been met based on quantitative vegetation data submitted.

Goal 4. Based on cover data from the permanent quadrats, 28.7% of the site is vegetated with nonnative plants in particular the aggressive aquatic weeds *Najas minor* and *Potamogeton crispus* (Table B3, Figure B1). The goal of <5% cover of aggressive weedy plants has not been met.

Goal 5. By most measures plant diversity in the enhanced area has declined or at best stayed the same since the preconstruction monitoring of this existing wetland (Tables B5 and B6, Figures B2 and B3). Areal cover of nonnative plants has increased markedly from less than 10% in 1997 and 2000 to 35.8% in 2002 (Tables B5 and B6, Figure B2). As determined by data from the permanent quadrats in the enhancement area, diversity has not increased and this goal has not been met.

Goal 6. Based on cover data from the permanent quadrats, 38.5% of the "enhanced area" was covered by *Juncus effusus* in 1997, 14.3% in 2000 and 22.5% of the "enhanced area" was covered by *Juncus effusus* in 2002 (Table B4). Although technically this goal has been met, cover of *Juncus effusus* is increasing and appears to be back on a trajectory towards preconstruction levels.

Goal 7. This was a narrative goal that the hydroperiod at the bank would range from seasonally inundated to regularly inundated during the growing season. If the growing season is April to October (6 months), then inundation/saturation should range from 0.75 to 1.5 months for the shallow emergent area, and 1.5 to 4.5 months for the deep emergent areas. Based on the maps in Appendix B-1 and B-2 of the 5th Year Report, most of the site was designed to be shallow emergent and a few relatively small areas of deep emergent. It appears that substantial part of the area of the wetland is now deep emergent to open water and is permanently inundated (as opposed to seasonal or regular). Arguably, this narrative goal has not been met since the seasonal and regularly hydroperiods have been superceded by permanent inundation and saturation over much of the bank.

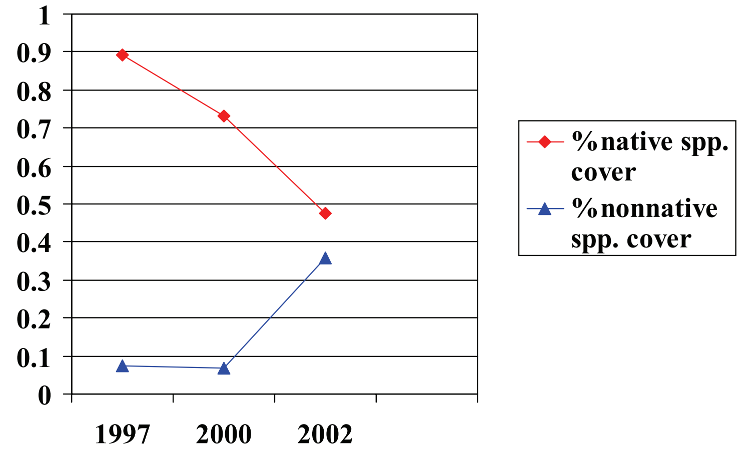

Figure B1. Relative cover of native and nonnative plant species within the enhancement area of the Sandy Ridge Mitigation Bank.

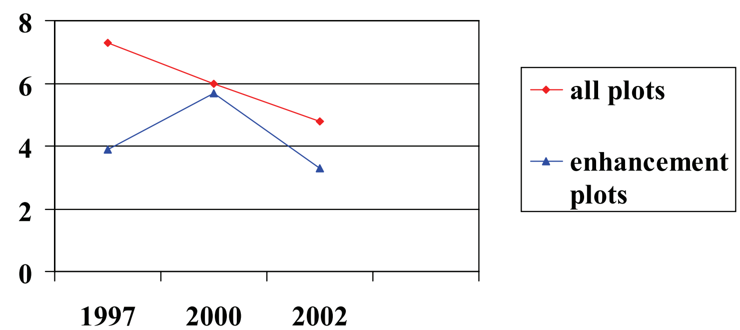

Figure B2. Average FQAI score.

Goal 8. This was a general narrative goal about the quality, types, and diversity of plant communities that would develop at the bank. The goal was to create "diverse, high quality" wetlands and to create a mix of emergent, shrub, and forested wetland areas. Shrub and forested areas were to develop on areas of seasonal inundation, and emergent on areas of seasonal to regular inundation. As a comparison to what high quality natural wetlands look like vegetatively, I would refer you to Tables 45-57 of *Vegetation Index of Biotic Integrity for Wetlands* available at http://www.epa.state.oh.us/dsw/wetlands/wetland_bioasses.html, or to the community descriptions in *Plant communities of Ohio* (Anderson 1982).

Comparing the vegetation data submitted

with the monitoring reports and vegetation data from natural high quality wetlands in Ohio EPA's reference wetland data set, the Sandy Ridge Bank shares very little in common with diverse, high quality natural marshes, shrub swamps, or forested wetlands in Ohio. Of concern is the complete demise of the existing wetland shrub thickets at the north end of the bank. Based on the preconstruction data and photo-documentation this area had several wetland tree and shrub species and appeared to be on a trajectory to shrub or forest wetland. This area has been drowned out by the high water levels and no forest or shrub wetland areas are developing at the site (I exclude the weedy colonization of areas at the south end by *Populus deltoides* (eastern cottonwood), a riparian flood plain species, as evidence of forest development, contrary to what the 5th Year Report concludes).

