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FUNCTIONAL ASSESSMENT OF FIVE WETLANDS CONSTRUCTED TO MITIGATE WETLAND LOSS IN OHIO, USA

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Abstract: Five replacement wetlands in Ohio, USA, were investigated to determine their ecological and legal success. Hydrology, soils, vegetation, wildlife, and water quality of each wetland determined their functional success. The progress of the wetlands was also compared to their legal requirements. Four of the five wetlands (80%) were in compliance with legal requirements and the same four wetlands demonstrated medium to high ecosystem success. For the four wetlands, a replacement ratio of 1.4:1 was achieved for area, and depressional wetlands were generally replaced with depressional wetlands.

Key Words: mitigation, wetland creation, freshwater marsh, hydrology, forested wetland, Ohio, functional assessment, created and restored wetlands

INTRODUCTION

It is now the policy in the United States to have "no net loss" of wetlands (Mitsch and Gosselink 1993). Regulations related to Section 404 of the Clean Water Act (CWA) require that wetlands lost due to dredging and/or filling be replaced at some ratio, determined on a state-by-state basis. While the protection of wetlands through Section 404 is somewhat effective, it may not prevent wetland losses as effectively as it should (Mitsch and Wilson 1996). Market processes are continually putting stresses on wetland protection efforts. Many property owners believe that wetlands on their land are their property and that they should be free to do what they want with them (Leitch 1985). The replacement of wetland area lost or disturbed by human activity, sometimes referred to as "wetland mitigation," could possibly remedy this conflict through construction or restoration of another wetland. This approach, however, is opposed by many ecologists who believe that there is a lack of knowledge about how to build a wetland properly (Roberts 1993). On the other hand, if wetland creation and restoration can be shown to provide a viable and reliable compensation for wetland loss, unavoidable losses of wetlands can be balanced with wetland gains.

In the mid-1980s, research began on the implementation of mitigation for wetland losses (e.g., Maguire 1985, Reimold and Cobler 1985). Although some scientists involved in wetland restoration and mitigation believed that mitigation was working (Harvey and Josselyn 1986), others suggested the need for more research (Kusler and Groman 1986, Race 1986). More recent reviews of the process (e.g., Kentula et al. 1992, Sifneos et al. 1992, Atkinson et al. 1993, Reinartz and Warne 1993, and Erwin et al. 1994) have suggested mixed results on the efficacy of the process.

The objective of this study was to estimate the success of five wetlands that were created/restored in Ohio to mitigate for wetlands that were lost elsewhere. The emphasis was on determining losses and gains in ecological function. Ecological function can be evaluated by comparing the replacement wetlands to reference wetlands (natural wetlands of the same type that may occur in the same setting) or to generally accepted "standards" of wetland function; legal success can evaluated by comparing the replacement wetlands to those that were lost (Figure 1) or by comparing the functioning of the replacement wetland to what was required in the permitting process. According to many Section 404 permits, the most important features in creating wetlands for mitigation of lost wetlands elsewhere are size, vegetative cover, and wildlife use. In a few cases, the prevention of water quality deg-

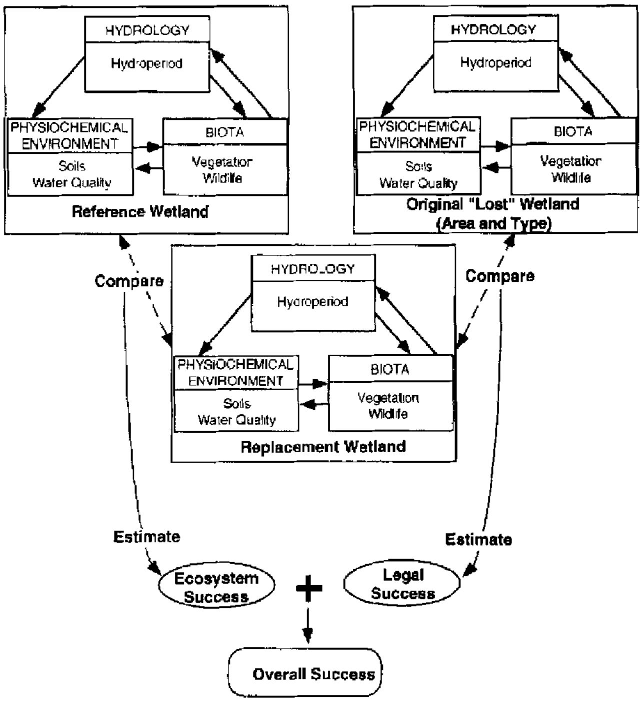


Figure 1. Schematic diagram of proper approach needed to determine success of replacement wetlands created for mitigation of wetland loss.

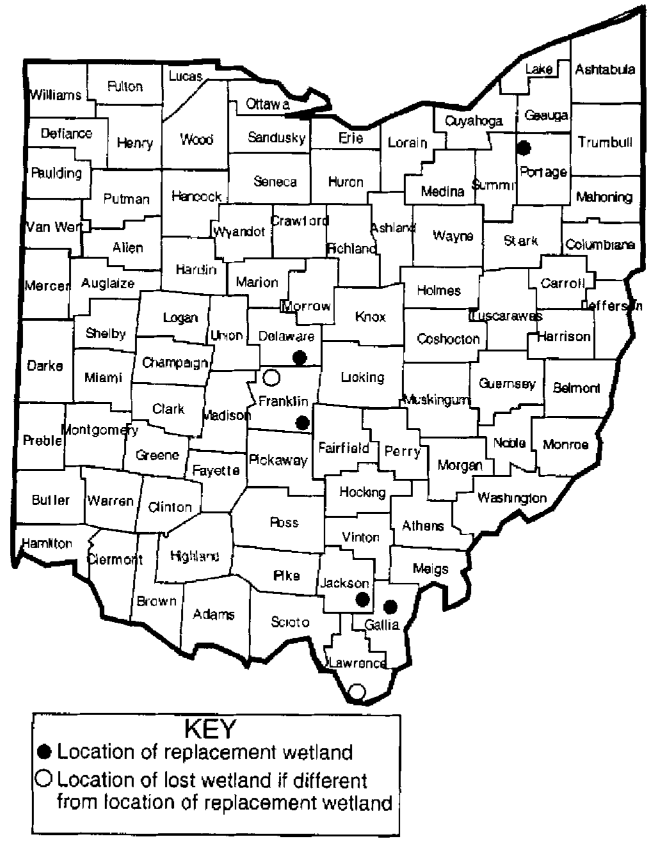


Figure 2. Locations of the five mitigation wetlands in Ohio, USA, included in this study and locations of the lost wetlands if different from the replacement wetland area.

radation is also considered (e.g., Niswander and Mitsch 1995). This study covered six different measures of replacement wetland function: hydrology, soils, vegetation, wildlife use, water quality, and compliance with 404 permits (legal success). The following questions were used to estimate the functional success of the mitigation sites:

- Hydrology and hydrogeomorphology: Is the mitigation site located in the same watershed? Has a hydrogeomorphic setting similar to the lost area been used in the replacement wetland?
- Soils: Were the soils in the creation site suitable for constructing a wetland? Are they now or will they over time show hydric characteristics?
- Vegetation: Has wetland vegetation established itself at the mitigation site? Is the vegetation present at the creation site similar to the vegetation lost to the dredge or fill activity? Is the diversity of the vegetation comparable to the lost vegetation or is there an indication that monocultures have or may occur?
- Wildlife: Is there evidence of wildlife using the mitigation site? Wildlife was chosen as one of the possible indicators of ecosystem success for this study because wetlands are often used by a variety of wildlife as nesting sites and as a food source. Absence of wildlife could indicate a functional problem with any wetland.
- Water Quality: Is the replacement wetland preventing degradation of water quality or is it adding to degradation of water quality in its watershed?
- Legal Success: Was the replacement wetland built on-site or off-site? Does each site under investigation follow, as closely as possible, the permit conditions issued to them and the original plans provided to the permitting agency?

