This is to certify that the

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Avian Breeding Use of Constructed and Established
Wetlands in Chippewa County, Michigan

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Michael Joseph Monfils

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AVIAN BREEDING USE OF CONSTRUCTED AND ESTABLISHED WETLANDS IN CHIPPEWA COUNTY, MICHIGAN

By

Michael Joseph Monfils

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ABSTRACT

AVIAN BREEDING USE OF CONSTRUCTED AND ESTABLISHED WETLANDS IN CHIPPEWA COUNTY, MICHIGAN

By

Michael Joseph Monfils

In order to determine the response of breeding waterfowl and other avian species, breeding bird use was compared between three constructed wetlands and three established wetlands in Chippewa County, Michigan. Waterfowl use of the open water/aquatic bed zone was monitored using weekly breeding pair and three brood surveys each year in 1994 and 1995. Other breeding birds were surveyed by vegetation zone using circular plot surveys and nest searches during early, mid, and late season periods.

Breeding pair densities of dabbling duck species at constructed wetlands were higher than nearby established wetlands. A similar pattern of use on constructed wetlands by waterfowl broods was observed. Nineteen breeding bird species used the study sites, and ten species were common to constructed and established wetlands. Avian use of the scrub-shrub and flooded emergent zones was similar. Densities of birds in the scrub-shrub, wet meadow, and flooded emergent zones were similar. Three species were unique to constructed wetlands, and six were unique to established wetlands. Species unique to constructed wetlands were associated with scrub-shrub communities, while species unique to the established wetlands were associated with wet meadow or flooded emergent zones.

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INTRODUCTION

The formation of both state and federal wetland protection laws and a policy of "no net loss" accentuates a number of important wetland values. When unavoidable impacts to wetlands are permitted, these laws often require the construction of mitigation wetlands to offset the loss of natural areas. Although constructed wetlands have been used to offset some of the lost wildlife value in the form of waterfowl breeding habitat, there have been few efforts to evaluate waterfowl use of such wetlands (Leschisin et al. 1992). By relying on constructed or restored wetlands to replace natural wetlands, it is assumed that these wetlands will provide the same functions as the natural wetlands. Even in the prairie pothole region, where restoration has occurred since the 1930s, the question of whether formerly drained and cultivated wetlands can fully recover as habitats for breeding birds is unclear (Delphey and Dinsmore 1993). Although the construction/restoration of wetlands is being encouraged by programs such as the North American Waterfowl Management Plan (NAWMP), little is known as to the extent that these areas will be used by breeding waterfowl.

Eastern Chippewa County, Michigan, is very conducive to wetland restoration and construction. A portion of the eastern Upper Peninsula has also been identified in the NAWMP as a grassland/wetland area of importance. Pickford and Rudyard soils are common throughout this region (USDA 1992). These soils are somewhat poorly drained and poorly drained, respectively. Both exhibit slow permeability, which makes these soils very suitable to wetland formation. Mitigation projects involving wetlands constructed for the purpose of providing habitat for waterfowl production have been implemented in this region. This provides an opportunity to compare the function of constructed wetlands with established wetlands, and to determine how well constructed areas function in providing avian breeding habitat. It is expected that mitigation wetlands which develop vegetation zones similar to established areas, should also obtain similar densities and diversities of breeding waterfowl and other avian species. Delphey and Dinsmore (1993) believe that systematic comparisons between restored and natural wetlands are needed to facilitate evaluation of restoration.

I set out to evaluate waterfowl and other avian breeding use of three constructed and three "established" wetland sites. The term "established" refers to areas with wetland plant communities of similar structure and hydrological conditions which have been in existence for a minimum of twenty-eight years. At established sites much of the nearby upland areas contain woody plants. All of the constructed wetlands were two or three years old, with wetland plant communities becoming developed and nearby recently disturbed upland areas dominated by herbaceous plants.

DESCRIPTION OF STUDY AREAS

Constructed Wetlands

Adamo wetland (AW)

This wetland is located adjacent to the beaver pond site, directly north of 13 Mile Rd. (T45N, R1E) (Fig. 1). The area is approximately 4.1 hectares (ha) in size and was created by a private landowner in the fall of 1993 through the construction of a small berm which blocked a small stream (Fig. 2). There was some existing willow (*Salix* spp.) and speckled alder (*Almus rugosa*) scrub-shrub wetland in this area which is now flooded. Common grasses at this site included canary reedgrass (*Phalaris arundinacea*), *Agrostis* spp., and *Festuca* spp.. Emergents such as woolgrass (*Scirpus cyperinus*), soft rush (*Juncus effusus*), and sedges (*Carex* spp.) are found in the wet meadow zone. Some small areas of cattail (*Typha* spp.) are found.

LaMantia mitigation project (LMP)

This area was created as mitigation for wetlands lost in the construction of a mall project in Sault Ste. Marie. It is located on Killackey Rd. between Six and Seven Mile Rds. (T46N, R1E) (Fig. 1). Final construction was completed in the summer of 1993. This area was designed to create approximately 27 ha of seasonally, semipermanently flooded marsh attractive to breeding and migrating waterfowl (Fig. 3). At this time there

