FOLLOW-UP VEGETATION AND AVIFAUNAL SURVEYS ON WETLANDS RESTORED THROUGH THE U.S. FISH AND WILDLIFE SERVICE PARTNERS FOR WILDLIFE PROGRAM

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ABSTRACT

There is a paucity of long-term, longitudinal follow-up studies for restored inland freshwater marshes. Long term monitoring of restoration projects is important if researchers are to evaluate the "success" of restoration efforts. Establishing project goals is a major component of the overall restoration plan because evaluation of "success" should be based on terms of the goal. In this study, I conducted vegetation, avifauna and amphibian surveys in the 6th and 7th years after restoration on 13 small (<1.50 ha) wetlands in Jefferson County, New York State. The original study of wetlands restored through the U.S. Fish and Wildlife Service Partners for Wildlife program was initiated in 1991 by Stephen Brown of Cornell University. I used Brown's (1995) sampling methods so that data could be compared among years. Results of vegetation surveys indicate that the average number of all plant species and the average number of wetland plant species were higher in 1994 than in 1997 or 1998 at all elevations (-30 cm, -20 cm, -10 cm, 0 cm, +10 cm), while the percentage of wetland plant species in the total plant community tended to increase from 1994 to 1998 at all elevations. At the five elevations, percentage of the total plant community comprised of wetland species ranged from 55-83% over all restorations in 1994, 77-94% in 1997 and 87-94% in 1998. As the average number of species at each elevation decreased between 1994 and 1998, the percent of surviving species represented by wetland plants increased. In 1997 and 1998, there were significantly fewer preferred wildlife food plant species per restoration than in 1994, but there were no significant differences among years in the percent cover of preferred wildlife food

plant species per restoration. Between 1994 and 1998, wetland index (WI) values tended to decrease both among restorations and within sites, suggesting a trend toward increased wetland status.

Between 1994 and 1998, the only significant difference in bird species richness within habitat preference groups (OBL=obligate, FACW=facultative wetland, FAC=facultative, UPL=upland) was a decrease in the average number of FAC species. Species richness tended to be highest in UPL and OBL habitat preference groups; however, in 1994 and 1997, the combined species richness of wetland birds (OBL + FACW) tended to be higher in the average number of species and percent species representation of the avifauna community. There were significant decreases in the average number of UPL and OBL individuals per census per restoration between 1994 and 1998. In all years, FACW birds tended to have the highest average number of individuals and the highest percent species representation. The UPL group tended to be higher in the average number and percent representation of individuals in 1994 than in 1997 or 1998, and the OBL group was lower than all other groups in the average number and percent representation of individuals in 1997 and 1998. However, when wetland habitat preference groups (OBL + FACW) were combined, they tended to be dominant in the average number of individuals and percent individual representation in all years. Regression analyses suggest that in 1997, a drought year, these restorations became more important as wildlife refugia. There was no significant difference in the number of amphibian species (n=8) found at each restoration between 1997 and 1998. The number of restorations (n=13) at which a species was found in 1997 remained relatively unchanged in 1998, except for the American toad (*Bufo americana*) which was found at 5 less sites in 1998 than in 1997. I conclude that the U.S. Fish and Wildlife Service has "succeeded" in its efforts to enhance wildlife habitat on the 13 restored wetlands in this study. Although the data show differences in avifaunal populations and composition among years and restorations, the absence of a species should not be interpreted as a restoration's "failure" in terms of wildlife habitat value. A wetland's response to changing environmental cues may mean undesirable conditions for one species while providing desirable conditions for another.

DEDICATION

I dedicate this thesis to my parents in their 50th year of marriage

You taught by example that:

Giving up is not an option.

Respect, Honor, and Strength of Character do not come for free.

To be a home, a house must have love and laughter.

"Normal" is an adjective that applies to other people.
(thank goodness for that!)

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INTRODUCTION

The United States has a long history of eliminating and converting wetlands to facilitate disease control, flood control, agricultural development, and settlement (Conservation Foundation 1988, Dahl 1990, Mitsch and Gosselink 1993, National Research Council 1995). During the 200-year span from 1780 to 1980, these activities resulted in the loss of over 46.8 million wetland ha (117 million ac), or 53% of the estimated 88.4 million ha (221 million ac) that once existed in the lower 48 states (Dahl 1990). Between 1970 and 1980, wetland destruction due to urban, industrial and agricultural development was in excess of 100,000 ha (250,000 ac) per year (Dahl and Johnson 1991). Further, "collective wetland losses have diminished the quality of our natural resource base to the extent that the balance of economic, social and environmental goals must be carefully considered" (Dahl 1990).

The National Wetland Policy Forum (NWPF) was convened by the Conservation Foundation in 1987 to "set significant goals for the nation's remaining wetlands" (Conservation Forum 1988, Mitsch and Gosselink 1993). The resulting objective set forth by the NWPF was "to achieve no overall net loss of the nation's remaining wetlands base. . ." (Conservation Foundation 1988). Although efforts to reduce wetland losses have been implemented at federal, state and local levels, wetland losses continue (Conservation Foundation 1988). Furthermore, the current national rate of wetland losses is not known and can only be roughly estimated using nationwide surveys (Conservation Foundation 1988). Dahl (1990) reported that although some state and federal agencies were implementing wetland restoration efforts, losses continued at an estimated 24 ha (60 ac) per hour in the lower 48 states. Based on the U.S. Fish and Wildlife Service (FWS) National Wetlands Inventory, wetlands are being lost "at a rate approximately 20 times greater than they are being gained" - an estimated 160,000 ha (400,000 ac) loss versus 10,000 wetland ha (25,000 ac) gained annually (FWS 1990).

The National Association of Conservation Districts (NACD) (1993) reported that wetlands support an estimated one-third of all bird species, approximately 190 species of amphibians, and 5000 plant species in the United States, in addition to wetland-dependent mammals such as beaver (*Castor canadensis*), river otter (*Lutra canadensis*) and muskrat (*Ondatra zibethicus*) (NACD 1993, National Research Council 1995). Wetlands are also important for fish spawning and nursery areas, and are essential for macroinvertebrates that spend all or part of their lifecycle in aquatic habitats (Voights 1976, Erwin 1990b, Mitsch and Gosselink 1993, National Research Council 1995). Many terrestrial animal species also routinely utilize wetland habitat

A description of the complex aspects of wetland functions is not within the scope of this study. Briefly, however, wetlands function to: 1) buffer flood waters by slowly releasing water stored during flood peaks; 2) abate soil erosion by reducing the overland flow of water; 3) filter excess nutrients released primarily by agricultural non-point sources of pollution by plant-uptake and by sequestering contaminants in bottom sediments; 4) improve the quality of water that recharges groundwater and aquifer supplies used for human consumption; 5) provide income through tree-harvesting activities, hunting and fishing, and grazing; and 6) provide valuable wildlife habitat (Mitsch and Gosselink 1993, National Research Council 1995). Comprehensive summaries of wetland functions and related effects, corresponding societal values, and relevant indicators of wetland functions can be found in Mitsch and Gosselink (1993) and the National Research Council (1995).

Of the remaining 41.6 million wetland ha (104 million ac) in the lower 48 states, an estimated 26 million ha (65 million ac) are owned by the private sector, primarily farmers, ranchers, corporations, land trusts and smaller land owners (Heinlich and Langner 1986, Conservation Foundation 1988). With approximately two-thirds of the nation's wetlands in private ownership, the future security of existing wetlands, and the addition of wetland acres to the resource base, will require cooperation and participation among land owners, non-government organizations and government agencies (Conservation Foundation 1988, FWS 1990, NACD 1993). To facilitate the goal of "no overall net loss" of wetlands, the NWPF encouraged promotion of private stewardship through education and recognition of the economic stake private landowners have in wetland resources (Conservation Foundation 1988). To this end, the NWPF recommended that federal, state and local governments cooperate in establishing "strong economic incentives to encourage and assist the private sector to exercise its management responsibilities" with regard to wetland conservation and preservation and to the "no net loss" initiative.

Additional wetlands can be added to the national resource base through: 1) mitigation - the actual restoration, creation or enhancement of wetlands to compensate for permitted wetland losses; 2) restoration - returning a wetland to its condition prior to alteration or disturbance; or 3) creation - the conversion of a persistent non-wetland area to a wetland through some activity of man (Lewis 1990).