METHODS

Site Descriptions

Five replacement wetlands in Ohio, USA, were selected for this study. The sites studied are located in Portage, Delaware, Franklin, Jackson, and Gallia counties (Figure 2). Complete Section 404 permits, public notices, mitigation plans, and current mitigation reports were needed for each site to conduct this study. Study sites were chosen based on the amount of information available on them. The five sites in this study were of various ages (years after completion of wetland creation or restoration). The replacement wetland in Franklin County (called "Franklin") was the newest; construction was completed in the fall of

1993. The Delaware and Portage County (called "Delaware" and "Portage" respectively) replacement wetlands were completed in 1992. The Gallia County replacement wetland (called "Gallia") was completed in 1991, and the Jackson County wetland (called "Jackson") was completed in 1990. Information on each of the mitigation sites was collected from material provided to the Ohio EPA by the permit applicants (mitigation plans, annual reports, etc.) and material provided directly by the Ohio EPA (Section 404 permits, public notices, etc.). This material provided information on the type and size of wetlands lost due to construction projects and dredge and fill activities. Additional material from the Ohio EPA, provided by the applicants, in some cases contains more information, such as vegetation lost, types of soils, hydrology, and water quality function of the destroyed areas. Details not outlined in the above information sources came directly from site visits.

The Portage site is the result of an after-the-fact mitigation for the disruption of a low quality wetland during construction of a service road. The mitigation site replaces approximately 0.4 ha of disturbed wetland area with 0.6 ha of restoration of an emergent wetland area on the same site. The wetland restoration included deepening the basin by less than one meter and restoring the flow characteristics by construction of culverts under the road. The source of water is sheet flow from a large adjacent natural wooded wetland. Outflow is channeled under the service road by three 61-cm culverts.

The Delaware site, before construction of a golf course, contained 34.2 ha of wetland, 3.7 ha of which were filled for construction. To mitigate the loss, 5.4 ha of wetland (1.5 ha wooded and 3.9 ha emergent) were created on the golf course. The area is located on a very gentle slope with two drainage areas. One flows from the northeast to a reservoir; the other, a drainage ditch (Spring Run), flows south. The system was designed to allow a one-year storm event to fill the wetland, with any excess flow moving southward in Spring Run. The water source for the mitigation basins is rainwater and runoff. Soil types were identified as Bennington-Pewamo-Cordington association. Forty percent of the soils on the site were classified as hydric in the monitoring report.

In Franklin County, 15 ha of jurisdictional wetlands were lost for the construction of a shopping center in the northeastern part of the county. The area was highly disturbed and had been farmed for over 37 years prior to the shopping center development. The mitigation area is located on a 34.3 ha site in southeastern Franklin County. The mitigation plan called for the creation/restoration of 28 ha of forested, emergent and submergent wetlands, and construction and planting was completed in 1993. Water for the pond comes from adjacent Blacklick Creek, and the inflow is controlled by a large permanent cement and steel weir. A similar weir is found at the outflow of the pond, and another weir is located at the end of the outflow drainage ditch into Blacklick Creek. Five soil types were listed for the area: one hydric, two having hydric inclusions, and two well-drained.

The disrupted site for the Jackson County mitigation project is located in Lawrence County, near the Ohio River in the southern tip of Ohio (Figure 2). A wetland of 6 ha was filled for the construction of a parking lot and access road to a new department store. The mitigation site was constructed in Jackson County along the floodplain of Symmes Creek. Restoration and construction of 7.2 ha of wetland were completed to mitigate for the loss of the 4.8 ha of wetland in Lawrence County. Six ha of forested wetlands, 0.8 ha of scrub/shrub emergent wetland, and 0.4 ha of emergent wetland were planted. The Jackson mitigation site used several control structures for the hydrology. An existing drainage ditch was used for inflow, along with an existing coal mine seep. Rainfall and runoff also contributed to the wetland's water supply. Outflow into the creek was not observed during site visits but a riprap drain on the southern half of the wetland was installed for drainage during high water periods.

The Gallia mitigation site covers 2.8 ha and is located along the embankment of U.S. Route 35 and a bottomland forest along an unnamed tributary of Raccoon Creek just southeast of Rio Grande, OH. The mitigation was to replace 0.5 ha of wetland destroyed during construction of U.S. Route 35 with 0.8 ha of wooded and herbaceous wetland. The Gallia site is built on a floodplain adjacent to the tributary, and the primary source of water comes from seasonal flooding of the creek and rainfall. A preconstruction survey of the site indicated that sampling areas were upland soils with no hydric characteristics, except for one site where hydric characteristics appeared 10 cm below the surface.

Hydrology and Hydrogeomorphology

Each created or restored wetland was reviewed to determine if it was located in the same watershed, if it was similar in hydrogeomorphic type (Brinson 1993) to the lost wetland, and if it had a hydroperiod that was consistent with what would be found in a natural wetland. Background information on the hydrogeomorphic type of the wetland lost was collected from existing sources (mitigation plans and annual reports). Water levels were measured five to six times between early spring 1994 and early spring 1995 during field visits by returning to a selected point at each wetland

and measuring the depth with a meter stick or staff gauge. Monthly rainfall data and deviations from normal for towns near the mitigation sites were collected from Ohio Agricultural Statistics to determine whether the wetlands' water levels were being influenced by abnormally low or high rainfall.

Soils

Available county soil maps, as well as county soil maps not yet published by the Soil Conservation Service (now Natural Resources Conservation Service), were used to determine the types of soil present in the wetland mitigation areas before construction of the basins. Some data on soil types were available from the mitigation plans and the monitoring reports provided to the Ohio EPA, and these were used to supplement the soil survey information.

Field soil data were collected in the early to mid-summer of the study year from four sampling stations per replacement wetland site. A 1.9-cm diameter manual soil corer was used to collect samples from the surface to 30.5 cm (12 inch) deep for color determination. Permanently flooded/intermittently flooded, semi-permanently flooded/seasonally flooded, saturated, and temporarily flooded/intermittently flooded areas (Mitsch and Gosselink 1993) were sampled at each site when possible. Soil color was determined by using a Munsell Soil Chart (Macbeth Division of Kollmogen Instruments Corporation 1990); soils were also checked for hydric characteristics such as gleying and mottling. Nutrient analyses (available phosphorus, potassium, calcium, and magnesium) and pH of the surface soil (USDA 1984) were determined by the OARDC Research and Extension Analytical Laboratory (R.E.A.L.) in Wooster, OH by using methods described in the North Dakota Agricultural Experiment Station (1988) manual. Units of lbs/acre reported by R.E.A.L. were converted to μg/g using the method described in Mitsch et al. 1989).

Vegetation

Information on vegetation was collected for all of the mitigation sites by the applicant and compiled in the existing mitigation plans as percent cover. Additionally, surveys were taken at each site by the applicants at least once per year to check the progress of introduced and volunteer plants. In some cases, invasive species had been removed by hand and dead trees replaced in-kind.

Vegetation was sampled along transects at each site; three random plots were surveyed using a 0.25 m^2 sampling square at sampling points every 10 to 20 m along the transects, depending on site size and information available on the sites. Randomization at each sampling point was accomplished by tossing the sampling square behind the back from a set point along the transect line (Kent and Coker 1992). Percent cover was estimated visually for each species present (Kent and Coker 1992). Vegetation was classified according to Reed (1988). Open-water areas were not surveyed unless submerged or floating aquatic vegetation was noted and the depth of the water was safe to work in (less than 1 m deep). Vegetation data collection occurred in the mid-to-late summer. Areas falling along the transect lines that were obviously not part of the mitigation project (points on high knolls, with dry and well drained soils, or with no wetland vegetation present) were not included in this study.