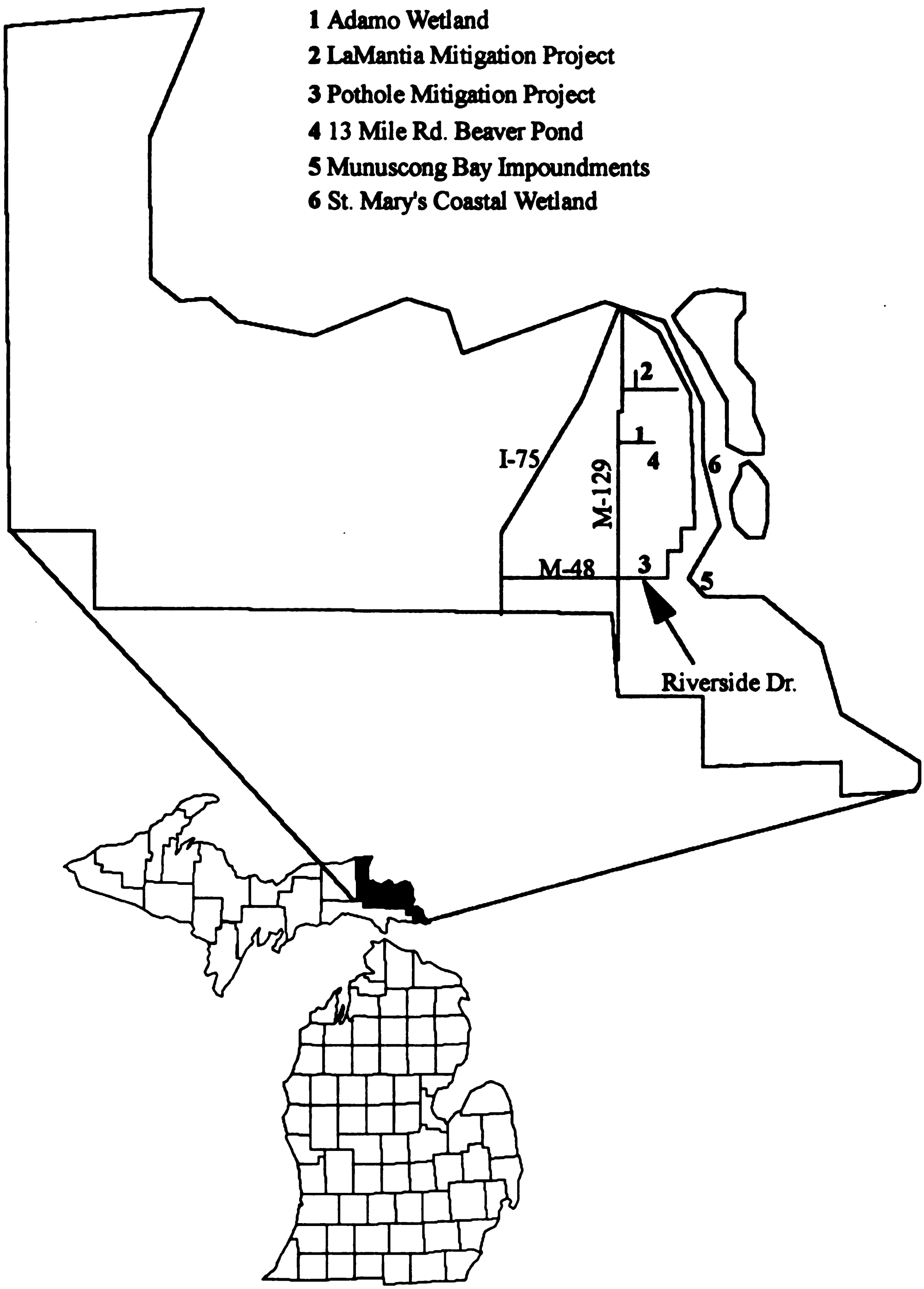

Figure 1. Site map of Chippewa County, Michigan. Numbers indicate location of study sites.

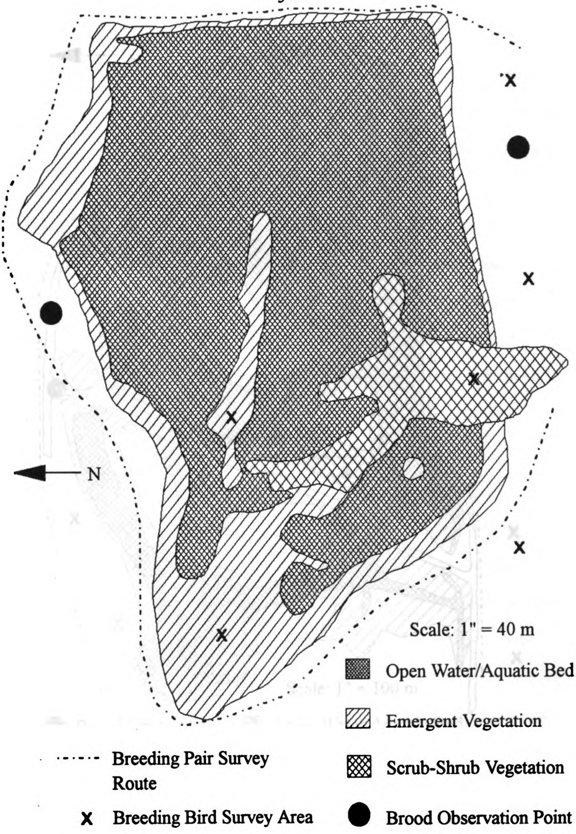

Figure 2. Adamo wetland site map.

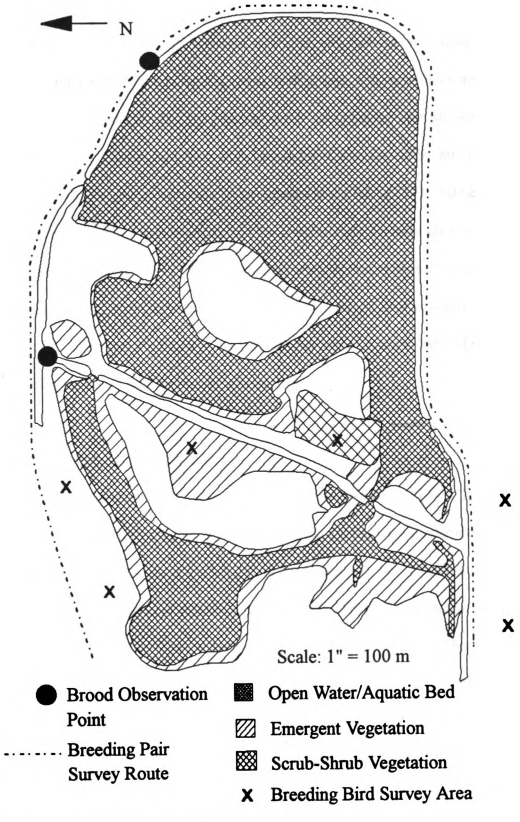

Figure 3. LaMantia mitigation project site map.

is approximately 19.4 ha of wetland present. The wetland was created via the construction of clay berms with concrete and rip-rapped spillways to maintain water levels (Fig 3). Concrete culvert nesting structures, loafing logs, and wood duck nest boxes were also incorporated into the design. White spruce (*Picea glauca*), bulrush (*Scirpus* spp.), buttonbush (*Cephalanthus occidentalis*), lake sedge (*Carex lacustris*), and sago pondweed (*Potamogeton pectinatus*) were planted in the fall of 1993. Some areas of willow scrub-shrub vegetation remained after construction. Grasses such as panic grass (*Panicum* spp.) and timothy (*Phleum pratense*) are common in the surrounding uplands. Emergents such as woolgrass, soft rush, and sedges such as *Carex praegracilis*, *C. stipata*, and *C. limosa* are found in the wet meadow zone. A small band of flooded cattail is found in the upper pool (west side of wetland).

Pothole Mitigation Project (PMP)

This complex is located east of M-129 on Riverside Drive (T44N, R1E) (Fig. 1). Eighteen small wetlands ranging in size from 0.05 to 1.0 ha, were constructed as mitigation for wetlands lost in the US 2 road expansion (Fig. 4). This area was designed by the Michigan Department of Natural Resources (MDNR) in conjunction with the Michigan Department of Transportation (MDOT) and Ducks Unlimited for the purpose of creating a waterfowl breeding and hunting area. These wetlands were created, through excavation and berm construction, in approximately 72 ha of fallow farm field and total approximately 8.0 ha of wetland area. These areas were constructed in the summer of 1992. Spoil banks were seeded with a mixture of timothy, orchard grass (*Dactylis glomerata*), treefoil (*Lotus corniculatus*), and redtop grass (*Panicum rigidulum*) to