Many government programs that directly or indirectly support the "no net loss" initiative employ these wetland conservation methods at the local, state and federal level. For example, federal programs include the North American Waterfowl Management Plan, North American Wetlands Conservation Act, Farm Bill Program, Agricultural Wetlands Reserve System, and the Wetland Incentive Award Program (FWS 1990). Other programs are administered by non-government organizations such as The Nature Conservancy, The Audubon Society and Ducks Unlimited (FWS 1990).

One important wetland conservation effort is the FWS Partners for Wildlife program. The objectives of the Partners stewardship program are to "protect and restore, through cooperative efforts with other governmental agencies and private partnerships, habitats on private lands"; and to "contribute to the conservation of biological diversity through. . . the careful selection, design and implementation of restoration projects" (FWS 1993). The FWS (1993) defines habitat restoration as "the rehabilitation of degraded or lost habitat in a manner such that the original vegetation community and hydrology are, to the extent practical, reestablished." Although restoration projects include riparian, prairie and bottomland hardwood habitats, most projects have been restorations on idled or less productive, low-lying agricultural fields (FWS 1993, 1997). By the year 2000, 13 years after inception, the FWS estimated that 21,557 landowners had voluntarily entered into stewardship contracts that resulted in the restoration of over 186,000 ha (464,816 ac) of wetlands nationally (FWS 2000).

The Partners for Wildlife program does not propose to replace specific losses of natural wetlands, but rather, to increase and improve wetland acreage and function as wildlife habitat (Brown 1995, FWS 1993). Fish and Wildlife Director John Turner called for the Service to "undertake restoration, enhancement, and management projects on and off Service lands to increase the acres of restored and the value of degraded wetlands," and to " . . . work with agencies and organizations and private individuals to pursue the goal of 'no overall net loss' of wetlands" (FWS 1990).

Wetland evaluation under the classical successional theory (Clements 1916) suggests the "replacement of plant species in an orderly sequence of development," a hydrarch succession that begins with a lake or open water habitat that eventually becomes a climax terrestrial forest community (Mitsch and Gosselink 1993). This classical definition suggests that succession is autogenic, e.g., "brought about by the plant community itself as opposed to externally caused environmental changes" (Mitsch and Gosselink 1993). However, this concept has been challenged as unrealistic.

Niering (1990) stated that "most ecologists have modified their views" regarding the traditional concepts of succession and climax communities proposed by Clements (1916). The traditional concept suggests that changes in the vegetation community are an orderly, predictable, and directional process, which, in the case of wetlands, ultimately result in an upland forest community (Niering 1990). Gleason (1917, 1927) introduced the "individualistic" hypothesis which holds that any change in plant species cover or community composition constitutes a successional change, and that every environment has its own biotic potential in which plants establish according to unique genetic tolerance limits. Development of the Gleasonian approach resulted in the "continuum" concept (Whittaker 1967) which suggests that assemblages of plants overlap along the landscape gradient in response to current habitat conditions, rather than within discreet vegetation zones (Willard and Hiller 1990, Niering 1990, Mitsch and Gosselink 1993).

The degree to which the "successful" restoration of wetland functions and ecosystem structure (described below) can be compared to the function and structure of natural, or reference, wetlands is still under discussion in the scientific community. Both of these variables involve complex interactions between the biotic and abiotic characteristics of the wetland (Mitsch and Gosselink 1993). For example, wetland functions are defined as ecological processes that include primary production, decomposition, consumption through the food chain, organic export, energy flow, and nutrient budgets (Mitsch and Gosselink 1993). Ecosystem structure consists of the vertical and horozontal composition of vegetation along the wetland-upland gradient, and is also defined by seed bank capacity, nutrient availability, and the complex assemblage of consumers, decomposers, invertebrates, mammals, birds and fish (Mitsch and Gosselink 1993). In freshwater marsh systems, ecosystem structure will change as a marsh cycles through characteristic stages of: a) dry marsh (resulting from periodic droughts); b) regenerating marsh (reestablishment of wetland plant species and emergent vegetation as normal rainfall patterns return); c) degenerating marsh (decline of emergent vegetation, usually due to "exploding" muskrat populations that decimate the marsh through lodge and trail building); and d) the reversion of the marsh to an open, shallow lake with little emergent vegetation (Mitsch and Gosselink 1993).

Confer and Niering (1992) suggested that because "emergent wetland development is so highly dependent on chance or the life history of the species," comparisons between restored and natural wetlands should be used only as a general assessment of "success". D'Avanzo (1990) stated that "local reference wetlands are critical for comparative purposes." Wilson and Mitsch (1996) contend that "ecological function can be evaluated by comparing replacement wetlands to reference wetlands. . ." or to "generally accepted 'standards' of wetland function." To facilitate such comparisons, researchers have developed a variety of methods that can be used to qualitatively and quantitatively compare wetland function and structure between reference (natural) and restored or created wetlands. Four such methods are discussed below.

The hydrogeomorphic (HGM) approach is a standardized index for the rapid assessment of wetland function and structure developed for use in determining compliance with Section 404(b)(1) guidelines of the Clean Water Act (40 CFR 230)

(Brinson 1995, Brinson and Rheinhardt 1996, Cole et al. 1997, Rheinhardt et al. 1997). This method requires that wetlands be "classified by hydrologic and geomorphic properties within a narrowly defined regional subclass, and that information on reference sites within the same HGM class be used to develop and calibrate standards for assessment" (Brinson 1993, Brinson and Rheinhardt 1996). The HGM approach develops assessment models for each wetland function within the HGM class to use as a reference data base (Brinson 1995).

The Evaluation for Planned Wetlands (EPW) is another index-based rapid assessment procedure for wetland function and structure (Bartoldus 1994a, 1994b). This method differs from the HGM approach in that EPW provides assessment models for six functions (shoreline bank erosion control, sediment stabilization, water quality, wildlife, fish, uniqueness/heritage) which can be modified to apply to specific wetland types and regions (Bartoldus 1994a, 1994b).

The FWS Habitat Evaluation Procedure (HEP) (FWS 1980) also can be used to assess relative wetland values (Josselyn et al. 1990, Jensen and Platts 1990). HEP is based on the integration of a Habitat Suitability Index (HSI) and Habitat Units (HUs) for individual species that can be used to compare habitat changes in a particular site over several monitoring periods, or to compare two areas at one point in time (Jensen and Platts 1990). If the goal of restoration is to enhance fish and wildlife resources, Jensen and Platts (1990) suggest that assessment techniques such as HEP are useful, but note that application is limited because: 1) HSI and HUs for different species cannot be aggregated; 2) HEP evaluations are no more reliable than the models used to generate the HSI; 3) interpretations are specific to the species evaluated and do not relate to other ecosystem components and functions; and 4) habitat suitability models have not been developed for many species. Selection of the species that reflect the goals of restoration is the most important (Jensen and Platts 1990) and controversial aspect of HEP because improper selection of evaluation species can convey misleading results (Kruczynski 1990).

The Wetland Evaluation Technique (Adamus et al. 1987) "rates a broad range of functional attributes on a scale of high, medium, and low" that result in a quality rating of three wetland attributes: 1) social significance, the value of a wetland to society in economic terms; 2) effectiveness, a wetland's "capacity to carry out a function because of it's physical, chemical, or biological characteristics"; and 3) opportunity, "the opportunity of a wetland to perform a function to its level of capability" (Mitsch and Gosselink 1993). Limitations of this method include the subjective assessment of the evaluator to determine the weight of each function that ultimately results in the integrated evaluation of the site (Mitsch and Gosselink 1993). WET "deals with some contextual issues but does not reflect a landscape focus. . . results are site specific and are only semiquantitative" (Mitsch and Gosselink 1993). Although all of these methods may be useful in evaluating the overall "success" of wetland restoration and creation efforts, their limitations cannot consider the biotic and abiotic dynamics that cause the development of one wetland to proceed differently than the development of a seemingly similar wetland.