Wildlife

One visit per site in the spring was dedicated to wildlife observation. Spring visits were scheduled to coincide with waterfowl spring migrations. Additional observations during other site visits were noted. Visual observation was the only data collection method used. Both direct (actual observation of an animal) and indirect (observation of tracks, burrows, scat, etc.) methods were used.

Water Quality

Water was collected in 250-ml plastic bottles and preserved according to APHA (1989); samples were filtered using a 0.45 micron, 47 mm filter and frozen for ortho-phosphate analysis. Collection took place at the inflow and outflow, or end of flow if no outflow was present at each site. Sampling began in the spring, with an inflow and outflow sample from each site collected once in April. A second set of samples at the inflows and outflows was collected once in April. A second set of samples at the inflows and outflows was collected from each site in June or July after a summer storm. Samples were analyzed for ortho-phosphorus at the Wetlands Ecology Lab in the School of Natural Resources, OSU on a LACHAT autoanalyzer using the ammonium molybdate and antimony potassium complex process (USEPA 1983).

Legal Success

All available documents related to the mitigation activities in this study were collected and analyzed. Legal success is defined by whether or not the permit applicants have honored the contractual agreements made with the permitting agencies. Specifications in permits and approved mitigation plans must be met to be considered legally successful.

Table 1. Hydrogeomorphic (Brinson 1993) and vegetation types of five wetlands lost and created in Ohio.

Site	Hydrogeomorphic setting		Vegetation Type	
	Lost Wetland	Replacement Wetland	Lost Wetland	Replacement Wetland
Portage	Slope	Channel	Emergent	Emergent and wooded
Delaware	Depressional (surface outlet only)	Depressional (surface outlet only)	Emergent and wooded	Emergent, wooded, and scrub/shrub
Franklin	Depressional (no inlet or outlet)	Depressional (inlet and outlet*)	Emergent	Emergent, wooded, and scrub/shrub
Jackson	Depressional (surface outlet only)	Depressional (surface inlet only)	Emergent	Emergent and scrub/shrub
Gallia	Depressional (no inlet or outlet)	Depressional (surface inlet only)	Emergent	Emergent and wooded

* Outlet was evident only early in study season; soil berm was added at outflow in June of 1994. A large, permanent weir replaced soil berm in August of 1994.

Ecosystem Success

Ecological success of the five wetlands was estimated by using an adaptation of the WET II system developed by Adamus et al. (1989).

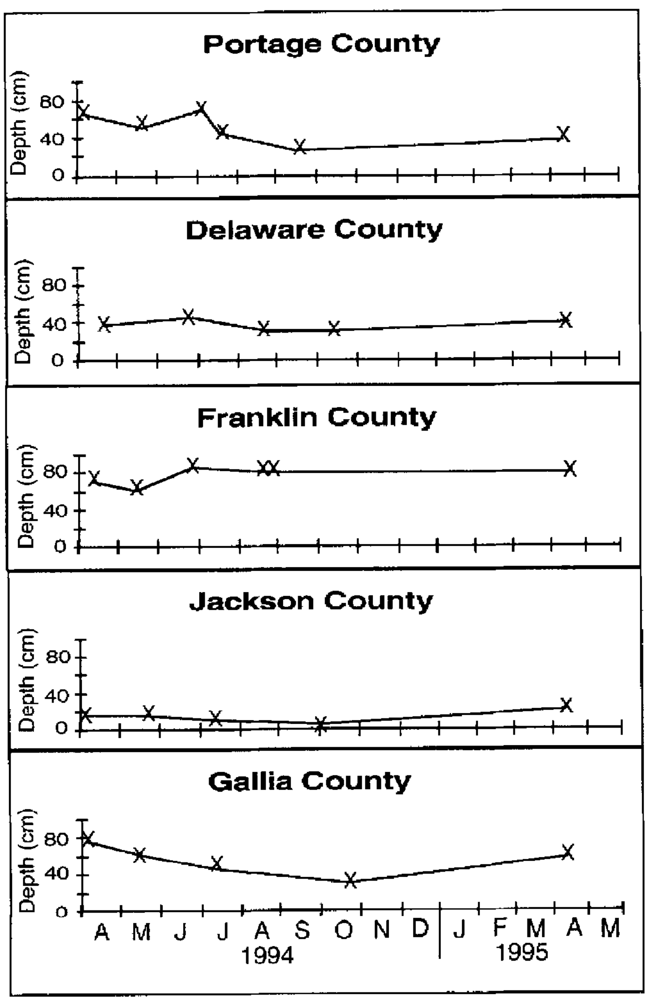


Figure 3. Hydroperiods (approximate standing water depth) for the five replacement wetlands in this study.

RESULTS AND DISCUSSION

Hydrology and Hydrogeomorphology

Because wetland functions are dependent on their hydrologic and geomorphic conditions (Brinson 1993), replacement of lost wetland hydrogeomorphic characteristics should be the desirable outcome for all mitigation projects. In four of the five wetland mitigation cases, depressional wetlands were replaced with depressional wetlands, but in only one of those cases (Delaware County) were the flow conditions (inflow and outflow) he same in the lost and replacement wetland (Table 1). The Franklin and Gallia mitigation projects replaced depressional systems having no surface inlets or outlets with systems that had at least an inlet, and the Jackson site replaced an outlet-only depressional wetland with a inlet-only depressional wetland. The replacement of a slope wetland with a channel wetland at Portage was the most dramatic change in hydrogeomorphic conditions noted in this study. In that case, the adjacent wetland that was "enhanced" for this mitigation project had slow sheet flow while the replacement wetland had channelized flow and did not provide the same amount and duration of saturation of the soil that was once present.

During the growing season (from early April to late October 1994), all but one site showed a drop in water level (Figure 3). The Portage and Gallia replacement wetlands both showed a drop in water levels of over 40 cm. The Delaware water levels dropped by 7.5 cm, and the Jackson water level dropped by over 10 cm. The Franklin replacement wetland water level rose (+10 cm) during this period because control structures were added to the site throughout the study period to slow the flow of water through the pond.

In four of the wetlands studied, the water supply seemed sufficient to support wetland habitat (1994 precipitation was normal for all of the sites except Jackson and Gallia, where precipitation was slightly below

Table 2. Soil color data collected from soil cores for replacement wetlands. Value and chroma based on Munsell Soil Chart (Macbeth Division of Kollmogen Instruments Corporation 1990).

Site	Sampling Station	Depth, cm	Hue	Value	Chroma	Color	Notes
Portage	1	17.8	7.5YR	3	2	Dark brown	Very dry on bottom of sample
	2	5	2.5Y	5	2	Grayish brown	
	2	5 –15.2	10YR	4	1	Dark gray	
	2	15.2–20.3	—	—	—	—	Oxidized rhizospheres
	3	10.2	2.5Y	5	2	Grayish brown	Very sticky
	3	12.2–20.3	2.5Y	4	0	Dark gray	Very sticky
	3	20.3–30.5	—	—	—	—	Oxidized rhizospheres
	4	15.2	2.5Y	6	2	Light brownish gray	
	4	15.2–35.6	5Y	5	1	Gray	
Delaware	1	20.3	10YR	3	1	Very dark gray	
	2	15.2	2.5Y	4	2	Dark grayish brown	Bottom 10–15 cm unconsolidated
	3	7.6	2.5Y	3	2	Very dark grayish brown	
	3	7.6–30.5	10YR	5	3	Brown	Oxidized rhizospheres
	4	30.5	10YR	6	1	Gray	Oxidized rhizospheres
Franklin	1	30.5	10YR	2	1	Black	Very unconsolidated silt and sand
	2	12.1	10YR	4	6	Dark yellowish brown	
	2	12.1–27.3	10YR	4	3	Dark brown	
	3	5	7.5YR	3	0	Very dark gray	Soft and semi-unconsolidated
	3	5 –11.4	10YR	4	4	Dark yellowish brown	Soft and semi-unconsolidated
	3	11.4–30.5	10YR	3	2	Very dark grayish brown	Firm clay and sand mixture
	4	11.4	10YR	3	2	Very dark grayish brown	
	4	11.4–27.9	10YR	3	1	Very dark gray	
Jackson	1	15.2	2.5Y	5	4	Light olive brown	Some mottling
	2	11.4	2.5Y	5	4	Light olive brown	Some mottling
	3	10.8	5Y	5	2	Olive gray	Very compact at 11.3 cm
	3	11.4–21.6	2.5Y	6	4	Light yellowish brown	Compact clay
	4	30.5	2.5Y	6	3	Light yellowish brown	Uniform color and texture
Gallia	1	22.9	10YR	5	3	Brown	Uniform color
	2	15.2	10YR	5	3	Brown	Sharp color difference in core
	2	15.2–26	5Y	3	2	Dark olive gray	Sharp color difference in core
	3	17.1	10YR	5	3	Brown	sharp color difference in core
	3	17.1–29.8	5Y	5	2	Olive grey	Sharp color difference in core
	4	10.1	10YR	5	4	Yellowish brown	Sharp color difference in core
	4	10.1–23.5	10YR	4	6	Dark yellowish brown	Sharp color difference in core