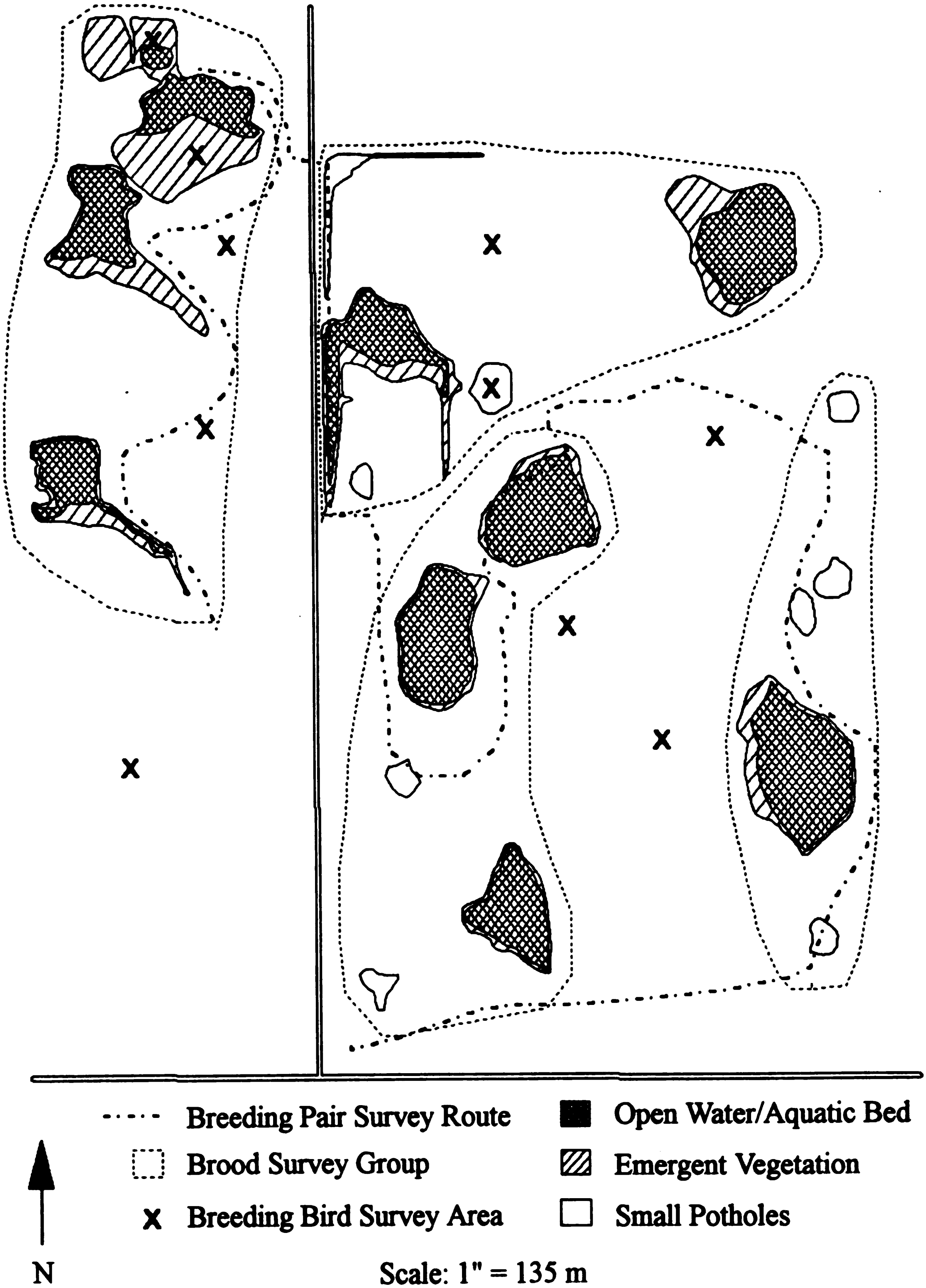

Figure 4. Pothole mitigation project site map.

promote dense nesting cover (Soulliere 1993). The natural seed bank was relied upon for the colonization of wetland plants. This complex is located within the Munuscong Bay Wildlife Management Area (MBWA). *Festuca* spp. grasses are common in the surrounding uplands. Wet meadow zones are dominated by woolgrass, soft rush, *Carex vulpinoidea*, and *C. stipata*. Small stands of flooded cattail are present in some potholes, and hardstem bulrush (*Scirpus acutus*) is found sporadically.

Established Wetlands

Thirteen Mile Road Beaver Pond (BP)

A beaver pond 12.1 ha in size is located directly south of 13 Mile Rd (T45N, R1E) (Fig. 1). This area has been in existence for at least 40 years according to the landowner (Fig. 5). It is dominated by emergent and aquatic bed vegetation zones interspersed with dead shrubs. The margin of this wetland is surrounded by scrub-shrub vegetation dominated by willow and speckled alder. Cattail and burreed were the most common emergents at this site. This area provides an example of long-term vegetative succession after an area is impounded and stabilized.

Munuscong Bay Wildlife Area Coastal Impoundments (MBW)

Three areas of coastal wetland on Munuscong Bay (T44N, R1E) (Fig. 1) were stabilized in 1965-66 via a system of dikes (Fig. 6). This allowed water levels to be controlled independently of the natural water level fluctuations of the St. Mary's River and Lake Huron. Zones of scrub shrub, emergent, and open water/aquatic bed vegetation are present within the 348.9 ha diked areas. Scrub-shrub zones contain willow, speckled alder, and *Spiraea* spp.. Sedges such as *Carex lacustris*, *C.stricata*, and *C. aquatilis*, and grass (*Calamagrostis canadensis*) are found in the wet meadow zone. Flooded emergent zones found at this site are dominated by cattail and hard-stem bulrush.

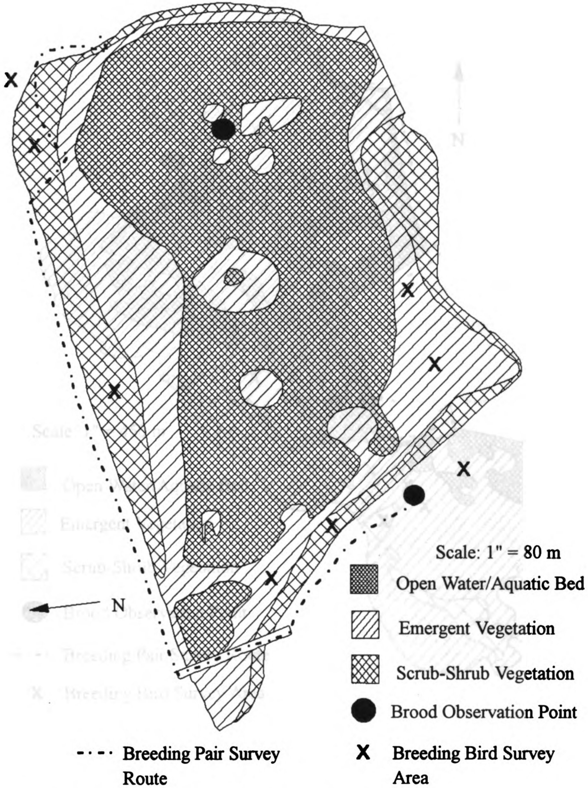

Figure 5. Thirteen Mile Road beaver pond site map.