Some wetland biologists have concluded that comparisons of wetland restorations and creations with natural or reference wetlands (for both vegetation and avifaunal communities) can be misleading. With regard to forested wetlands, Clewell and Lea (1990) contend that "similarity indices are invalid measures of project success due to the disparity in similarity between natural sites." Further, Clewell and Lea (1990) advise against "adoption of success criteria that requires direct comparisons with a specific natural 'reference' wetland." Niering (1990) stated that "no two sites, even though similar, will support exactly the same plant association." Delphey and Dinsmore (1993) cautioned that "comparisons of restored prairie potholes to a set standard, or to data from natural prairie potholes studied in different years, may be misleading because regional, local, and site specific conditions changed with precipitation patterns among years." Erwin (1990b) asserted that a restoration project is set up for failure if its "success" is measured upon the impossible goal of creating a "mirror image" of the original wetland. The majority of scientists "recognize that duplication [of wetlands] is impossible and simulation is improbable" (Zedler and Weller 1990). Many wetlands are being "created" or restored as a result of permitted development projects that require wetland mitigation to comply with state regulations (Erwin 1990a), Section 404 of the Clean Water Act (Kruczynski 1990), and the "no net loss" of wetlands initiative (FWS 1990). Further, "mitigation efforts cannot yet claim to have duplicated lost wetland functional values. . . and it has not been shown that restored or constructed wetlands maintain regional biodiversity and recreate functional ecosystems" (Zedler and Weller 1990). Some wetlands may look like natural ones, but few data exist to show they behave like natural wetlands (Zedler and Weller 1990).

Wetland researchers agree that long-term, detailed monitoring is essential for effective wetland management, and for assessing the "success" of wetland mitigation, restoration, and creation efforts (Conservation Foundation 1988, D'Avanzo 1990, Erwin 1990a, Confer and Niering 1992, Brown 1995, Sleggs 1997). However, published reports of long-term monitoring projects are scarce in the literature (Lowry 1990). Further, few projects incorporate monitoring wetland development beyond five years (Dane 1959, Erwin 1990a, Levine and Willard 1990, Delphey and Dinsmore 1993, Sleggs 1997). The NWPF encouraged government agencies to integrate wetland restoration and creation into their current programs and to "incorporate. . . maintenance, monitoring and management activities. . . to increase the prospects of a successful effort" (Conservation Foundation 1988). Erwin (1990b) suggests that post-construction monitoring is essential to ensure that project goals are met. D'Avanzo (1990) stated that 1-2 years of monitoring was too short a time, and that evaluations spanning 10-20 years were preferred.

Brown (1995) also suggested that after three years of monitoring, results were preliminary and that follow-up studies were needed to evaluate the progression of wetland development for the 13 restorations surveyed in this study.

In 1991, Stephen Brown of Cornell University began a longitudinal study of restored wetlands in the St. Lawrence River Valley in Jefferson County, NY. Thirteen wetlands were restored through the FWS Partners for Wildlife Program in

1991, and Brown monitored vegetation and avifaunal variables for the following three years (1992-1994). The objectives of Brown's study were to: 1) restore previously existing wetland areas on land that had been drained for agricultural purposes, and 2) conduct long-term monitoring to assess the progression of wetland reestablishment in terms of sustained hydrology, vegetation development, and enhanced wildlife habitat for avifaunal species.

The goals of this study were to: 1) continue detailed monitoring of Brown's (1995) original 13 restorations in the 6th and 7th years post-restoration; 2) evaluate FWS "success" in providing enhanced wildlife habitat through wetland restoration; and 3) establish this project as a long-term, longitudinal study using standardized survey protocols that can be statistically compared over the years. Furthermore, this study is one of the few (Brown 1995, Sleggs 1997) that statistically evaluates vegetation and avifauna by indicator species groups (Cowardin et al. 1979, Reed 1986, Brooks and Croonquist 1990). Compiling vegetation and avifaunal species data in this manner offers a more in-depth view of changes in community composition over time. I describe the condition of ten restorations with regard to vegetation development, and avifaunal use of 13 restorations, in the sixth and seventh years after restoration (1997 and 1998). Although I do not attempt direct comparison of restoration variables to those at natural or reference sites, I infer similarities to natural sites referred to by Brown (1995) for the purpose of consistency between our projects.

STUDY AREA

All restorations are located in Jefferson County, New York State (Appendix A) and lie within the Eastern Ontario Plains Ecozone (Andrle and Carroll 1988) in close proximity to Lake Ontario and the St. Lawrence River (Appendix B). The site selection process is described in Brown (1995) and is not reiterated in detail here. Briefly, all sites were established at historic wetland areas that had been ditched and drained for 40 years or more for agricultural purposes. Land use was primarily for pasture and forage crops, with only small patches of hydric soils and wetland vegetation persisting. Sites were grouped according to soil taxonomy, all having similar parent material and determined to be similar regarding plant growth characteristics (Brown 1995). All areas included in the study were restored by the U.S. Fish and Wildlife Service as part of the Partners for Wildlife Program. Actual construction was done in conjunction with the United States Department of Agriculture Natural Resource Conservation Service (Brown 1995). Potential sites were reviewed for similarities in basin morphometry, hydrogeology, watershed size, watershed land use, and watershed soils (Brown 1995).

ORIGINAL STUDY BACKGROUND

Stephen Brown (1995) reported vegetation data for 1991 (pre-restoration) and 1992-1994 (post-restoration) from 13 restorations. The initial study focused upon the comparison of restoration sites with natural sites, but due to a paucity of undisturbed wetlands in northern New York State, only four natural (reference) sites having similar characteristics as restored wetlands were identified (Brown 1995). Vegetation surveys were conducted at those four reference sites for 1991-

1994, and data were used for comparative analyses (Brown 1995). However, Brown (1995) noted that on average, reference sites were smaller than restoration sites (0.404 ha vs 0.691 ha).

Avifaunal surveys were conducted on 17 restorations in 1992 and 18 in 1993-1994. In 1992, bird surveys were conducted at four reference sites (Brown 1995). In 1993, seven reference sites were surveyed; of the original four, one site was drained and four additional sites were added to the study (Brown 1995). The additional four sites were larger than the restored wetlands and were part of larger watersheds (Brown 1995). To compensate for size difference, an area of each larger reference site comparable to that of restored sites was measured and censused (pers. comm., Brown 1997). In 1994, another reference site was drained, but an additional site was included in the study, keeping the total number of reference sites at seven (Brown 1995).

CURRENT STUDY BACKGROUND

I used ten of the original 13 restorations for vegetation surveys, and 13 of the 18 original restorations for avifaunal surveys.

In 1997 and 1998 only two reference sites used by Brown were available for survey in this study. One site was a maturing forested wetland included by Brown as representative of a late successional wetland (pers. comm., Brown 1997). In addition, beaver (*Castor canadensis*) that had previously maintained hydrology at the second area had abandoned the site.

After consulting with the New York State Department of Environmental Conservation and U.S. Fish and Wildlife representatives, I identified two additional reference sites. However, only one of these sites was surveyed to establish a sampling transect in 1997 (described in Vegetation Sampling), while the second site could not be surveyed until 1998. Bird surveys were conducted at both reference areas in 1997; however, due to a change in landowners, only one site could be surveyed in 1998.

Consequently, small sample size and lack of consistency prevented quantitative comparisons between restoration and reference sites, but I infer trends with regard to Brown's (1995) reference sites. I present quantitative comparisons for vegetation and avifauna among restorations in 1994, 1997 and 1998, and presence / absence of amphibian species in 1997 and 1998.

Brown (pers. comm., 1997) provided vegetation and avifaunal data collected during 1994, the last year of his study, which I use as the reference year to assess subsequent changes in restorations. I followed protocols employed by Brown (1995) to analyze changes in vegetation cover, diversity and composition. I also analyzed changes in avifaunal diversity and community composition since 1994. In addition, I: 1) ranked and analyzed avifaunal species as to their habitat preference groups (i.e., wetland dependency) (Brooks and Croonquist 1990); 2) added the response of wading birds to audio cues (Chabot and Helferty 1995) to the avifaunal survey protocol; and 3) determined presence / absence of amphibian species using audio (Chabot and Helferty 1995) and general observation surveys.

METHODS

Vegetation Sampling

In 1997 and 1998, I conducted all vegetation surveys between the last week in July and the end of August to facilitate the identification of the maximum number of plants.