normal for the sampling year) . The Delaware wetland was designed to be full after a one-year storm event; therefore, the probability of this replacement wetland becoming dry is low except in the cases of severe drought. The Portage wetland is adjacent to a large natural wetland system that is the replacement wetland's main source of water. It is doubtful whether this wetland will revert to an upland system except in periods of extreme drought. The Jackson wetland, with its two sources of water, will most likely remain a wetland. The amount of annual rainfall can severely affect the vegetation and, since precipitation was below normal for 1994, it is doubtful whether the wetlands will be dry in the future. The Gallia wetland had a sufficient water source from the nearby stream and precipitation, which was low for the sampling year. Runoff received by this wetland was limited due to the construction measures taken to prevent road runoff from entering the system. The Franklin replacement wetland, while receiving sufficient water from the adjacent creek, may never become a wetland. The areas of major concern are the pond and the surrounding uplands planted in trees—essentially the entire mitigation area. The pond receives and holds too much water, now that dams have been installed, to be considered a wetland. The areas surrounding the pond re-

Table 3. Comparison of soil nutrients for the five replacement wetlands in this study, Lake Erie coastal wetlands in northern Ohio, and the Des Plaines River Wetlands (DPRW) constructed wetlands in Lake County, IL (nutrient concentrations are averages ± std. error).

Location/Reference	# Samples	P µg/g	K µg/g	Ca µg/g	Mg µg/g
This study					
Portage	4	6 ± 2	80 ± 34	1334 ± 688	311 ± 198
Delaware	4	6 ± 2	133 ± 33	1908 ± 559	414 ± 207
Franklin	4	18 ± 21	49 ± 14	870 ± 255	81 ± 31
Jackson	4	9 ± 2	57 ± 30	2575 ± 778	285 ± 97
Gallia	4	12 ± 6	51 ± 15	608 ± 269	132 ± 62
Natural Wetlands[1]					
Lake Erie diked	5	26 ± 33	521 ± 362	7148 ± 3897	321 ± 258
Lake Erie undiked	4	43 ± 22	586 ± 231	5202 ± 1914	320 ± 93
Constructed Wetlands[2]					
DPR-EW 3	8	5 ± 4	92 ± 19	5663 ± 907	982 ± 232
DPR-EW 4	7	20 ± 10	108 ± 17	4383 ± 894	732 ± 140
DPR-EW 5	7	12 ± 6	119 ± 35	3716 ± 719	642 ± 191
DPR-EW 6	7	23 ± 6	97 ± 44	3930 ± 727	816 ± 449

[1] Data from Mitsch et al. 1989.
[2] Data from Fennessey 1991 (DPR-EW = Des Plaines River-Experimental Wetland).

ceive no flooding from the creek and drain rapidly after large storms. The hydrology of this mitigation attempt seems inadequate to create a long-lasting wetland.

Soils

Color and Classification. All of the replacement wetlands showed indications of hydric soils. Because these wetland replacements mostly involved wetland restoration rather than creation, the soils were presumably hydric before the construction occurred. At least one station per site contained a soil sample with a chroma of two or less (Table 2). Additionally, the Portage , Delaware , and Jackson soil samples showed other hydric characters such as mottling and oxidized rhizospheres. Most of the soil samples at the Gallia mitigation site showed a sharp demarcation in color.

Chemistry. Comparison of nutrient concentrations in soil for the five replacement wetlands in this study with those from natural, although managed, wetlands along Lake Erie in northern Ohio (Mitsch et al. 1989) and for four experimental wetlands at the Des Plaines River Wetlands Demonstration Project (DPRW) in northeastern Illinois (Fennessy 1991) are given in Table 3. All analyses were performed by the same laboratory. The five replacement wetlands in this study consistently showed lower concentrations of phosphorus, potassium, calcium, and magnesium. Most of the similarities in nutrients are found between the two groups of created wetlands. Phosphorus levels for the study wetlands and the constructed DPRW wetlands were similar. Phosphorus levels in the Lake Erie wetlands were higher than those for either set of created wetlands, probably reflecting the sediment-rich and phosphorus-rich streams that enter Lake Erie and its coastal zone from Ohio. Potassium levels in the Great Lakes wetlands were higher than those in either of the groups of created wetlands. Calcium concentrations in the study wetlands were low when compared to the Great Lakes wetlands, but there was some overlap between the two groups of created wetlands. Magnesium concentrations in the Franklin and Gallia replacement wetlands were low when compared to the natural and restored wetlands. Magnesium in the other three mitigation sites was comparable to the Lake Erie wetland concentrations. The concentrations of magnesium were much higher at the DPRW experimental wetlands.

Vegetation

A large variety of plant species was reported at the five replacement wetlands. Data collected from annual mitigation reports indicated that there was a combined total of 99 herbaceous species and 37 woody species present across all of the sites. The 1994 vegetation surveys of the five sites conducted for this study identified 114 herbaceous plant species and 4 woody species along the random sampling transects.

The distribution of plant taxa in wetland indicator categories (Reed 1988) for all the sites is represented in Figure 4, and the percent cover of each plant species

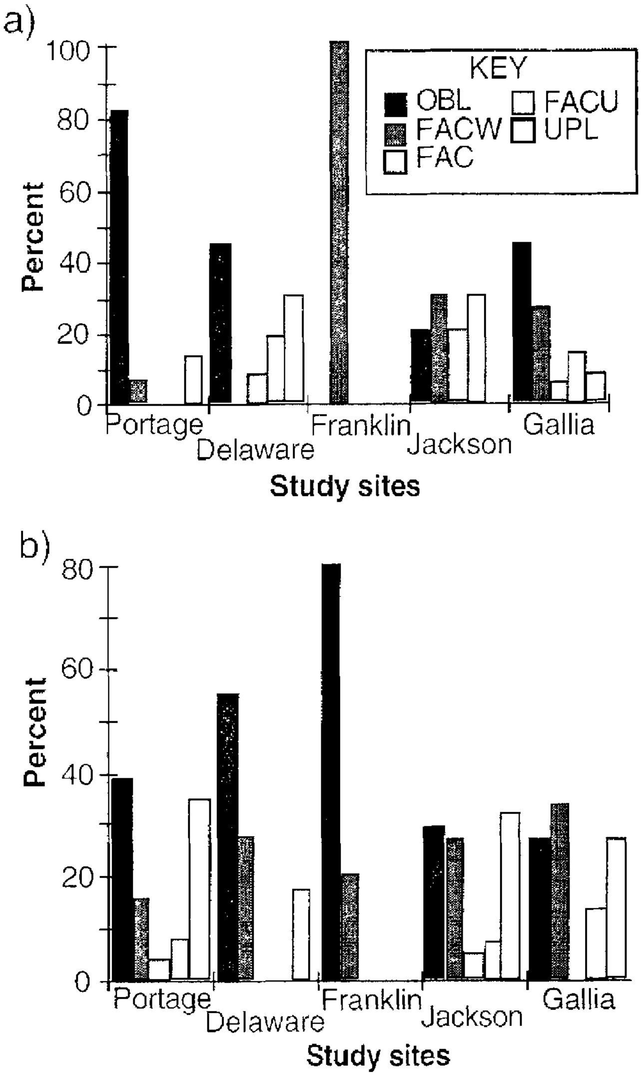


Figure 4. Percent cover per class (Reed 1988) of vegetation per site found in a) mitigation reports and b) 1994 vegetation survey of the five mitigation wetlands. OBL = obligate; FACW = facultative wet; FAC = facultative; FACU = facultative upland; and UPL = upland.