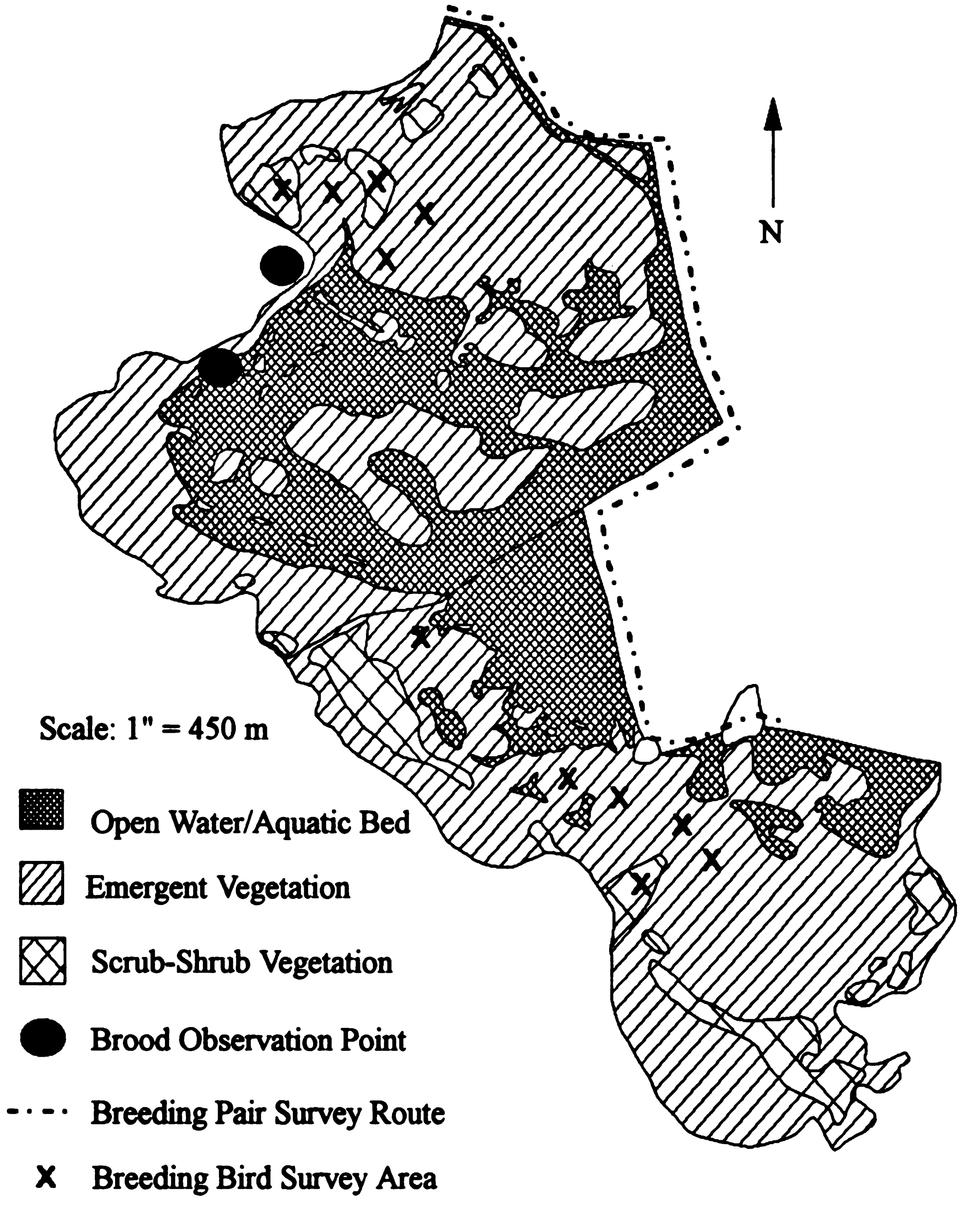

Figure 6. Munuscong Bay coastal impoundments site map.

St. Mary's River Coastal Wetland (SMCW)

A 1.2 km zone of coastal wetland on the St. Mary's River between 12 and 13 Mile roads (T46N, R2E) (Fig. 1) was monitored. The 31.9 ha area surveyed in this study contains scrub-shrub, emergent, and open water/aquatic bed vegetation zones (Fig. 7). This area provides an example of avian use of a natural, uncontrolled riverine wetland. Scrub-shrub vegetation is dominated by willow, speckled alder, and *Spiraea* spp. Wet meadow zones contain grasses (*Calamagrostis canadensis*, *Phalaris arundinacea*), woolgrass, and sedges (*Carex vesicaria*). The flooded emergent zone is dominated by hard-stem bulrush, cattail, horsetail (*Equisetum* spp.), and *Juncus canadensis*.

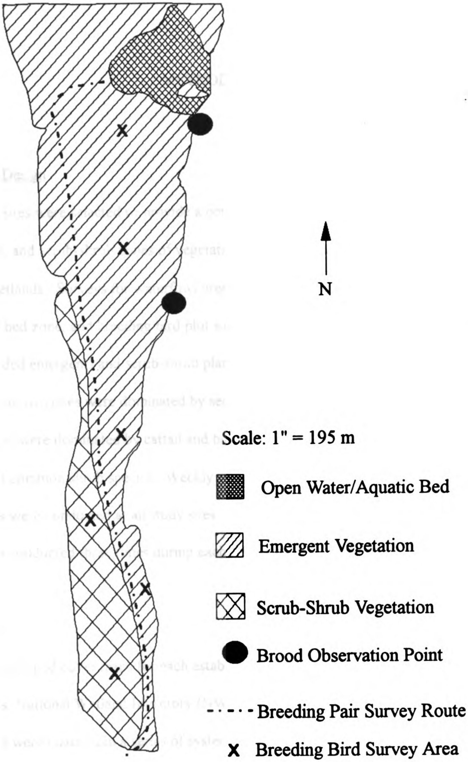

Figure 7. St. Mary's River coastal wetland site map.

METHODS

Experimental Design

Study sites were selected to provide a contrast of avian use of open water/aquatic bed, emergent, and scrub-shrub zones of vegetation between constructed and nearby established wetlands. Surveys for waterfowl breeding pairs and broods in the open water/aquatic bed zone, and breeding bird plot surveys and nest searches of emergent (wet meadow, flooded emergent) and scrub-shrub plant zones were conducted on all study sites. Wet meadow zones were dominated by sedges, grasses, and woolgrass. Flooded emergent zones were dominated by cattail and bulrush species. Willow and speckled alder were the most common shrub species. Weekly waterfowl breeding pair and three yearly brood surveys were conducted at all study sites. Breeding bird plot surveys and nest searches were conducted three times during each field season at each site.

Habitat Zones

We developed cover maps for each established study site based on on-site measurements, National Wetland Inventory (NWI) maps, and aerial photographs. On-site measurements were made from a series of systematic transects using a meter tape and/or rangefinder. Cover maps of constructed sites were based on site plans and on-site measurements. Cover maps were then digitized using the ARC-INFO geographic information system (GIS). The area and proportion (%) of scrub-shrub, emergent (wet meadow and flooded emergent), and open water/aquatic bed were estimated using ARC-INFO. Due to their small size (8.6% of total area), the small potholes (Fig. 4) were not used in estimating the proportions of emergent and open water/aquatic bed cover at the PMP site. To characterize the potential upland nesting habitat for waterfowl, the amount of grassland and forest found within 500 m of each wetland was estimated from aerial photos using a dot grid.

Waterfowl Breeding Pair Surveys

Weekly waterfowl breeding pair surveys were conducted at each site from early-May through early-June. Surveys were conducted by walking along set observation routes, and counts were varied so that some were done in the morning, afternoon, and evening. The number of pairs and indicated pairs (lone males and groups of males of five or less) (Hammond 1969, Leschisin et al. 1992, Delphey and Dinsmore 1993) using open water/aquatic bed zones were counted. All birds observed within 100 m of the survey route were counted by species and vegetation zone being used.

Waterfowl Brood Surveys

Brood surveys were conducted at each site in mid-June, mid-July, and early-August. Observations of open water/aquatic bed zones were made from fixed observation points, a method similar to counts made by Beard (1964). Surveys lasted for four hours beginning at sunrise. Observation points were varied in 1994. In 1994 we determined that brood observations at the PMP site were not possible to conduct from one observation point. A sample of the potholes were observed from a tree stand, but this proved impractical as growing vegetation impaired vision. Surveys were modified by walking to each wetland and observing for 5 to 15 minutes.

In 1995 a standardized method for brood surveys was developed. We conducted three brood surveys at each site: early (mid June-early July), mid (early-mid July), and late (late July-early August) season. Each survey began at sunrise and lasted for four hours. Two observers surveyed broods from two separate observation points at each site (Figs. 2, 3, and 5-7). Species, number of ducklings, age (Class I, II, and III) (Gollop and Marshall 1954), and time of observation was recorded for each brood observed within a specific area. Class I is the downy stage, which covers a period of about three weeks, from hatching until body feathers begin to appear. Class II stage covers weeks four through six, and is the period during which body feathers replace down plumage. Class III is the stage during which the young are fully feathered by juvenile plumage, prior to flight (Bellrose 1980), and this stage usually lasts about ten days (Gollop and Marshall 1954). At the PMP site we divided the 18 potholes into four groups of three to five (Fig. 4). Two consecutive mornings were used to survey the four pothole groups (two groups per morning, one observer per group). Ten minutes were spent at each pothole, and the observer rotated between all potholes within a group for a four hour survey period. When compiling the results we only counted the number of Class II broods spaced approximately two weeks apart. This was done to avoid recounting young broods which stayed within an area for more than one survey.