Brown (1995) established 130 permanent 1 m^2 vegetation plots at 13 restored wetland sites (Table 1). Two "mirror image" transects (A and B) were surveyed per site, each comprised of five 1 m^2 plots established relative to the proposed maximum water level at -30 cm, -20 cm, -10 cm, 0 cm and +10 cm elevations (Figure 1). Brown (1995) also established a third set of plots that were not aligned in a transect, but randomly located within the restoration; however, those plots were not included in this study because it was not possible to identify each elevation. The maximum high water level was represented by the 0 cm elevation (or spillway if one had been installed) and all other plots were surveyed from that point. Opposite corners of each plot were marked with pvc pipe for plot identification year to year.

In 1997 and 1998, I was able to identify only 100 of the original 130 m^2 plots at ten of the original 13 restorations used in Brown's 1991-1994 vegetation surveys (Table 1). At three restorations (P-1, P-2, W-1), I could not locate the corner markers indicating each m^2 plot along transect elevations. Most likely, animal activity and freeze-thaw conditions accounted for the disappearance of markers.

To sample vegetation, a 1 m X 1 m frame was placed between the opposite pvc-marked corners to identify the area to be sampled, and when possible, all plants within the perimeter were identified to genus and species. When positive identification could not be made in the field; samples were collected, dried and pressed for later identification. Anne Johnson, Civilian Botanist at the Fort Drum Military Installation, and Dr. Bruce Gillman, Biologist, Finger Lakes Community College, provided assistance with plant identification.

Following Brown (1995), I used Reed's (1986) wetland plant indicator status index to classify each plant species (OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland). The index reflects a species' frequency of occurrence in wetland versus non-wetland conditions as defined by Cowardin, et al. (Table 2). All vegetation data are reported in terms of these classifications.

Brown (1995) determined percent cover individually for each species, and total cover within each m^2 plot exceeded 100% in many cases. Unlike Brown (1995), I quantified percent cover of each plant species within each m^2 plot so that the maximum cover in any plot did not exceed 100%. This adjustment in methodology allowed cover data to be normalized using the arcsin transformation which is "applicable only if the data came from a distribution that lies between 0 and 100%" (Zar 1996). I reevaluated Brown's 1994 cover data so that it could be arcsin transformed to facilitate statistical comparisons among years. For example: a one m^2 plot was determined to have a total of 145% cover with 90% represented by OBL species, 40% by FACW species and 15% by FAC species.

Total m^2 cover would be reduced to equal the maximum of 100% such that the prominent trend in species dominance remained true, even though the actual numbers were adjusted. Therefore, given that visual quantification of percent cover is a subjective evaluation, it is fair to assume that 100% total cover of the plot could be represented by 70% OBL species, 25% FACW species and 5% FACW and the dominance hierarchy of the representative cover would be maintained.

Plant Species

I calculated the average number of plant species in each classification (OBL, FACW, FAC, FACU, UPL) per transect (all elevations combined) per restoration by summing the average number of plant species in a class in each transect (A+B / 2) at each restoration and dividing by the total number of restorations (n=10):

$$\frac{\sum [(\text{total spp. in a class transect A} + \text{total spp. in a class transect B}) / 2 \text{ transects}]}{10 \text{ restorations}}$$

I calculated the average number of all plant species per elevation per restoration by summing the average number of all plant species at an elevation in each transect (A+B /2) at each restoration and dividing by the total number of restorations (n=10):

$$\frac{\sum [(\text{all spp. at an elev. transect A} + \text{all spp. at an elev. transect B}) / 2 \text{ elev. plots}]}{10 \text{ restorations}}$$

For each restoration I calculated the average number of wetland plant species (OBL+FACW+FAC) per elevation by summing the average number of wetland plant species at an elevation in each transect (A+B / 2) and dividing by the total number of restorations (n=10):

$$\frac{\sum [(\text{total wet. spp. at an elev. trans. A} + \text{total wet. spp. at an elev. trans. B}) / 2 \text{ trans.}]}{10 \text{ restorations}}$$

For each restoration I calculated the percent plant species composition per plant class per elevation by summing the average number of plant species in a class at an elevation per transect (A+B / 2) divided by the average number of plants in all classes at an elevation per transect (A+B / 2) x 100 for each restoration:

$$\sum \left[\left(\frac{\text{total spp. in a class at an elev. trans. A + B per restoration}}{\textit{total spp. in all classes at an elev. transect A + B per restoration}} \right) \div 2 \text{ elev. plots} \right] \times 100$$

<u>Vegetation Cover</u>

As described in <u>Plant Species</u>, I calculated 1) average percent cover of each plant classification per elevation per restoration; 2) average percent cover of all plant species combined per elevation per restoration; 3) average percent cover of wetland plant species per elevation; and 4) average percent cover composition of each plant classification per elevation.

Cattail (*Typha latifolia*) was not abundant in the permanent plot data, and I did not attempt to analyze this species independently as in Brown (1995). However, *Typha* had established at all but two sites, and some restorations had substantial stands. Subsequently, to facilitate a general assessment, I visually evaluated percent cover of cattail as 1) negligible (1-5%); 2) slight (5-15%); 3) low

(15-25%); 4) moderate (25-40%); 5) optimal (40-55%) and 6) high (>55%) for each restoration used in both vegetation and avifaunal surveys (Tables 1 and 4).

Preferred Wildlife Food Plant Species

As described in Plant Species, I calculated the average number of preferred wildlife food plant species per transect per restoration. The average percent cover of preferred wildlife food plant species per transect per restoration was calculated as described in Vegetation Cover. I also reported these results for individual sites.

Weighted Average Wetland Index

As in Brown (1995), I calculated the weighted average wetland index (WI) which reflects an area's position within the wetland-upland gradient, based on wetland plant indicator status (Reed 1986) and percent cover (Eicher 1988). I also used Eicher's (1988) frequency midpoint index values (OBL=1.0; FACW=1.67; FAC=3.0; FACU=4.33; UPL=5.0) and Reed's (1986) wetland plant indicator status (Table 2) to calculate the weighted average wetland index using the formula:

$$\mathbf{WI} = \sum_{i=1}^{n} (IV_i * \mathbf{WIS}_i)$$

Wetland Index: WI = Position within the wetland-upland gradient
The lower the number, the higher the status

Importance Value: $IV = \frac{\text{percent cover of a species classification}}{\text{total cover of all classes}}$

Wetland Indicator Status: WIS = Frequency Midpoint Index Value (defined above)

I calculated the 1) average WI per restoration (represented by the WI value per transect) and 2) average WI per elevation per restoration as described in Plant Species. I also reported average WI values per transect and per elevation for individual sites.

Statistics

I used one-way ANOVAs to detect significant differences ($p \leq 0.05$) among years in vegetation variables. With regard to vegetation cover, percentages were arcsin transformed using the equation $p' = \arcsin \sqrt{p}$ (Zar 1996).

I used the paired sample signed-rank test, to detect significant differences ($p > 0.05$) in the average percent cover of preferred wildlife food species among years.

Table 1. Summary of restoration sites used by Brown (1991-1994) and those used by Robinson (1997-1998) for vegetation surveys. Sites in parentheses indicate new property owners.