This narrative goal does not appear to have been met. The vegetation data submitted shows a species poor community dominated by a few native tolerant plant species or aggressive non-native species.

RECOMMENDATIONS AND CONCLUSIONS

Given the failure to achieve all but 2 of the 8 performance goals listed in Table 1, the monitoring period should be extended for an additional 5 years and substantial adaptive management activities undertaken including the following:

1. Diagnostic activities of soil and water chemistry should be undertaken to determine whether nutrient deficiencies, lack of organic carbon, or other biogeochemical factors are inhibiting the site from developing into a high quality wetland.

2. Water levels are too deep and the hydroperiod is too long. The hydrologic goals specified in the design plan should be adhered to. Given the abundance of *Najas minor* and *Potamogeton crispus* in the open water areas, a complete draw down of the site for most of a growing season may be necessary to get these invasive plants under control again.

3. An aggressive re-vegetation plan focusing on conservative native species should be undertaken to increase species diversity and provide native competitors for the invasives:

   a. Submersed and floating aquatics: *Nuphar advena, Nymphaea odorata, Ceratophyllym demersum, C. echinatum, Utricularia vulgaris, Ricciocarpus natans, Spirodela polyrhiza,* native *Najas* spp., additional native *Potamogeton* spp., etc.

   b. Shallow emergent to wet meadow: The site appears to be basically lacking a sedge community except perhaps at vary margins of pools. Competitive sedge meadow community should be brought in including *Carex lacustris, C. scoparia, C. cristatella, C. lurida, C. comosa, Bolboschoenus fluviatilis, Schoenoplecutus pungens, Eleocharis erythropoda.* Wetland forbs for deeper water emergent communities and wet meadow would include *Iris versicolor, I. shrevei, Eupatorium maculatum, E. perfoliatum, Lycopus americanus, L. rubellus, Lythrum alatum, Scutellaria galericulata, Sagittaria* spp., *Acorus americanus, Hibiscus moscheutos, Polygonum punctatum, P. hydropiperoides, P. amphibium, Cicuta bulbifera, C. maculata,* etc., and other species listed in Tables 45-57 of *Vegetation Index of Biotic Integrity for Wetlands* available or the community descriptions in *Plant communities of Ohio* (Anderson 1982).

   c. Shrub species: a buttonbush swamp community with native willows, alders, and

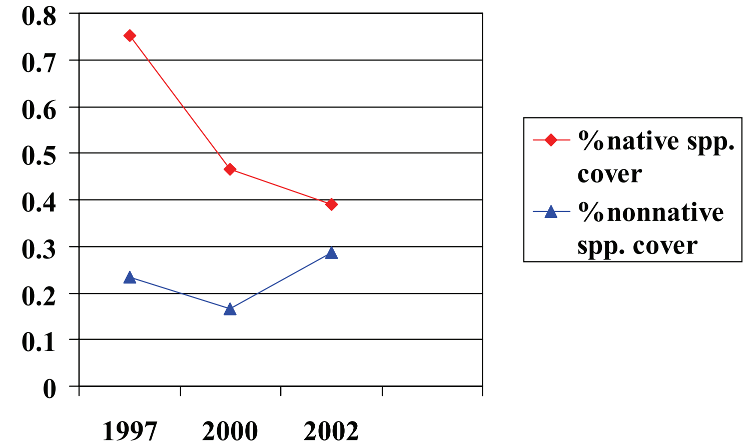

Figure B3. %native and %nonnative species cover.

roses would be an achievable woody community intermediate between marsh and forest that could be established in both areas of both seasonal and regular inundation. Forest species like swamp white oak, green ash, silver maple, etc. could be planted in drier margins of this area.

Table B1. Performance goals for Sandy Ridge Mitigation Bank, North Ridgeville, Ohio. From 5th Year Report, pages 3-4.

#	goal	description
1	meet hydrology criteria for jurisdictional wetlands	At the end of five years, restored and enhanced areas of mitigation bank should meet the hydrology parameter as specified by 1987 Corps Delineation Manual as determined by data from permanent sample quadrat points
2	soil saturation and depth of indundation as specified in final design plan	"Generally, soil saturation and water depths should be achieved as shown on the wetlands design plan..." as determined by data from permanent sample quadrat points
3	80% cover by native, perennial hydrophytes	At the end of five years, 80% of restored and enhanced wetland areas, excluding open water areas, will have a minimum of 80% cover by native, perennial plants that are FAC, FACW, or OBL as determined by "in-field" inspections of established plant communities
4	<5% cover by invasive weedy plants	At the end of 5 years, less than 5% of the total areal coverage should consist of invasive weedy plants such as *Phragmites australis, Lythrum salicaria, Solanum dulcamara, Phalaris arundinacea, Rhamnus frangula*, etc., as determined by "in-field" inspections of established plant communities
5	increased plant diversity in enhanced wetland area	At the end of 5 years, plant diversity should increase in the enhanced wetland area, as determined by data from permanent sample quadrat points
6	<25% cover of *Juncus effusus* in enhanced wetland area	At the end of 5 years, the areal coverage of *Juncus effusus* in the enhanced wetland area should be less the 25% as determined by data from permanent sample quadrat points
7	hydrologic regime	Achieve a mixture of areas which have seasonal (12.5% to 25% growing season) and regular inundation or saturation (25% to 75% of growing season
8	Vegetation	Diversity in vertical strata of plant communities Replace wetland types that were impacted by bank users Create diverse, high quality wetlands Establish scrub/shrub and forested wetlands in areas seasonally inundated Establish emergent wetlands in areas seasonally to regularly inundated
9	Wildlife	By achieving Goals 7 and 8, wildlife diversity will also be increased.