Avian Surveys of Vegetation Zones

Breeding birds using emergent (wet meadow and flooded emergent) and scrub-shrub plant zones were surveyed early (mid-late May), mid (early-mid June), and late season (late June-early July). Surveys were conducted between sunrise and 1000 hours. One or two plots (0.1 ha) were placed in each zone of vegetation at each site, resulting in three to seven plots total per site, depending on the number of zones present and the size of the study site. After arrival at the survey plot five minutes were waited before beginning the survey, so that normal bird activity could resume. All birds observed and/or heard within an 18 m radius were recorded during eight-minute observation periods (Delphey and Dinsmore 1993; Brown and Dinsmore 1986). Taped calls played during the final four minutes of the survey period, were used to elicit responses from secretive birds such as the least bittern (*Ixobrychus exilis*), american bittern (*Botaurus lentiginosus*), virginia rail (*Rallus limicola*), yellow rail (*Coturnicops noveboracensis*), and sora (*Porzana carolina*) (Brown and Dinsmore 1986, Delphey and Dinsmore 1993). The number of responses and the estimated distance of the response from the center of the plot was recorded. Birds observed outside of the survey plot, but within the vegetation zone being sampled, were recorded to aid in the identification of the breeding bird species found in each zone. After the count period, the area within a 13 m radius plot (0.05 ha) around the same observation point was searched for nests (Brown and Dinsmore 1986, Delphey and Dinsmore 1993). A species was classified as breeding if we observed an active nest, flightless young, or adults during 2 of 3 visits (Brown and Dinsmore 1986). On two occasions, I also considered a species as breeding when nests with identifiable eggshells were found.

Analysis

The Statistical Analysis Software (SAS) system was used. The general linear model (GLM) procedure was used to conduct an unbalanced analysis of variance (ANOVA) on waterfowl breeding pair use of open water/aquatic bed plant zones, using the following multiple factor model:

$$Y_{ijkl} = \mu + \alpha_i + \beta_{(i)j} + \vartheta_k + \delta_l + \alpha\delta_{il} + \alpha\vartheta_{ik} + \beta\delta_{(i)jl} + \epsilon_{ijkl}$$

Where Y_{ijkl} = natural log (pair density); μ = true population mean; α_i = wetland type (constructed or established); $\beta_{(i)j}$ = study site (nested within wetland type: {AW, LMP, PMP} and {BP, MBW, SMCW}); ϑ_k = week of survey; δ_l = year of survey; $\alpha\delta_{il}$, $\alpha\vartheta_{ik}$, and $\beta\delta_{(i)jl}$ are interactions of these factors; and ϵ_{ijkl} = the error associated with the model. Preliminary tests indicated that there were not significant $\beta\vartheta_{(i)jk}$ or $\vartheta\delta_{kl}$ interactions, so they were eliminated from the final model. Pearson product-moment correlation coefficients were used aid in determining the physical factors associated with the breeding pair use of the wetlands. The following physical factors were used in the correlation analysis: surface area; ha of scrub-shrub; ha of emergents; ha of open water; emergent:open water ratio; edge length:surface area ratio; ha of surrounding grassland (within 500 m); and ha of surrounding forest (within 500 m).

Waterfowl brood use of open water/aquatic bed plant zones were analyzed using the GLM procedure within the SAS system to conduct an unbalanced ANOVA. The following model was used:

$$Y_{ijk} = \mu + \alpha_i + \beta_{(i)j} + \theta_k + \epsilon_{ijk}$$

Where Y_{ijk} = natural log (Class II duckling density); μ = true population mean; α_i = wetland type; $\beta_{(i)j}$ = study site (nested within wetland type: {AW, LMP, PMP} and {BP, MBW, SMCW}); θ_k = survey period (early, mid, or late season), and ϵ_{ijk} = the error associated with the model.

The coefficient of similarity (Oosting 1956) was calculated to compare the avian use of the scrub-shrub and emergent wetland plant zones between constructed and established wetland types. The equation used was $2w / a + b$, where w = the sum of the lowest of each pair of percentages for species occurring in each wetland type, a = the sum of percentages in constructed wetlands, and b = the sum of percentages in established wetlands. A value greater than 0.5 indicates that bird use of the vegetation zone is similar between wetland types.

RESULTS

Habitat Zones

Constructed wetlands had a greater proportion of open water/aquatic bed habitat zones than established wetland sites (Table 1). Constructed wetlands had less total emergent cover (21.0 - 32.6%) when compared to established wetlands (30.3 - 70.0%). Although small amounts (0.9 - 3.8 ha) of wet meadow had developed at constructed wetlands, 135.8 and 7.1 ha of wet meadow were present on two established sites (MBW and SMCW). More flooded emergent (cattail/bulrush spp.) cover was present on established (3.7 - 76.1 ha) compared to constructed sites (0.1 - 0.3 ha). Two constructed wetlands had zones of scrub-shrub cover present before and not destroyed during construction (Table 1). Emergent:open water ratios ranged from 0.30 to 0.48 at constructed wetlands, and 0.59 to 6.97 at established. Ratios of edge length:surface area (Km/ha) tended to be higher at constructed (0.22 - 0.47) compared to established wetlands (0.07 - 0.23). The constructed wetlands had a greater proportion of grassland surrounding them (61.3 - 87.2%), whereas the established wetlands had more adjacent forest (38.7 - 92.9 %).

Table 1. Comparison of size (ha) and proportion (%) of habitat zones distributed on constructed and established wetland study sites.

Habitat Zone	Constructed			Established		
	AW	LMP	PMP	BP	MBW	SMCW
Wetland Habitat						
Scrub-shrub	0.4 (9.7)	1.6 (8.5)	---	2.1 (17.2)	24.4 (7.0)	6.3 (19.8)
Emergent						
Wet Meadow	0.9 (22.0)	3.8 (19.6)	2.3 (28.8)	---	135.8 (38.9)	7.1 (22.3)
Flooded Emergent	0.1 (2.4)	0.3 (1.4)	0.3 (3.8)	3.7 (30.3)	76.1 (21.8)	15.2 (47.8)
Total	1.0 (24.4)	4.1 (21.0)	2.6 (32.6)	3.7 (30.3)	211.9 (60.7)	22.3 (70.0)
Open Water/ Aquatic Bed	2.7 (65.9)	13.7 (70.5)	5.4 (67.4)	6.3 (52.5)	112.6 (32.3)	3.2 (10.2)
Total Area	4.1	19.4	8.0	12.1	348.9	31.9
Emergent: Open Water Ratio	0.37	0.30	0.48	0.59	1.88	6.97
Edge length: Surface Area Ratio (Km/ha)	0.35	0.22	0.47	0.23	0.07	0.11
Upland Habitat						
Grassland	75.5 (61.3)	132.1 (69.1)	199.5 (87.2)	84.6 (55.3)	8.9 (2.8)	9.1 (9.9)
Forest	31.9 (25.9)	57.4 (30.0)	19.3 (8.4)	59.3 (38.7)	295.8 (92.9)	71.5 (77.7)

Waterfowl Breeding Pair Surveys

Waterfowl breeding pair densities were two to five times greater at constructed compared to established wetlands (P = 0.0001) (Table 2). Breeding pair densities were different between years (P = 0.014) and weeks (P = 0.0001). Mean breeding pair densities ranged from 0.9 to 2.2 pairs/ha on constructed sites, and 0.1 to 0.7 pairs/ha on established sites (Table 3). Pair densities varied by study site (P = 0.0001). There were three significant interactions; $\alpha\beta_{ik}$ = treatment-week (P = 0.0001), $\alpha\delta_{il}$ = treatment-year (P = 0.0001), and $\beta\delta_{(i)jl}$ = site-year (P = 0.0009).