Brown's Sites	Sites Used by Robinson
D	*
N-1	*
N-2	*
N-3	*
P-1 (L-1)	
P-2 (L-2)	
S-1	*
S-2	*
S-3	*
S-4	*
W-1	
W-2	*
V	*
TOTAL 13	10

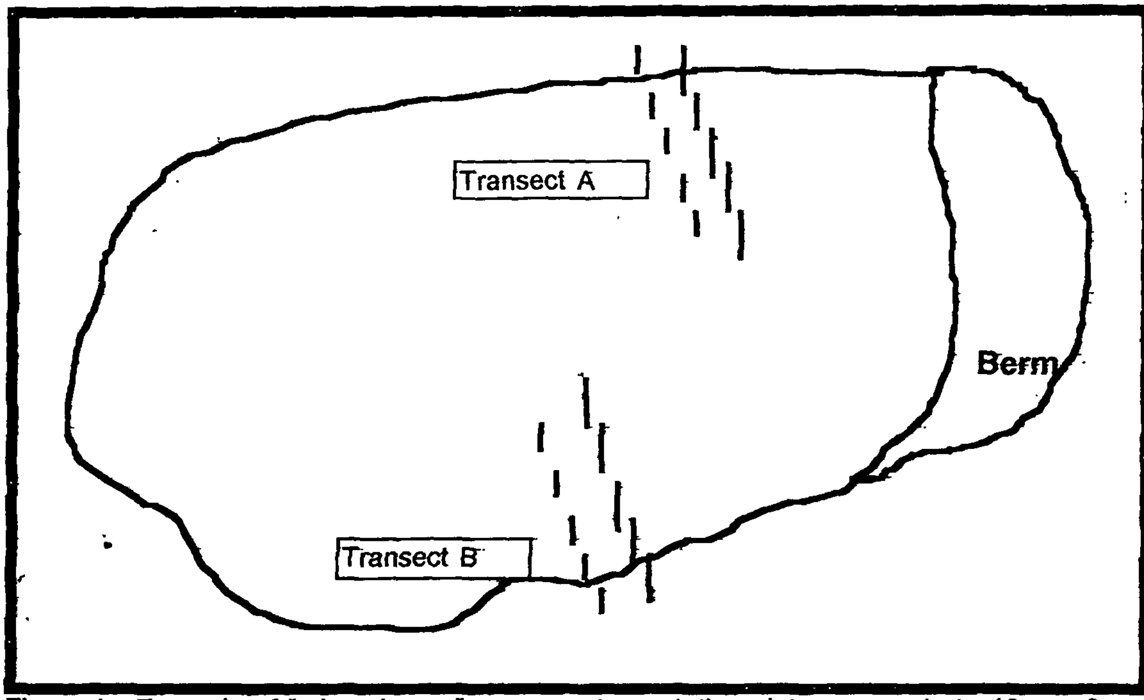

Figure 1. Example of "mirror image" permanent vegetation plots surveyed at +10 cm, 0 cm, -10cm, -20cm and -30 cm above and below the high water mark (0 cm or spillway). Each plot is identified by two pvc pipes that are set on the diagonal so that the 1 m X 1 m quadrat could be placed in the same sampling area year to year.

Table 2. Wetland plant classifications and frequency found in wetlands (Reed 1986, Cowardin et al. 1979).

Obligate (OBL) - Always found in wetlands under natural (not planted) conditions (frequency greater than 99%), but may persist in non-wetlands if planted there by man or in wetlands that have been drained, filled, or otherwise transformed into non-wetlands.
Facultative Wetland (FACW) - Usually found in wetlands (67-99% frequency), but occasionally found in non-wetlands.
Facultative (FAC) - Sometimes found in wetlands (34-66% frequency), but also occurring in non-wetlands.
Facultative Upland (FACU) - Seldom found in wetlands (1-33% frequency), and usually occurs in non-wetlands.
Non-wetland (UPL) - May occur in wetlands in another region, but not found (<1% frequency) in wetlands in the region specified. If a species does not occur in wetlands in any region, it is not on the list.

Marsh Bird Surveys

I prepared for marsh bird surveys by studying recorded calls provided by the Long Point Bird Observatory (Chabot and Helferty 1995) and the Cornell Laboratory of Ornithology to become familiar with bird species found in the project area. As in Brown (1995), I conducted unlimited radius point counts at each site by determining the best vantage point at which to listen and observe birds (Figure 2). Although I was not able to determine the vantage points used by Brown in 1991-1994, restorations are relatively small and it is doubtful that vantage points used in 1997 and 1998 were any less effective than those used in the original study.

Brown (1995) recorded all birds flushed upon approaching the wetland, but I but counted only birds that ranked as obligate or facultative wetland species (described below). Most of the restorations are located within large expanses of grasslands and other species flushed were grassland birds that lacked wetland status ranking. I did not count fly-overs and eliminated those species from Brown's 1994 data set to standardize statistical comparisons, nor did I segregate bird counts into behavioral activities.

Only birds positively identified by sight or call within the wetland were counted. As in Brown (1995), I conducted surveys between May 23 and June 30, with each observation period lasting 20 min. Each site was sampled four times with one survey each between the hours of 0500-0630, 0631-0800, 0801-0930, 0931-1100 EST. Sampling times were randomized so that no one wetland was sampled in consecutive time periods in one day, and when possible no less than four days between surveys. Instead, the period between sampling times usually varied from one to three weeks to maximize the number of individuals and species that could be observed throughout the four-week sampling period. As in Brown (1995), surveys were conducted in all weather except heavy rain storms and extremely windy conditions.

Because wading birds are more secretive than other marsh birds (Chabot and Helferty 1995), I sampled these species separately for richness and abundance using a portable broadcast speaker and bird call recordings provided by the Long Point Bird Observatory Marsh Monitoring Program (Chabot and Helferty 1995) and the Cornell Laboratory of Ornithology. Calls of the pied-billed grebe (*Podilymbus podiceps*), least bittern (*Ixobrychus exilis*), great blue heron (*Ardea herodias*), green heron (*Butorides virescens*), black-crowned night heron (*Nycticorax nycticorax*), king rail (*Rallus elegans*), Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), common moorhen (*Gallinula chloropus*), American coot (*Fulica americana*) and yellow rail (*Coturnicops noveboracensis*) were broadcast. Each sampling period lasted one minute per call at each site (30 sec of actual calling followed by 30 sec of silence). I continued to listen and observe each wetland for five minutes after the conclusion of the broadcast tape. Each site was sampled four times from the same vantage point and within the same survey times as marsh birds (described above) (Figure 2). Although the use of broadcast tapes is very effective in eliciting wading bird responses, it is also very disruptive to the marsh bird community as a whole (Chabot and Helferty 1995). To minimize disruption, audio tapes were broadcast following the 20 min marsh bird observation period. Because some wading birds are known to call at night, in 1997 and

1998 I conducted one evening survey at each site in late June between 2100 and 2400 EST.

I classified bird species into habitat preference groups using Brooks and Croonquist (1990). This index reflects a species' dependency on and frequency found in wetland versus non-wetland conditions (Table 3). All bird data are reported in terms of these classifications.

Bird Species

I conducted avifaunal surveys on 16 of 18 restorations used by Brown (1995) (Table 4). Two sites (F-1 and F-2) were not available for survey. I made an adjustment when surveying Brown's sites S-1, S-2, S-3 and S-4. Although Brown classified these sites as separate restorations, they constituted a system of wetlands and birds did not seem to show fidelity towards any one site. Subsequently, I did not survey each pool individually, but rather used two survey points on the property: one for S-1 and S-2 and another for S-3 and S-4. By choosing a vantage point between the two sites being surveyed, I was able to gain a full view of both wetlands while minimizing recounts. Results of the two surveys were then averaged and the value used throughout this section as representative of that property is simply referred to as "S". Brown's 1994 data were reassembled in this manner to allow statistical comparison among years. Therefore, I conducted avifaunal surveys on 13 original restorations (Table 4).

The average number of bird species in each habitat preference group (OBL, FACW, FAC, UPL) per restoration was calculated by summing the total number of bird species in each group per restoration divided by the total number of restorations (n=13):

$$\frac{\sum \text{total number of bird species in each group per restoration}}{13 \text{ restorations}}$$

The average number of wetland bird species (OBL+FACW+FAC) per restoration was calculated by summing the total number of wetland bird species per restoration divided by the total number of restorations (n=13):

$$\frac{\sum \text{total number of wetland bird species in each group per restoration}}{13 \text{ restorations}}$$

The average number of bird species in all habitat preference groups combined per restoration was calculated by summing the total number of bird species in all groups per restoration divided by the total number of restorations (n=13):

$$\frac{\sum \text{total number of bird species in all groups per restoration}}{13 \text{ restorations}}$$

Average avian community composition for each habitat preference group per restoration was calculated by summing the total number of bird species in a group per restoration divided by the total number of bird species in all groups per restoration x 100:

$$\sum\left(\frac{\text{total number of bird species in a group per restoration}}{\text{total number of bird species in all groups per restoration}}\right) \text{X } 100$$

Number of Individuals

The average number of individuals in each habitat preference group per census per restoration was calculated by summing the total number of individuals observed in all census periods per restoration divided by 4 census periods divided by the total number of all restorations (n=13):

$$\left(\frac{\text{total number of individuals in all census periods per restoration}}{\text{4 census periods}} \right) \div \text{13 restorations}$$

The average number of wetland individuals per census per restoration was calculated by summing the total number of wetland individuals observed in all census periods per restoration divided by four census periods divided by the total number of restorations (n=13):

$$\left(\frac{\text{total number of wetland individ. in all census periods per restoration}}{\text{4 census periods}} \right) \div \text{13 restorations.}$$

The average percent representation of individuals by habitat preference group per restoration was calculated by summing the total number of individuals in a group per restoration divided by the total number of individuals in all groups per restoration x 100:

$$\left(\frac{\text{total number of individuals in a group per restoration}}{\text{total number of individuals in all groups per restoration}} \right) \text{X } 100$$

Abundance of Obligate Wetland Bird Species

The overall total of OBL individuals was calculated by simply adding the number of OBL individuals recorded at each restoration.