identified in the replacement wetlands is shown in Figure 5. According to the mitigation annual reports, each site contained at least 50 percent and up to 100 percent of the plant species in the categories facultative (FAC), facultative-wet (FACW), and obligate (OBL) (Figure 4; nomenclature according to Reed 1988). The field study results varied from the data found in the monitoring reports. In three instances, the percent of species found at the sites was less than that found in the reports. On one occasion, it matched, and on another occasion, the field study found a higher percentage of plant species in the above grouping. While data differ, the percentage of taxa at each site for the categories FAC, FACW, and OBL was greater than 50 percent in all instances.

Table 4. Wildlife observations for the five replacement wetlands.

Location[a]	Total Observed	Wetland-Dependent Taxa: Birds	Mammals	Other	Total	% Dependent
Portage	17	6	2	0	8	47
Delaware	20	6	0	4	10	50
Franklin	21	7	0	0	7	33
Jackson	25	3	1	3	7	28
Gallia	13	3	1	2	6	46

[a] Site visit dates dedicated to wildlife observations: Portage: 6 April, 21 May 1994; Delaware: 22 April, 20 May 1994; Franklin: 12 April, 16 May 1994; Jackson: 5 April, 17 May 1994; Gallia: 5 April, 17 May, 1994. Wildlife were also observed on other dates in June, July, August, September, and October 1994 during site visits for other purposes.

In all cases, dominance of wetland vegetation was established at the replacement wetland sites; however, the diversity of plants present in these mitigation areas varies from site to site. The Franklin replacement wetland seems to be the most successful in vegetation establishment in terms of total percent cover of vegetation classes. However, there were only four species of submerged plants identified during random sampling and they were from a relatively small part of the entire site. The Gallia replacement wetland fared the worst when looking at the total percent cover of vegetation classes; however, there was a much higher diversity of plants noted on the site. Trees were planted at the Jackson and Franklin sites in "random clumps." However, our field survey indicated that the trees were planted on 10 to 20 m grids. This does not mimic natural establishment of trees.

In the cases of the Portage and Delaware sites, and partially in the cases of the Jackson and Gallia sites, the same type of wetland vegetation lost was reesta-

Table 5. Ortho-phosphate concentrations (μg-P/l) at the inflows and outflows of replacement wetlands in the spring and after a summer storm.

Site	Date	Ortho-phosphate (μg-P/l): Inflow	Outflow	Change	% Decrease
Portage	4/94	32	26	6	18.7
	7/94	72	58	14	19.4
Delaware	4/94	36	14	22	61.1
	6/94	52	18	34	65.4
Franklin	4/94	53	7	46	86.8
	6/94	51	50	1	2.0
Jackson	4/94	90	22	68	75.6
	7/94	87	67	20	23.0
Gallia	4/94	25	17	8	32.0
	7/94	17	20	−3	−17.6

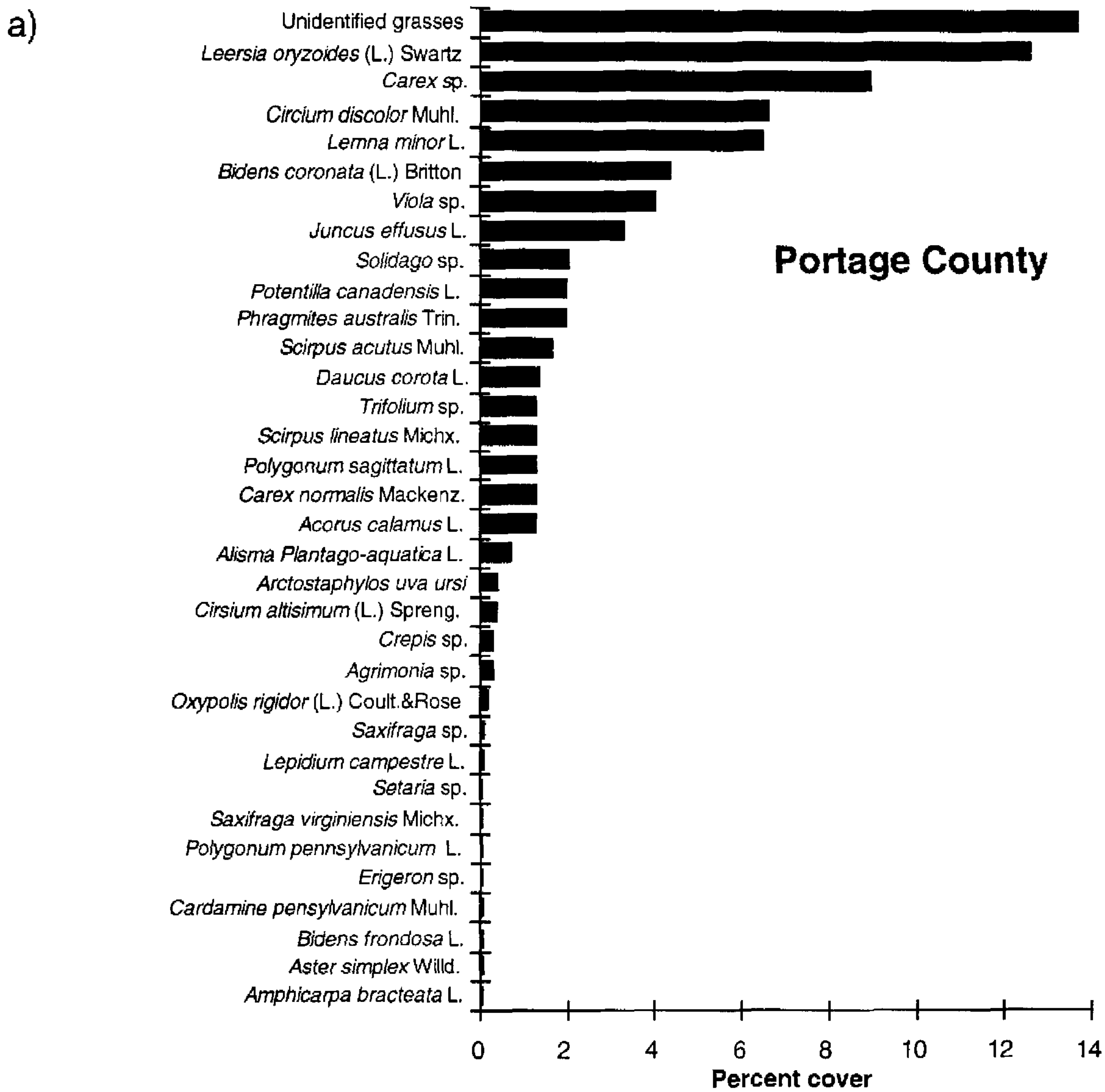


Figure 5. Percent cover of vegetation species identified at mitigation wetlands in a) Portage County b) Delaware County c) Franklin County d) Jackson County and e) Gallia County.

blished at the replacement wetland (Table 1). Jackson and Gallia both required the replacement of some woody vegetation along with the herbaceous vegetation even though no woody vegetation was lost due to construction. The Franklin wetland failed in replacing the type of plants lost due to construction. The type of lost vegetation was emergent; it was replaced with submerged vegetation in the pond and thousands of planted trees on an upland floodplain.