Table 2. Estimated waterfowl breeding pair densities ($\bar{x} \pm$ SE) by week and wetland type for 1994 and 1995.

	Wetland Type	
Week	Constructed	Established
1	1.6 ± 0.11	0.7 ± 0.11
2	1.5 ± 0.13	0.4 ± 0.13
3	1.1 ± 0.14	0.5 ± 0.13
4	1.2 ± 0.12	0.3 ± 0.12
5	1.7 ± 0.15	0.2 ± 0.14
Mean	1.4 ± 0.06	0.4 ± 0.06

Table 3. Estimated waterfowl breeding pair densities ($\bar{x} \pm$ SE) by wetland type and year.

	Wetland Type					
	Constructed Sites			Established Sites		
	AW	LMP	PMP	BP	MBW	SMCW
1994	1.3 $\pm$ 0.22	0.6 $\pm$ 0.14	2.1 $\pm$ 0.14	0.8 $\pm$ 0.15	0.1 $\pm$ 0.15	0.7 $\pm$ 0.18
1995	1.1 $\pm$ 0.12	1.2 $\pm$ 0.12	2.4 $\pm$ 0.12	0.7 $\pm$ 0.12	0.1 $\pm$ 0.12	0.2 $\pm$ 0.12
Mean	1.2 $\pm$ 0.13	0.9 $\pm$ 0.09	2.2 $\pm$ 0.09	0.7 $\pm$ 0.10	0.1 $\pm$ 0.09	0.5 $\pm$ 0.11

Mallard (*Anas platyrhynchos*) was the most common waterfowl species on Chippewa County wetlands (Table 4). Mallard, blue-winged teal (*A. discors*), gadwall (*A. strepera*), american wigeon (*A. americana*), and green-winged teal (*A. crecca*) were present in higher densities on constructed wetland types (P = 0.0001). Mallard breeding pair densities on established wetland types were similar to those of ring-necked duck (*Aythya collaris*), blue-winged teal, Canada goose (*Branta canadensis*), and american wigeon. Ring-necked duck pair densities were significantly greater on established wetland types (P = 0.0001). There was no significant difference in breeding pair densities of Canada geese between wetland types (P = 0.50).

Table 4. Estimated waterfowl breeding pair densities ($\bar{x} \pm$ SE) by species and wetland type.

Species	Wetland Type: Constructed	Wetland Type: Established
Canada goose	0.05 ± 0.011	0.06 ± 0.010
American wigeon	0.16 ± 0.018[a]	0.02 ± 0.017
Gadwall	0.21 ± 0.017[a]	0.01 ± 0.017
Green-winged teal	0.13 ± 0.016[a]	---
Mallard	0.41 ± 0.030[a]	0.13 ± 0.029
Blue-winged teal	0.34 ± 0.031[a]	0.07 ± 0.030
Ring-necked duck	0.01 ± 0.014	0.09 ± 0.013[a]
Common goldeneye	0.06 ± 0.009[a]	---

[a] Significantly greater ($P = 0.0001$).

Dabbling duck pair densities were negatively correlated with surface area, scrub-shrub cover, emergent cover, and amount of adjacent forest cover (Table 5). Positive correlations with edge length:surface area ratio and area of adjacent upland grassland cover were observed. American wigeon, mallard, and blue-winged teal exhibited similar habitat associations, except mallard was negatively correlated with area of open water.

Table 5. Significant (P<0.05) correlations of mean waterfowl breeding pair densities with several physical features of the study sites (N = 6).

	Breeding Pair Densities			
Physical Parameters	Dabblers	AMWI	MALL	BWTE
Wetland Habitat				
Surface Area	-0.925[a]	-0.876	-0.944[a]	-0.964[a]
Scrub-Shrub	-0.942[a]	-0.927[a]	-0.875	-0.932[a]
Emergent	-0.933[a]	-0.891	-0.928[a]	-0.977[a]
Open Water	---	---	-0.844	---
Emergent:Open Water	---	---	---	---
Edge Length:Surface Area Ratio	0.950[a]	0.919[a]	0.895	0.969[a]
Upland Habitat				
Grassland	0.866	0.844	---	0.887
Forest	-0.973[a]	-0.947[a]	- 0.966[a]	-0.962[a]

[a] P < 0.01

Waterfowl Brood Surveys

More Class II ducklings were observed on constructed compared to established wetland types (P = 0.008). Duckling densities were similar between sites within treatment (P = 0.61) and between survey periods (P = 0.73) (Table 6). Breeding pair and Class II duckling densities were positively correlated (r = 0.75, P = 0.086).

Although mallard (P = 0.05) and blue-winged teal (P = 0.02) had significantly greater densities of Class II ducklings on constructed compared to established wetlands, other species were not present in great enough densities to provide a contrast (Table 7).

Table 6. Estimated density ($\bar{x} \pm SE$) of Class II ducklings by period, site, and wetland type in 1995.

	Constructed			Established		
	AW	LMP	PMP	BP	MBW	SMCW
Early	1.5	2.6	0.8	0.5	0.5	2.5
Mid	5.6	3.9	4.7	0.5	1.9	0.2
Late	3.0	2.3	3.9	0.9	1.2	0
Combined	3.3 ± 0.81	2.9 ± 0.81	3.1 ± 0.81	0.6 ± 0.81	1.2 ± 0.81	0.9 ± 0.81
Treatment Combined		3.1 ± 0.41			0.9 ± 0.41	

Table 7. Estimated densities ($\bar{x} \pm SE$) of Class II ducklings by species and wetland type in 1995.

Species	Constructed	Established
Canada goose	0.30 ± 0.18	0.20 ± 0.18
Wood duck	0.05 ± 0.04	0
Gadwall	0.40 ± 0.17	0.02 ± 0.17
American wigeon	0.70 ± 0.21	0.20 ± 0.21
Mallard	0.90 ± 0.24[a]	0.24 ± 0.24
Blue-winged teal	0.60 ± 0.13[b]	0.09 ± 0.13
Ring-necked duck	0	0.10 ± 0.06
Hooded merganser	0.10 ± 0.14	0

[a] Significantly greater ($P = 0.05$).
[b] Significantly greater ($P = 0.02$).

Avian Surveys of Vegetation Zones

Nineteen avian species (13 at constructed and 16 at established) were considered to be breeding during the two years of surveys (Table 8). Ten species were found at both constructed and established wetlands. Three species were unique to constructed wetlands, and six were unique to established wetlands (Table 8). At the constructed wetlands no species were observed breeding exclusively in flooded emergent vegetation. Four species were present only in wet meadow, and seven species exclusively in scrub-shrub. Red-winged blackbirds bred in scrub-shrub, wet meadow, and flooded emergent zones at constructed sites. Seven species were present in flooded emergent vegetation, one species in wet meadow, and four species in scrub-shrub vegetation at established sites. The american bittern and virginia rail were present in wet meadow and flooded emergent zones at established sites. Swamp sparrows (*Melospiza georgiana*) and red-winged blackbirds used the scrub-shrub, wet meadow, and flooded emergent zones at established sites.