Species Diversity

The average Shannon-Weiner (S-W) diversity index is a measure of uncertainty in predicting the identity of the next randomly encountered observation, meaning that the less predictable the identity, the higher the diversity. Or, in terms of the equation below, diversity increases with the value of H' (Zar 1996). I calculated S-W values using:

$$H' = \sum_{i=1}^{k} (p_i)(\log_2 p_i)$$

where

H' = Index of species diversity

k = Number of species

p_i = Proportion of observations found in category i (Zar 1996).

I calculated average species diversity per restoration by summing the S-W value per restoration divided by the total number of restorations:

$$\frac{\sum \text{S-W value per restoration}}{13 \text{ restorations}}$$

Statistics

I used one-way ANOVAs to detect significant differences ($p \leq 0.05$) among years in bird variables. With regard to community representation of individuals by habitat preference group, percentages were arcsin transformed using the equation $p' = \arcsin \sqrt{p}$ (Zar 1996).

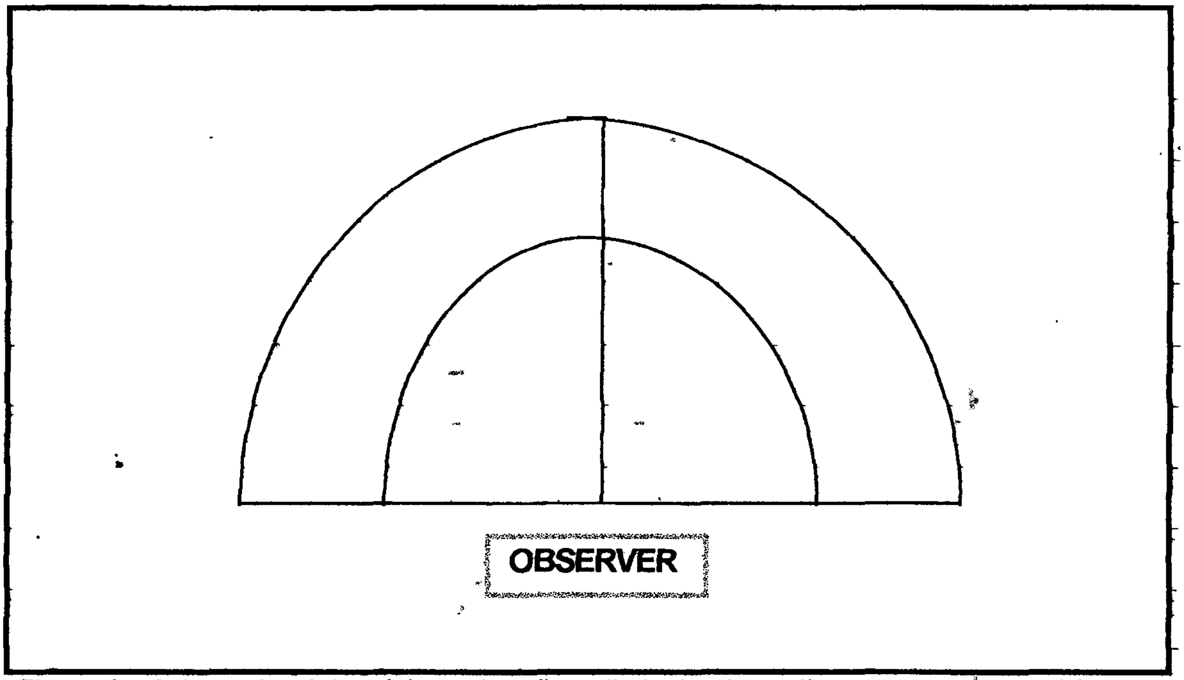

Figure 2. Schematic of the sight and audio unlimited point radius survey area used in avifaunal observations.

Table 3. Description of bird classifications from Brooks and Croonquist (1990). Because FACD and UPL species both score "0" in this index, these species were combined as UPL for this study.

Obligate (OBL) >99% in wetlands (score 5)
Facultative Wet (FACW) 57-99% in or near wetlands (score 3)
Facultative (FAC) 34-66% found in wetlands, but wetlands not essential (score 1)
Facultative Dry (FACD) 1-33% occasional or no use (score 0)
Upland (UPL) 1-33% occasionally or never found in wetlands (or 99% found in uplands) (score 0)

Table 4. Summary of restoration sites used by Brown (1991-1994) and those used by Robinson (1997-1998) for avian surveys. Sites in parentheses indicate property owner changes since Brown's survey.

Brown's Sites	Robinson's Sites
D	*
B	*
N-1	*
N-2	*
N-3	*
P-1 (L-1)	*
P-2 (L-2)	*
S-1	*
S-2	*
S-3	*
S-4	*
R-1	*
R-2	*
W-1	*
W-2	*
F-1 (VIS)	
F-2 (VIS)	
VEN	*
TOTAL 13	10

Restoration Size, Distance to Nearest Wetland and Percent Emergent Vegetation

Brown (1995) took aerial photographs of the restorations to determine areas of open water, wet meadow and emergent vegetation; however, those photographs were not available for this study. To facilitate correlations between site and avifaunal variables, I used aerial photographs and slides provided by the Jefferson County Farm Service Agency, Watertown, New York, to determine wetland areas in 1998 (Table 5). I used the Agency's Numonics Corporation

Digitizer Model 1211H-1-2424E to measure areas within 10% margin of error, as suggested by Farm Service Agency staff (pers. comm., Florence Bast). I was not able to determine accurate boundaries of wet meadows or emergent vegetation; therefore, areas were determined by digitizing the obvious perimeter of each wetland. I also measured the distance from each restoration to the nearest wetland, defined by Brown (pers. comm. 1998) as any water type; i.e., stream, river, pond, lake, etc. (Table 5).

I visually estimated the percent of emergent vegetation at each restoration to facilitate regression analysis of potential relationships between avifaunal use of restorations and this variable. In addition, knowledge about open water:cover ratios is valuable in wetland management decisions (Table 5).

Table 5. Approximate wetland area and distance to the nearest wetland measured from 1998 aerial photographs and slides, and visual estimate of percent emergent vegetation at each restoration in 1998. Sites in parentheses indicate property owner changes since 1994.

Site Name	Area (ac)	Area (ha)	Distance to Nearest Wetland (km)	Percent Emergent Vegetation (Visual Estimate)
B	1.80	0.72	0.606	5
D	0.20	0.08	0.303	50
N-1	0.70	0.28	0.106	95
N-2	0.40	0.16	0.106	100
N-3	0.40	0.16	0.106	100
P-1 (L-1)	3.70	1.48	0.091	85
P-2 (L-2)	1.00	0.40	0.091	50
R-1	3.00	1.20	0.106	15
R-2	0.40	0.16	0.106	75
S-1	0.50	0.20	0.038	5
S-2	0.30	0.12	0.038	5
S-3	0.30	0.12	0.038	5
S-4	0.40	0.16	0.038	5
V	3.00	1.20	0.227	10
W-1	2.50	1.00	0.182	90
W-2	0.90	0.36	0.182	25

Regression Analysis

Regression analyses were performed to determine significant relationships between selected site habitat predictors and avian response variables. Results represent data collected at the 13 restorations for which bird surveys were conducted in 1997 and 1998 (B, D, N-1, N-2, N-3, P-1, P-2, R-1, R-2, S, W-1, W-2, V). I did not attempt to analyze 1994 data because I calculated site habitat predictors differently than Brown (See Methods, Restoration Size, Distance to Nearest Wetland and Percent Emergent Vegetation).