Wildlife

A total of 48 bird, mammal, and other animal taxa were noted at the five replacement wetland sites (Table 4). Each taxon was only counted once; number of observations of each would have served no purpose because there was only one organized trip to observe wildlife (April), with observations from other site visits used as supplements. The Portage and Gallia mitigation sites had the smallest number of taxa noted (17 and 13, respectively). The other three sites in the study had at least 20 taxa noted. The Jackson site had the highest number of taxa (25) noted during site visits.

The low numbers of wildlife at the Gallia wetland are most likely due to the proximity to a major highway (<200 m away). The Portage site is close to a medium-use road that could affect wildlife use of the site. The proximity of the wetland to the wastewater treatment plant access road, where large trucks were often observed, and to a school bus turn-around may

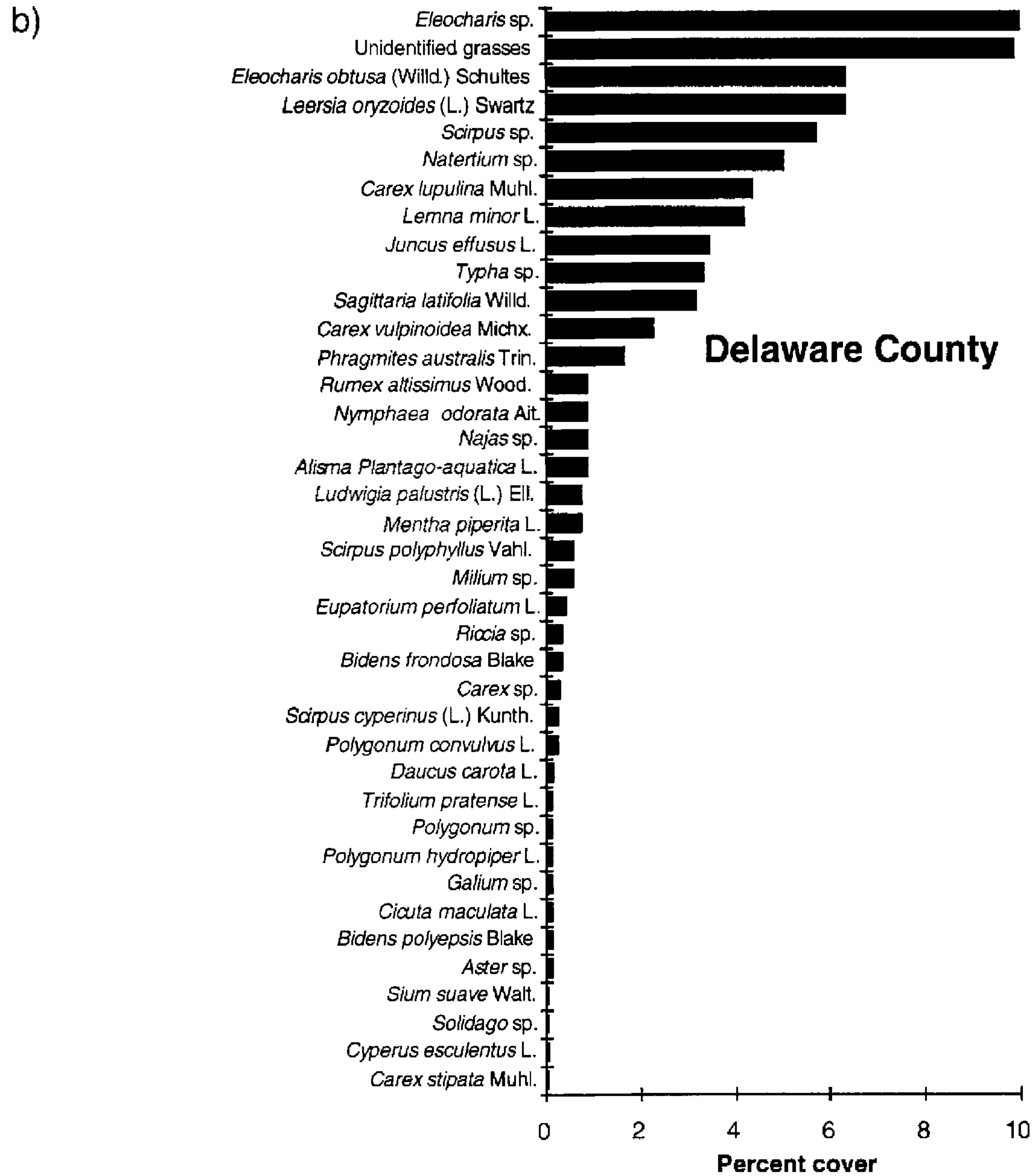
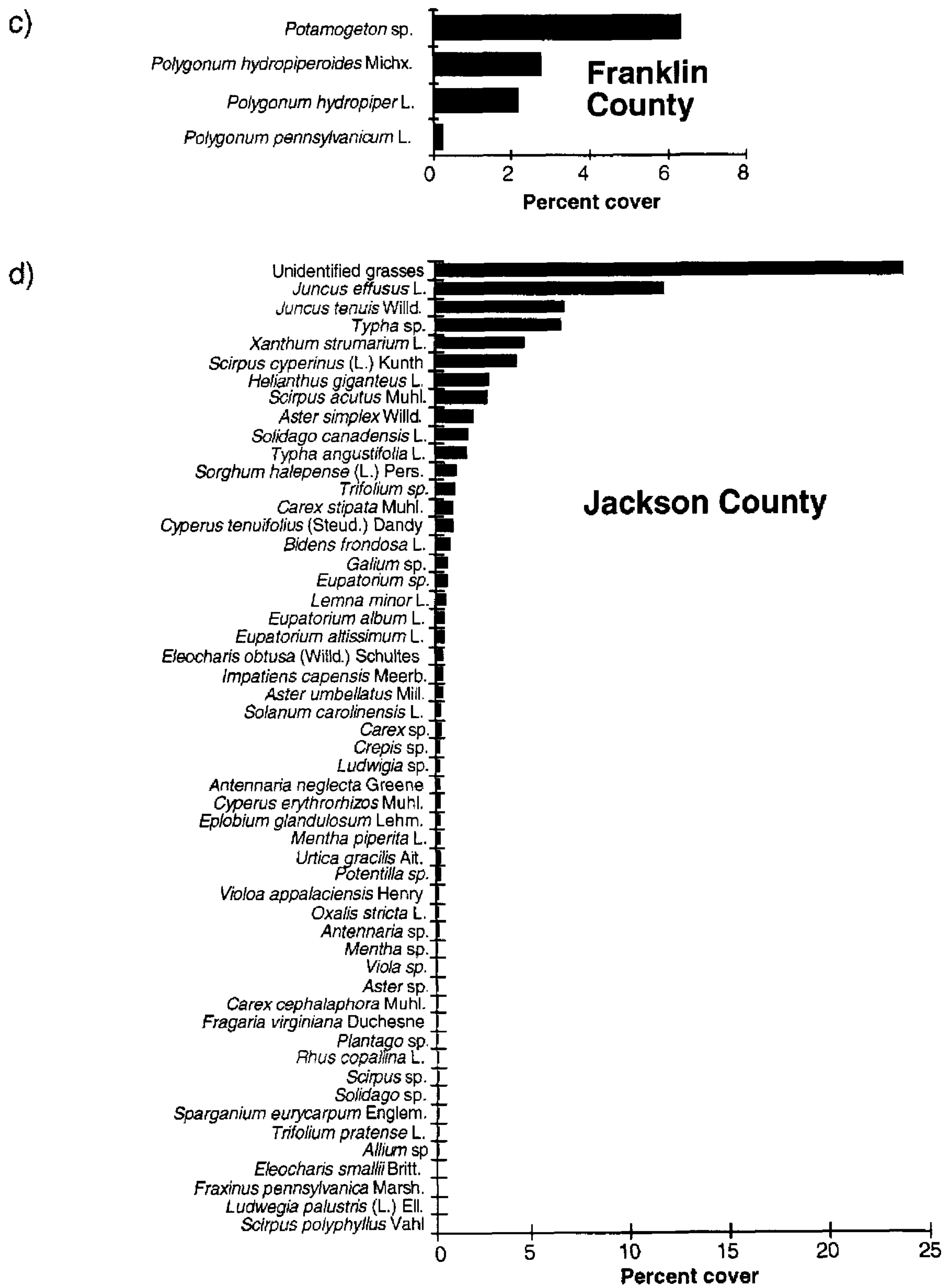