Table B2. Measures of species diversity from quantitative vegetation data from permanent quadrats at the Sandy Ridge Mitigation Bank. Data from Preconstruction and 5th Year Monitoring Report, N=18.

	type	1997	2000	2002
total species	richness	37	16	16
native species	richness	26	11	11
nonnative species	richness	11	3	4
FAC, FACW, OBL species	richness	18	15	12
FACU, UPL species	richness	17	0	1
forb species	richness	20	10	13
graminoid species	richness	6	6	2
shrub species	richness	5	0	1
tree species	richness	4	0	0
FQAI score	index	7.3	6.0	4.8

Table B3. Relative cover of hydrophytes, native and invasive plants from quantitative vegetation data from permanent quadrats at the Sandy Ridge Mitigation Bank. Data from Preconstruction, 3rd, and 5th Year Monitoring Report, N=18. Relative cover calculated by summing all cover values of a species across all quadrats and dividing by the total cover of all species in all quadrats.

	1997	2000	2002
FAC, FACW, OBL species	0.403	0.667	0.653
native species	0.753	0.465	0.390
nonnative species	0.234	0.167	0.287

Table B4. Relative cover of *Juncus effusus* from quantitative vegetation data from permanent quadrats at the Sandy Ridge Mitigation Bank. Data from Preconstruction, 3rd and 5th Year Monitoring Report, N=18. Relative cover calculated by summing all cover values of a *Juncus effusus* across all quadrats and dividing by the total cover of all species in all quadrats (%cover of open water excluded).

	1997	2000	2002
Enhanced area (quadrats 8-12, 17, 18)	0.385	0.143	0.225
Entire site (all quadrats)	0.172	0.081	0.080

Table B5. Measures of species diversity from quantitative vegetation data from ENHANCED AREA permanent quadrats 8, 9, 10, 11, 17, and 18 at the Sandy Ridge Mitigation Bank. Data from Preconstruction, 3rd and 5th Year Monitoring Report, N=6.

	type	1997	2000	2002
total species	richness	15	16	12
native species	richness	12	11	8
nonnative species	richness	3	3	4
FAC, FACW, OBL species	richness	7	15	10
forb species	richness	7	10	10
graminoid species	richness	1	6	0
shrub species	richness	3	0	1
tree species	richness	0	0	0
FQAI score	index	3.9	5.7	3.3

Table B6. Relative cover of hydrophytes, native and invasive plants from quantitative vegetation data from ENHANCED AREA permanent quadrats at the Sandy Ridge Mitigation Bank. Data from Preconstruction, 3rd year and 5th Year Monitoring Report, N=18. Relative cover calculated by summing all cover values of a species across all quadrats and dividing by the total cover of all species in all quadrats.

	1997	2000	2002
FAC, FACW, OBL species	0.608	0.775	0.783
native species	0.891	0.733	0.475
nonnative species	0.075	0.067	0.358

Table B7. Preconstruction, Design Plan, and Actual plant community at each permanent quadrat. Comparison of maps in Appendix B-1 and B-2 in 5th Year Report.

transect	quadrat	Preconstruction	Design Plan	Actual
1	1	upland old field	shallow emergent	shallow emergent
1	2	upland old field	shallow emergent	shallow emergent
1	3	upland old field	deep emergent	deep emergent
1	4	upland old field	shallow emergent	shallow emergent
1	5	upland old field	shallow emergent	shallow emergent
1	6	upland old field	shallow emergent	deep demergent
1	7	upland old field	shallow emergent	deep emergent
2	8	wet meadow	shallow emergent	shallow emergent
2	9	wet meadow	shallow emergent	shallow emergent
2	10	wet meadow	deep emergent	open water
2	11	wet meadow	deep emergent	open water
2	12	wet meadow	shallow emergent	deep emergent
3	13	upland old field/shrub thicket	deep emergent	open water
3	14	wet meadow/shrub thicket	tree/shrub	deep emergent
3	15	wet meadow/shrub thicket	tree/shrub	deep emergent
4	16	upland old field	shallow emergent	deep emergent
4	17	upland old field	deep emergent	open water
4	18	wet meadow	shallow emergent	shallow emergent
			% actual = design	44%

APPENDIX C
MAPS OF BANK SITES