The eastern kingbird (*Tyrannus tyrannus*), yellow warbler (*Dendroica petechia*), common yellowthroat (*Geothlypis trichas*), and swamp sparrow used scrub-shrub habitat at both constructed and established wetlands. The song sparrow (*Melospiza melodia*) was observed in the scrub-shrub zone at both wetland types, however, it was not seen often enough to be considered a breeder at established sites. The american robin (*Turdus migratorius*) and clay-colored sparrow (*Spizella pallida*) were found only in scrub-shrub zones at constructed sites, while the gray catbird (*Dumetella carolinensis*) was present only in scrub-shrub at the established BP site.

Table 8. Avian species determined to be breeding based on 1994 and 1995 surveys, listed by wetland type, study site, and vegetation zone (SS = Scrub-shrub, WM = Wet meadow, and FE = Flooded Emergent).

	Constructed						Established							
	AW		LMP		PMP		BP		MBW			SMCW		
Species[a]	WM	SS	WM	SS	WM	FE	FE	SS	WM	FE	SS	WM	FE	SS
Pied-billed grebe	?[b]	?	?	?			X			X			X	
American bittern	X						X		X[c]				X	
Virginia rail			X		X		X[c]		X[c]	X[c]			X	
Sora	X[c]						X[c]			X			X	
American coot										X				
Sandhill crane							X[c]							
Common snipe	X		X		X		X			X			X	
Black tern										X			X	
Eastern kingbird				X				X						
Sedge wren									X					
Marsh wren										X[c]				
American robin		X[c]		X[c]										
Gray catbird								X						

Table 8 (Cont'd).

	Constructed						Established							
	AW		LMP		PMP		BP		MBW			SMCW		
Species[a]	WM	SS	WM	SS	WM	FB	FB	SS	WM	FB	SS	WM	FB	SS
Yellow warbler		X[c]		X[c]				X			X			X
Common yellowthroat				X				X			X[c]			X
Clay-colored sparrow				X[c]										
Song sparrow				X										
Swamp sparrow		X[c]		X				X	X[c]	X	X[c]	X		X
Red-winged blackbird		X	X[c]	X	X	X[c]	X[c]	X[c]	X	X[c]			X[c]	

[a] See Appendix for scientific names.
[b] Flightless young were observed at two constructed wetlands, but zone where nesting occurred is unknown.
[c] Nests observed.

Although the pied-billed grebe *(Podilymbus podiceps*) was not observed on any of the survey plots, it was often seen/heard in flooded emergent stands at the established wetlands. It was considered a breeder at two constructed sites (AW and LMP) as well, due to the observance of adults and flightless young.

Species richness was greater (seven vs. zero species) at established wetlands for the flooded emergent zone compared to constructed wetlands. Wet meadow zones were exclusively used by more species at constructed compared to established sites (four vs. one species). Sedge wren (*Cistothorus platensis*) was the only species exclusively using wet meadow zones of established wetlands, and was not present at constructed sites. All of the species using the wet meadow zone at constructed wetlands were present in flooded emergent zones, or both wet meadow and flooded emergent zones at established wetlands (Table 8). The american coot (*Fulica americana*), sandhill crane (*Grus canadensis*), black tern (*Chlidonias niger*), and marsh wren (*Cistothorus palustris*) used flooded emergent stands at established sites, but were absent from constructed wetlands. Thirty-one nests were located on 26 (13 %) of 198 plots searched. Sixteen of the nests found were those of red-winged blackbirds (*Agelaius phoeniceus*).

Densities of breeding birds per ha were similar between constructed and established wetlands for the scrub-shrub, wet meadow, and flooded emergent zones (Table 9). Densities of breeding birds were greater for the cattail flooded emergent zone at established wetlands. No bulrush stands large enough to sample had developed at constructed sites. Coefficients of similarity indicated that species use of wet meadow zones was not similar, while bird use of the scrub-shrub and flooded emergent zones was similar on constructed and established wetlands (Table 9).

Table 9. Density of birds per hectare ($\bar{x} \pm$ SE) (number of plots sampled in parantheses) and coefficient similarity indices by vegetation zone.

	Density		
Vegetation Zone	Constructed	Established	Similarity Index
Scrub-shrub	35 $\pm$ 5 (24)	36 $\pm$ 3 (50)	0.605
Emergent			
Wet Meadow	15 $\pm$ 6 (11)	15 $\pm$ 2 (49)	0.191
Flooded Emergent	27 $\pm$ 6 (7)	34 $\pm$ 3 (57)	0.640
Cattail	27 $\pm$ 6 (7)	39 $\pm$ 3 (37)	0.633
Bulrush	---	27 $\pm$ 5 (20)	---

DISCUSSION

Long-term ground studies of mallards indicate that breeding pair populations fluctuate yearly between some high and low values (Dzubin 1969). Since the open water/aquatic bed zones on study sites resulted from activities with different management objectives, differences in pair densities between sites was expected. The wetland type-year and site-year interactions appear to stem from the changes in pair densities from 1994 to 1995. Densities tended to increase or stabilize at constructed wetlands over this period, while they tended to decrease at established wetland sites. Since the mitigated wetland sites were designed to appeal to proximal cues used by dabbling duck pairs (Kaminski and Prince 1981a, 1981b), a differential response to the habitat could be expected. A constant density was observed at constructed wetlands over the five weeks surveyed, while density decreased at established wetlands. Declining densities of dabbling duck breeding pairs over time has been reported by others (Jackson et al. 1985, Humburg et al. 1978).

The importance of open water/aquatic bed zones on constructed wetlands to dabbling duck breeding pairs has been noted by Kaminski and Prince (1981a,b), Leschisin et al. (1992), Ruwaldt et al. (1979), and Lokemoen (1973). This study demonstrates that constructed wetlands in early plant successional stages result in habitat with higher densities of dabbling duck breeding pairs compared to established wetland communities in the eastern Upper Peninsula of Michigan. Wigeon, gadwall, green-winged teal, mallard, and blue-winged teal pairs all responded to the newly created wetland habitats. Similar densities of wigeon, gadwall, green-winged teal, and mallard were found on constructed wetlands in northwestern Minnesota (Leschisin et al. 1992). Ring-necked duck (*Aythya collaris*) was the only waterfowl species with higher breeding pair densities on established wetlands. Nesting ring-necked ducks favor marshes at least partially surrounded by wooded vegetation (Bellrose 1980). All of the established wetland types were surrounded by scrub-shrub vegetation and upland forests. The waterfowl breeding pair densities estimated for the constructed wetlands in this study were intermediate between the relatively low densities of the established wetlands and the high densities found by other workers in the prairie potholes (Kantrud and Stewart 1977) and large prairie marshes (Kaminski and Prince 1981a, b).

Waterfowl breeding pairs occupy open water/aquatic bed zones of wetlands based on proximate cues provided by the open water and emergent habitat configuration (Kaminski and Prince 1981a, b). The findings of Leschisin et al. (1992) suggested that dabbling duck breeding pairs select constructed wetlands primarily on the basis of proximate cues. Kaminski and Prince (1984) surveyed quarter sections by helicopter for waterfowl breeding pairs, and found that even though vegetation-water interspersion was not the strongest habitat correlate with dabbling duck use of prairie marshes, its frequent individual occurrence coupled with that of shoreline development suggested that emergent vegetation-water interspersion does influence dabbler pair densities and species richness. The constructed wetland types in this study were designed to provide an abundance of shallow water and maximum shoreline length, thus simulating the 50:50 open water to emergent, or hemi-marsh (Weller and Spatcher 1965, Weller and Fredrickson 1974) configuration. Edge length:surface area ratio was positively correlated with breeding pair densities, whereas emergent:open water ratio was not correlated with pair densities. This is consistent with the small quantity of emergent vegetation present on the constructed sites. The constructed wetlands were created within substantial areas of grassland vegetation, and as Kaminski and Prince (1981a, b) demonstrated, the interspersion of water and grassland is structurally the same as would be found in a marsh. The shallow flooding of surface drains at constructed sites increased shoreline length and interspersion of water and vegetation. The PMP had the greatest amount of interspersion and the highest mean density of breeding pairs. The LMP incorporated a high degree of interspersion and loafing logs into the design. Evrard (1975) noted the highly significant correlation between waterfowl use of constructed ponds and the presence of loafing structures.