Figure 5. Continued.

have affected the wildlife use. The Delaware and Franklin replacement wetlands had a number of wildlife observations. The Franklin site is located near a highway; during site visits, traffic noise could not be heard. It is also along Blacklick Creek, which most likely contributes to the higher number of wildlife observations. The Delaware replacement wetland is not near any large roads, but it is located on a golf course. If it were not for the heavy golf cart traffic around the wetlands, wildlife use of the site might have been higher. All of the mitigation ponds at the Delaware site are adjacent to natural wetlands close to a major reservoir. The Jackson site had the greatest number of wildlife observations. This wetland is in a rural area that receives very little traffic (less than one car per hour on the adjacent road), and the replacement wetland is along an existing stream.

All of the replacement wetlands in this study supported at least three and up to five wetland-dependent species of birds (Brooks and Croonquist 1990). One site (Portage) gave evidence of beaver (*Castor canadensis* Kuhl) use, and three (Portage, Jackson, and Gallia) showed signs of muskrat (*Odontra zibethicus* L.) use. Both of these mammals have been classified as wetland dependent species (Brooks and Croonquist 1990).



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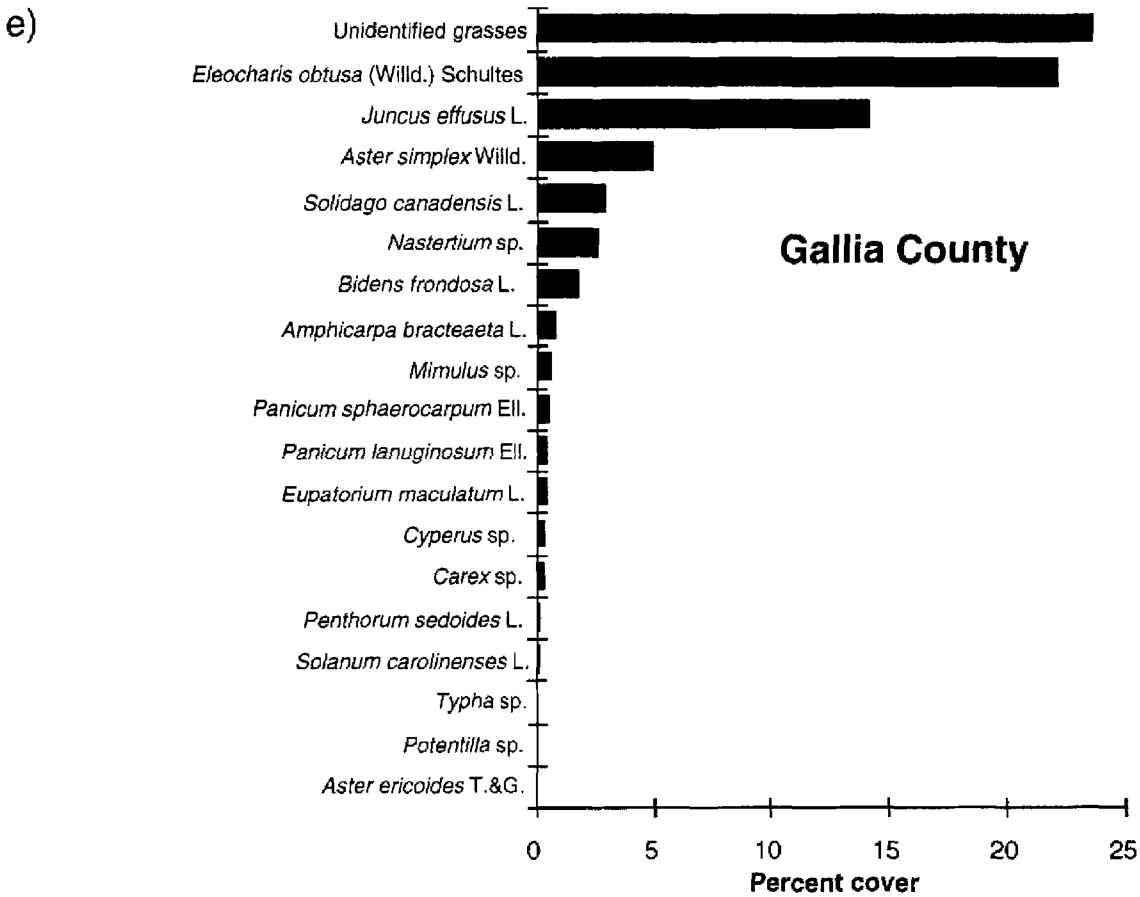

Figure 5. Continued.

It is doubtful that the low number of taxa present at the replacement wetlands is due to a flaw in the replacement wetlands themselves. The low numbers are probably reflect outside disturbances and the relative "youth" of the wetlands. While replacement wetlands are generally not specified to support wildlife, they usually do. Most of the study's wetlands were small or consisted of a number of small wetlands to cover the required area. Gibbs (1993) indicated that small wetlands are of vital importance to the support of many wetland-associated animals.

Water Quality

The water quality function of the replacement wetlands was estimated from one parameter, ortho-phosphate (OP) (Table 5). Water quality samples were taken once in the spring and once within 24 hours of a large storm in the summer. Storm intensity and duration could only be estimated due to the distance of the sites from any weather station. In all but one instance (Gallia site for July, 1994), the OP concentration at the outflow of the wetland was lower than it was at the inflow of the wetland (Table 5). The Delaware replacement wetland did show a higher percentage of OP concentration decrease from inflow to outflow after a summer storm than it did during regular flow. The Franklin, Jackson, and Gallia replacement wetlands all removed a smaller percentage of OP from the water after a storm than during dry weather flow. The higher OP retention at the Delaware replacement wetland could be a bad data point. Terramark™ dye is periodically added to the inflow and outflow water for aesthetics by the golf course staff and it could interfere with analytical methods.

Legal Success

On-Site vs. Off-Site. Wetlands constructed for mitigation of wetland loss are often built on or in the same area where the disruption occurred ("on-site"); Portage County, Delaware County, and Gallia County are all on-site mitigation projects. In two cases, no on-site mitigation was done (Franklin County and Jackson County). The Franklin County disturbance site is located at a headwater of an unnamed tributary of the Olentangy River, whereas its mitigation site is located on Blacklick Creek, which flows into Big Walnut

Table 6. Permit requirements and compliance for the five replacement wetlands in this study.

Site	Area Lost, ha	Vegetation Lost	Vegetation to be Replaced	Area to be Re-placed, ha	Vegetation Replaced (1994)	Area Re-placed (1994), ha	% of Re-quired Area Replaced
Portage	0.4	Emergent	Emergent/woody	0.6	Emergent/woody	0.6	100.0
Delaware	3.7	Emergent/woody	Emergent	3.9	Emergent	~3.0	74.0
			Woody	1.5	Woody	~1.0	
Franklin	15.0	Emergent	Submergent	28.0	Submergent	3.2	—
			Emergent		Emergent	0.0	
			Woody[1]				
Jackson	4.8	Emergent	Emergent and scrub/shrub;	7.2	Emergent and scrub/shrub:	1.5	104.0
			woody		woody	6.0	
Gallia	0.5	Emergent	Emergent and woody	0.8	Emergent	0.7	88.0
Total	24.4			42.0		~16.0	~91.5[2]

[1] Area of planted woody vegetation not surveyed in this study.
[2] Average of percent area replaced does not include Franklin County mitigation wetland.