Site habitat predictor variables included :

1) area of the wetland;

2) distance to the nearest wetland; and

3) visual estimation of percent emergent vegetation.

Avian response variables included:

1) average number of all species combined (OBL+FACW+FAC+UPL);

2) average number of OBL species;

3) average number of OBL+FACW species;

4) average species diversity for all species combined (Shannon-Wiener);

5) average species diversity for OBL species;

6) average species diversity for OBL+FACW species;

7) average number of individuals per census for all species combined;

8) average number of individuals per census for OBL species; and

9) average number of individuals per census for OBL+FACW species.

For analysis of the relationship between vegetation variables and bird response variables, I included only the seven restorations on which both bird and vegetation surveys were conducted in all three years so that vegetation predictors and bird response variables would be represented by the same number of restorations. As described previously, ten restorations were included for vegetation surveys and 13 for avian surveys; however, only seven shared both surveys (D, N-1, N-2, N-3, W-2, S, V). As with avian surveys I averaged the values for S-1, S-2, S-3 and S-4 which is represented here as "S".

Vegetation predictor variables included:

1) average number of all plant species combined (OBL+FACW+FAC+FACU+UPL);

2) average number of wetland plant species (OBL+FACW+FAC);

3) average percent cover of all plant species combined; and

4) average percent cover of wetland plant species.

Avian response variables included:

1) average number of all species combined (OBL+FACW+FAC+UPL);

2) average number of OBL species;

3) average number of OBL+FACW species;

4) average species diversity for all species combined (Shannon-Wiener);

5) average species diversity for OBL species;

6) average species diversity for OBL+FACW species;

7) average number of individuals per census for all species combined;

8) average number of individuals per census for OBL species; and

9) average number of individuals per census for OBL+FACW species.

Amphibian Surveys

I prepared for amphibian surveys by studying recorded calls provided by the Long Point Bird Observatory Marsh Monitoring Program (Chabot and Helferty 1995). Calls included those of the American toad (*Bufo americanus*), bullfrog (*Rana catesbiana*), chorus frog (*Pseudacris triseriata*), gray tree frog (*Hyla versicolor*), green frog (*Rana clamitans*), northern leopard frog (*Rana pipiens*), spring peeper (*Pseudacris crucifer*) and wood frog (*Rana sylvatica*).

Sampling followed protocol outlined by the Long Point Bird Observatory Marsh Monitoring Program (Chabot and Helferty 1995). I established a 180°, 100 m fixed-radius point survey location (Figure 2) at each restoration by determining the best vantage point from which to listen for calling amphibians, and marked each location with flagged pvc pipe.

Air temperature and wind speed are the primary factors affecting amphibian sampling because anuran body temperatures reflect the surrounding environment. (Chabot and Helferty 1995). Breeding cycles among species are staggered so that early breeders begin calling at lower temperatures than those that breed at warmer temperatures later in the season (Zug 1993). Ideally, the first amphibian survey should be conducted when the temperature is between 7-12°C (46-54°F), the second between 13-20°C (55-68°F) and the third from 21+°C (70+°F) (Chabot and Helferty 1995). Sampling should not be conducted when wind speed registers higher than "three" on the Beufort Wind Scale (Chabot and Helferty 1995) (Appendix C).

Each location should be approached quietly and surveys conducted in silence between dusk and midnight once between April 15-30, May 15-30 and June 15-30 on an evening that meets wind and temperature parameters (Chabot and Helferty 1995). The total sampling time per location is for 5 min and is divided into a 3 min period to record calls and a 2 min validation period (Chabot and Helferty 1995). I recorded calling species on data sheets provided by Long Point Bird Observatory Marsh Monitoring Program that use call level codes to denote species and number of individuals calling (Chabot and Helferty 1995) (Appendix D).

In 1997, I conducted one survey each month between April 15-30, May 15-30 and June 15-30 between dusk and midnight. In 1998 it was not possible to conduct the April survey; however, May and June surveys were completed. I do not feel that numbers of amphibian individuals were accurately represented by recorded call level codes and instead present results in terms of presence/absence of amphibian species that includes observations recorded during daytime visits to each restoration. Since each restoration was visited the same number of times, non-survey observations can be considered equal among sites.

Statistics

I used a two-tailed t-test ($p \leq 0.05$) to detect differences in the number of amphibian species found at each restoration. The number of restorations at which each amphibian species was recorded is presented simply in terms of presence/absence. I did not attempt statistical analyses of survey data with regard to call level codes for the following reasons:

1) Although the monitoring protocol was developed to sample amphibians in the Great Lakes basin, meeting "ideal" temperature and wind conditions was challenging, if not impossible, especially in April and May. Due to distances between sites and time needed to reach remote locations, I required a minimum of four to six evenings of suitable conditions to survey all 13 wetlands. Most restorations are located in open grasslands and fields within 1.6 to 3.2 km of Lake Ontario or the St. Lawrence River, where I did not experience extended periods of ideal sampling conditions during the early spring.

2) The protocol describes setting up "stations" within a wetland as a series of sampling locations that can be surveyed in the same evening. In this study, only one "station" was necessary to sample each wetland, resulting in only one representative value for the site, rather than several values from a series of locations, and as noted above, it was not possible to sample all wetlands on the same evening. Rather, surveys were conducted over the prescribed two-week period in each month. Consequently, the "series" of values recorded for this study were compiled from unique sites, under differing weather conditions from different nights.

To avoid this problem in future follow-up surveys, all wetlands could be surveyed in one evening by assigning a team of three to four people specific wetlands to survey simultaneously, and by repeating surveys three times in each sampling period. The additional surveys would also compensate for surveys conducted under less than ideal weather conditions and increase the ability to record early "explosive" breeding species such as the wood frog.

RESULTS

Vegetation

Differences in Species Richness Among Years

Overall, the average number of species in all plant classifications decreased between 1994 and 1997 but remained relatively stable between 1997 and 1998 (Figure 3). Between 1994 and 1998, there was a significant decrease in the average number of OBL, FACW, FACU and UPL species, total species richness (OBL + FACW + FAC + FACU + UPL) and wetland species richness (OBL + FACW + FAC) (Figure 3, see Table 6 for ANOVA results). There were no significant differences in species richness between 1997 and 1998 in any plant classification (Figure 3, see Table 6 for ANOVA results). Plant species observed in restored wetlands in 1994, 1997 and 1998 are summarized in Appendix E.