The constructed wetlands were designed to attract breeding dabbling ducks and on average, had smaller surface areas, higher edge length:surface area ratios, and more adjacent grassland nesting cover compared to established wetlands (Table 1). All of these factors were positively correlated ($P < 0.05$) with breeding pair densities. Several workers have found higher densities of breeding pairs on smaller wetlands (Evans and Black 1956, Lokemoen 1973, Leschisin et al. 1992). Leschisin et al. (1992) found greater pair use of wetlands with longer shoreline lengths for all species except the gadwall. Lokemoen (1973) found that pairs seemed to prefer stock ponds with open shorelines, and that all species combined were significantly associated with grassy shorelines. Breeding pair densities in this study were negatively correlated with the amount of emergent and scrub-shrub vegetation. Evans and Black (1956) found that potholes with excessively dense vegetation were used very little by breeding pairs, and that those with sparse cover, or no vegetation at all, were clearly preferred.

The higher densities of Class II ducklings on constructed compared to established wetland types are consistent with the increased density of breeding pairs and the presence of grassland nesting cover adjacent to all of the constructed wetlands. Ball et al. (1975) found a significant linear correlation between distance of overland travel completed prior to two weeks of age and number of surviving ducklings in broods. Rotella and Ratti (1992) found that broods that moved farther had lower duckling survival. With increased duckling survival due to close proximity of nesting cover, a greater density of Class II ducklings would be expected at the constructed wetlands. Several workers have noted that brood density in constructed wetlands is primarily a function of the physical features (Lokemoen 1973, Mack and Flake 1980, Hudson 1983, Belanger and Couture 1988). Belanger and Couture (1988) found that size, shoreline irregularity, and proportion of emergent coverage were the most important features in determining brood densities. Man-made ponds greater than 0.5 ha in size and with more irregular shorelines were used most by broods (Belanger and Couture 1988). Mack and Flake (1980) found that shoreline length was positively correlated with the number of blue-winged teal, mallard, and pintail broods using South Dakota stock ponds, and that it was a better predictor of brood use than pond size. A similar relationship between shoreline length and brood use was found on beaver ponds in Ontario (Patterson 1976). Average edge length:surface area ratio was higher at constructed wetlands, which could have made them more attractive to broods. Mack and Flake (1980) found that ponds located within idle grassland tended to have a higher occurrence of blue-winged teal broods. The substantial grassland areas surrounding the constructed wetlands in this study are likely making the wetlands more attractive to dabbling duck broods. Waterfowl broods select habitats in which the highly nutritious foods needed for growth are readily available (Sedinger 1992). The presence of greater Class II duckling densities at the constructed wetland sites suggests that adequate food is available.

Although avian use of the flooded emergent zone was similar between constructed and established wetlands, more species and a higher density was found in cattail zones at established sites. This similarity appeared to be related to red-winged blackbird abundancy at both the constructed and established flooded emergent zones.

Use of the wet meadow zone was not similar between constructed and established wetlands, and more species were found in wet meadow zones at constructed sites. However, all of the species found in constructed wet meadow were found in either the flooded emergent zone, or both the wet meadow and flooded emergent zones at established wetlands (Table 8). The greater number of species found in wet meadow at constructed sites could be attributed to the lack of flooded emergent zones. It appears that the wet meadow zone at constructed wetlands is providing breeding habitat for species that use both flooded emergent and wet meadow habitat. The wet meadow zone should continue to be important to several breeding bird species at the constructed sites until flooded emergent stands become established. Five of the six species unique to the established sites were associated with the flooded emergent or wet meadow zones. These species included american coot, sandhill crane, black tern, sedge wren, and marsh wren. Marsh-nesting species can nest only when the physical environment is suitable, and nest-site selection involves primarily physical features of the habitat which protect the nest, eggs, and young from floods, heat stress, and predators (Burger 1985). The lack of development of flooded emergent cover at constructed wetlands was probably the most important factor limiting some of the marsh-nesting species. The smaller average size of the constructed wetlands could also be limiting species richness. Brown and Dinsmore (1986) found that as wetland area increased, so did species richness, however the rate of increase decreased as marshes became larger. Tyser (1983) found similar results in cattail marshes in Wisconsin. The large sizes of the flooded emergent stands at the MBW and SMCW established sites, was most likely an important factor in attracting more species to these areas. Three of the six species which were unique to established wetlands have been found to be area-dependent (black tern) or possibly area-dependent (american coot, marsh wren), meaning they were more frequently found in larger marshes (Brown and Dinsmore 1986). Wetlands within wetland complexes have also been shown to attract more breeding bird species than isolated marshes (Brown and Dinsmore 1986). Two of the established sites (MBW and SMCW) were situated within large coastal emergent wetland complexes, which could have also contributed to a greater species richness in these areas.

The coefficient of similarity index indicates that bird use of the scrub-shrub zone was similar between constructed and established wetland types. This was expected since the scrub-shrub zones at constructed wetlands were established before construction took place. The presence of american robin and clay-colored sparrow in the scrub-shrub zone at constructed wetlands is explained by the presence of grassland cover adjacent to the shrubs at these sites. American robins could use this grassland cover for feeding, and clay-colored sparrows prefer breeding habitats near to water which have a combination of grasses, trees, and shrubs (Knapton 1979, Ehrlich et al. 1988).

The scrub-shrub and wet meadow zones were very important to breeding birds at the constructed sites. Eleven of the thirteen species present at constructed wetlands exclusively used either the scrub-shrub or wet meadow zones. It would be advantageous to construct wetlands adjacent to patches of various wetland plant zones to increase avian breeding use of these areas. Overall species richness of the constructed wetlands was limited by the lack of flooded emergent cover. Sufficient time has not passed since construction of these areas for cattail/bulrush stands to fully develop.

The data in this study indicate that breeding waterfowl will quickly respond to constructed wetland habitats when proximate cues are considered in the wetland designs. Other avian breeding species respond to these habitats based on the physical features of the vegetation zones present, thus colonization takes longer because of the time involved with vegetation development. The constructed wetlands are already providing breeding habitat for several avian species due to the presence of patches of vegetation zones, and more species would be expected as the zones continue to develop.

APPENDIX

Table A-1. A list of common and scientific names of breeding birds identified during 1994 and 1995 surveys (AOU 1982).

Common Name	Scientific Name
pied-billed grebe	*Podilymbus podiceps*
american bittern	*Botaurus lentiginosus*
virginia rail	*Rallus limicola*
sora	*Porzana carolina*
american coot	*Fulica americana*
sandhill crane	*Grus canadensis*
common snipe	*Gallinago gallinago*
black tern	*Chlidonias niger*
eastern kingbird	*Tyrannus tyrannus*
sedge wren	*Cistothorus platensis*
marsh wren	*Cistothorus palustris*
american robin	*Turdus migratorius*
gray catbird	*Dumetella carolinensis*
yellow warbler	*Dendroica petechia*
common yellowthroat	*Geothlypis trichas*
clay-colored sparrow	*Spizella pallida*
song sparrow	*Melospiza melodia*
swamp sparrow	*Melospiza georgiana*
red-winged blackbird	*Agelaius phoeniceus*

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