Creek. While the disturbed and creation areas in Franklin County are both in the Scioto River watershed, they are located approximately 20 km apart and in separate and smaller catchments (Olentangy River and Big Walnut Creek watersheds, respectively). The disturbance and the mitigation sites in Lawrence and Jackson Counties are also located in the same large watershed (ODNR 1985). The disturbed area is located in an isolated basin wetland with a direct outflow to the Ohio River. The replacement wetland in Jackson County is located on Symmes Creek, which is the major drainage stream of a smaller catchment in the same watershed.

Comparison to Permit Requirements. The wetlands in this study showed varying degrees of success and failure according to Section 404 permit conditions (Table 6). Both the Portage and Jackson replacement wetlands met the two most prevalent permit conditions (area of replacement and vegetation cover). The Jackson wetland was actually 0.3 ha larger than the area required to be replaced. Neither the Delaware nor the Gallia replacement wetlands attained the required area to be covered by the specified vegetation. According to annual reports and field observations, the Gallia replacement wetland has had a problem in establishing woody vegetation, thus keeping the wetland below the required area of cover with specified vegetation types. The Franklin replacement wetland is also incomplete. and the only noticeable change in the landscape of the mitigation area is the addition of the 3.2 ha pond. Trees that will grow in a wetland area have also been planted at the mitigation site. The trees are on a well-drained surface, and standing water was never observed in those areas even immediately after a large summer storm.

The Delaware replacement wetland is making reasonable progress toward meeting the specified permit requirements. The Franklin replacement wetland, on the other hand, has not made any reasonable progress in vegetation success beyond the construction of the deepwater pond and the tree planting. The inflow and outflow from the deepwater pond have been controlled by a large man-made dam. This does not encourage natural hydrology. The sides of the pond are too steep and result in water too deep to support any amount of wetland vegetation. Vegetation noted in the pond at the time of the survey had most likely become established before the completion of the outflow dam. It is doubtful that vegetation will come back for a second year. The planting of trees does not automatically make the area a forested wetland. There is not sufficient water retention in the tree-planting area to support a wetland ecosystem, nor is there any way to deliver water to the area in the site's present state without pumps to get the water over a high constructed berm. The Portage, Jackson, and Gallia replacement wetlands all reached legal completion (construction completed and vegetation planted) within specified time limits.

The Portage wetland met most of the permit conditions specified in terms of area but it has not reached the 80 percent cover of vegetation required in the Section 404 permit. While the wetland area is sufficient, the permit specifies maximization of shallow water areas. There is no shallow area on the site that lasts for more than a day after a large storm. The establishment of a deep stream channels water out of the wetland

Table 7. Ranking of each replacement wetland for site five criteria based on the WET II[1].

Function	Portage		Delaware		Franklin		Jackson		Gallia	
Hydrology	M	2	H	3	L	1	M	1	M	2
Soils	H	3	H	3	M	2	M	2	M	2
Vegetation	M	2	H	3	L	1	H	3	M	2
Wildlife	H	3	H	3	M	2	M	2	H	3
Water Quality	H	3	—	—	L	1	H	3	L	1

[1] H, M, L (High, Medium, Low) from Adamus et al., 1989; numeric ranking of Adamus et al. (1989) is as follows: H = 3, M = 2, L = 1.

quickly, and the steeper grade of the wetland edges does not encourage a shallow water system. The Delaware replacement wetland seems to have met all of the permit requirements set forth in the Section 404 permit except the area requirement (Table 6).

Not only does the Franklin replacement wetland fail in area and hydrology sufficient to meet permit requirements, it also appears to fail in vegetation. The permit specifies that a variety of vegetation types be introduced to the system. To date, the only manual introduction of plants on the site has been tree planting on a 10 m grid outside of the ponded area.

The Jackson replacement wetland has met all of the permit conditions specified except for planting trees in clumps. While this is non-compliance with the permit, trees are establishing themselves naturally on the site. This may be considered a viable replacement for the wetland builders' failure to establish clumps of trees. The Gallia County wetland has also met all of the conditions in the permit but one. Although FAC, FACW, and OBL plants represent over 51% of the vegetative cover on the site, the site's total area is slightly less than required.

At the end of this study, four of the five replacement wetlands (Franklin excluded) replaced 91.5 percent of the area required by regulatory agencies. A 1.4:1 replacement-to-loss ratio was achieved for these four sites by the end of the study. A replacement ratio of 1.5:1 had been expected upon completion of all four of these sites. When the Franklin site is included, it is estimated that 66% of the lost wetland area was replaced successfully.

Ecosystem Success

Ranking the success of the five wetlands using an adaptation of the WET II system gave variable results (Table 7). The Delaware replacement wetland scored highest in the evaluation, rating a 3 out of 3. All areas except water quality (which was not judged in this instance) were marked as high. While the score for this site is the highest, it does not indicate that this wetland represents the "best" ecosystem of the five under study. The Delaware site is highly managed, and degradation of the system is not likely to occur. Both the Portage and the Jackson replacement wetlands scored well using the evaluation system (2.4 and 2.2, respectively). This indicates a medium-to-high rating. The Gallia wetland received a score of 2 (medium), and the Franklin replacement wetland scored 1.4 (medium-to-low).

CONCLUSIONS

Only two of the five wetlands are in complete compliance with legal requirements; however, there is time for most of the permit applicants to correct site problems before the end of their monitoring periods. The only site that seems out of compliance, with little chance of coming into compliance, is the Franklin replacement wetland. There, the creation of a wetland has turned into the construction of a shallow pond (which technically could be a wetland) surrounded by a much larger area of trees (which probably will never be a wetland).

Varying degrees of "success" can be seen in those wetlands that have met the permit conditions or that are very close to meeting them. The Delaware wetland has a large variety of plant taxa along with a high percentage of obligate wetland plants. The Jackson, Gallia, and Portage replacement wetlands had relatively high species variety, yet the percentage of obligate wetland plants was lower. The Delaware replacement wetland is highly managed; there is a full-time horticulturist who works at the golf course to keep the wetland "looking good." The other wetlands do not have this amount of management (nor do natural wetlands) and will, in time, resemble native wetlands in their area if the hydrology is maintained.

It is not clear why some specifications are made in the permits. While size of the replacement wetland is always specified, it is not always justified. Plant type and cover specified for a site often seem to be arbitrary and not supported by any existing research. Replacement of one hydrogeomorphic type of wetland with another type is often allowed, and mitigation plans that are not always very detailed are often accepted. Decisions on vegetative replacement (replacing an emergent marsh with a wooded one) are often unsupported.

In some instances it seems that regulatory agencies overcompensate for the loss of a low quality wetland. The Franklin mitigation project is an example. The disturbed area was prior-converted (at one time it was a wetland, but in the recent past, it was used for farming), but it reverted to a hydrologically isolated wetland. The regulators required that a large area be created to replace the lost area. Requirements by the U.S. EPA and the U.S. Army Corps of Engineers to replace the small, low-quality wetland with a large wetland do not seem justified.

Replacement of area is the most important aspect of wetlands mitigation in Ohio, with less emphasis placed on the quality of the replacement wetlands. The replacement of area at a ratio of 1.4:1 was realized overall when combining four of the five cases studied; however, there are few indications that lost wetland functions or the replacement of these functions for each wetland were emphasized in the Section 404 permitting process. Regulatory agencies need to consider the lost ecosystem when writing permits for dredge and fill activities involving wetlands. In order for the wetland protection programs to be better able to control wetland losses, scientifically based guidelines must be drawn up for replacing lost function as well as lost wetland area.

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