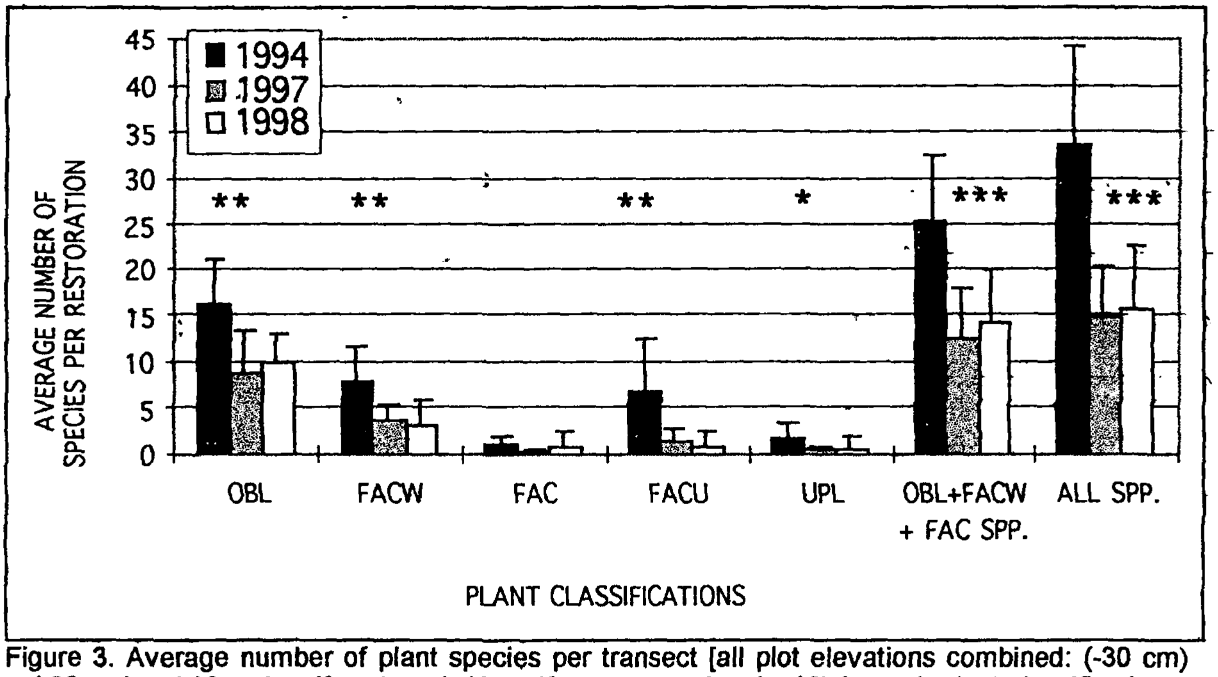

Figure 3. Average number of plant species per transect [all plot elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] per restoration (n=10) in each plant classification (OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU=facultative upland, UPL= upland). *=p≤.05 **=p≤.01 ***=p≤.001 One-Way ANOVA; df=2,27. Error bars show +1 standard deviation.

Table 6. Summary of F values and significance levels (p) for the average number of plant species per transect [all plot elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] per restoration (n=10) in each plant classification (OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland). One-Way ANOVA; df=2,27.

	OBL	FACW	FAC	FACU	UPL	ALL SPECIES	OBL+FACW +FAC SPECIES
F Value	8.28	7.81	1.09	7.56	3.44	17.87	11.40
Significance Level (p)	0.002	0.002	0.350	0.002	0.047	0.000	0.000

Differences in Plant Species Richness at Each Elevation

There were no significant differences in the average number of plant species among classifications or elevations between 1997 and 1998, but between 1994 and 1998 there was a general decrease in the average number of species in each classification at each elevation (Figure 4).

The average number of OBL plant species was significantly higher in 1994 at -30 cm, -20 cm, -10 cm and 0 cm than in 1997 or 1998 (Figure 4, see Table 7 for ANOVA results).

In 1994 there were significantly more FACW plant species at -10 and 0 cm than in 1997 or 1998, but there were no significant differences in the average number of FAC species at any elevation (Figure 4, see Table 7 for ANOVA results).

Significantly more FACU plant species were found at 0 cm and +10 cm in 1994 than in 1997 or 1998, and the average number of UPL species at +10 cm was significantly higher in 1994 than in 1997 or 1998 (Figure 4, see Table 7 for ANOVA results).

The average number of wetland plant species combined (OBL + FACW + FAC) was significantly higher at -30 cm, -20 cm, -10 cm and 0 cm in 1994 than in 1997 or 1998 (Figure 5, see Table 8 for ANOVA results).

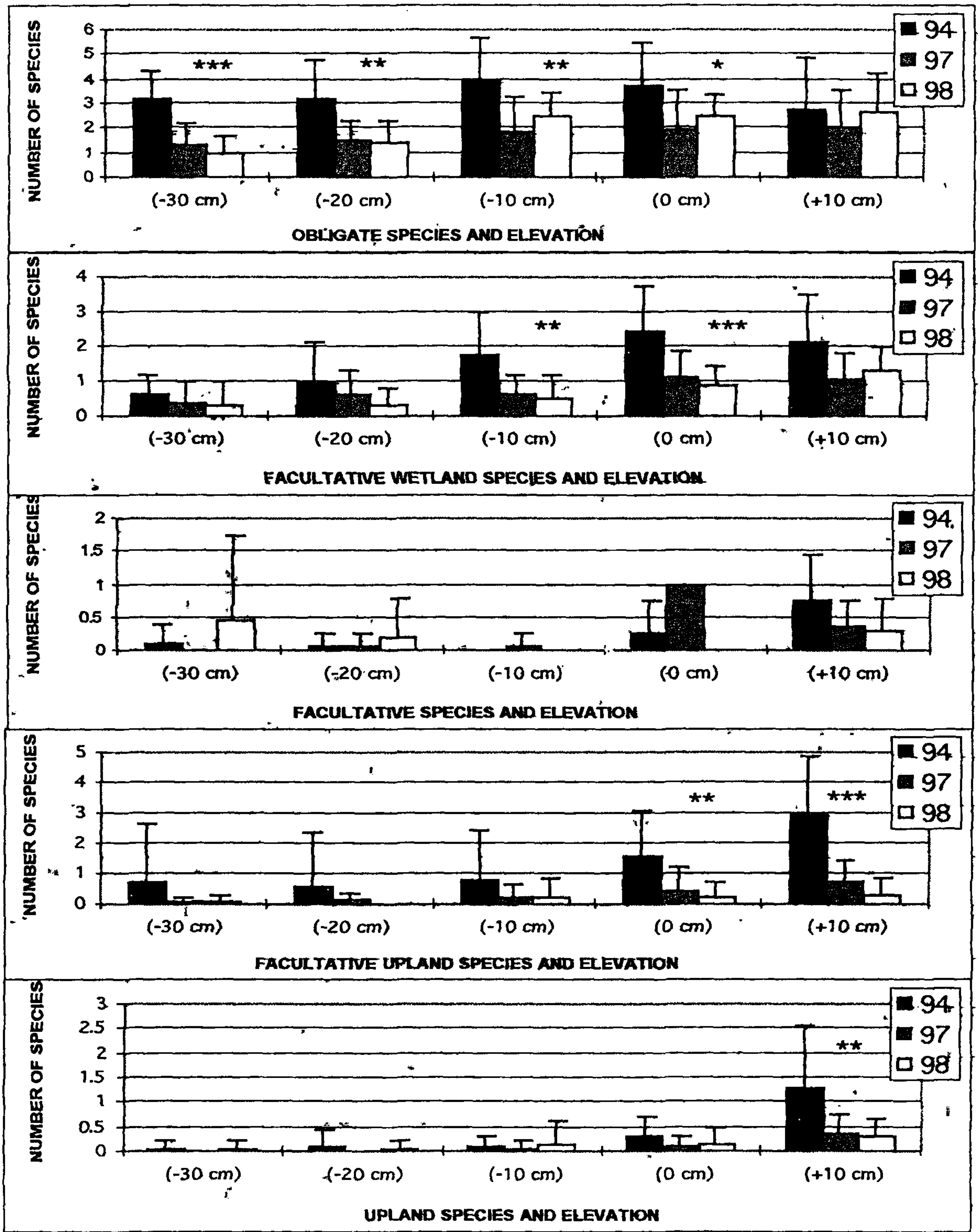

Figure 4. Average number of plant species per elevation per restoration (n=10) in each classification (OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland). *=p≤.05 **=p≤.01 ***=p≤.001 One-Way ANOVA; df=2,27. Error bars show +1 standard deviation.

Table 7. Summary of F values and significance levels (p) for the average number of plant species per elevation per restoration (n=10) in each classification (OBL=obligate, FACW= facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland). One-Way ANOVA; df=2,27.

SPECIES CLASS		-30 cm	-20 cm	-10 cm	0 cm	+10 cm
OBLIGATE						
	F Value	15.93	7.17	5.92	4.06	0.50
	Significance Level (p)	**0.000**	**0.003**	**0.007**	**0.029**	0.613
FACULTATIVE WETLAND						
	F Value	0.61	1.48	6.35	8.77	2.98
	Significance Level (p)	0.553	0.246	**0.006**	**0.001**	0.068
FACULTATIVE						
	F Value	1.00	0.50	1.00	1.21	2.12
	Significance Level (p)	0.382	0.612	0.381	0.313	0.140
FACULTATIVE UPLAND						
	F Value	1.28	0.96	1.14	5.55	13.94
	Significance Level (p)	0.295	0.396	0.333	**0.01**	**0.000**
UPLAND						
	F Value	0.50	0.60	0.25	0.97	5.13
	Significance Level (p)	0.612	0.556	0.777	0.393	**0.013**

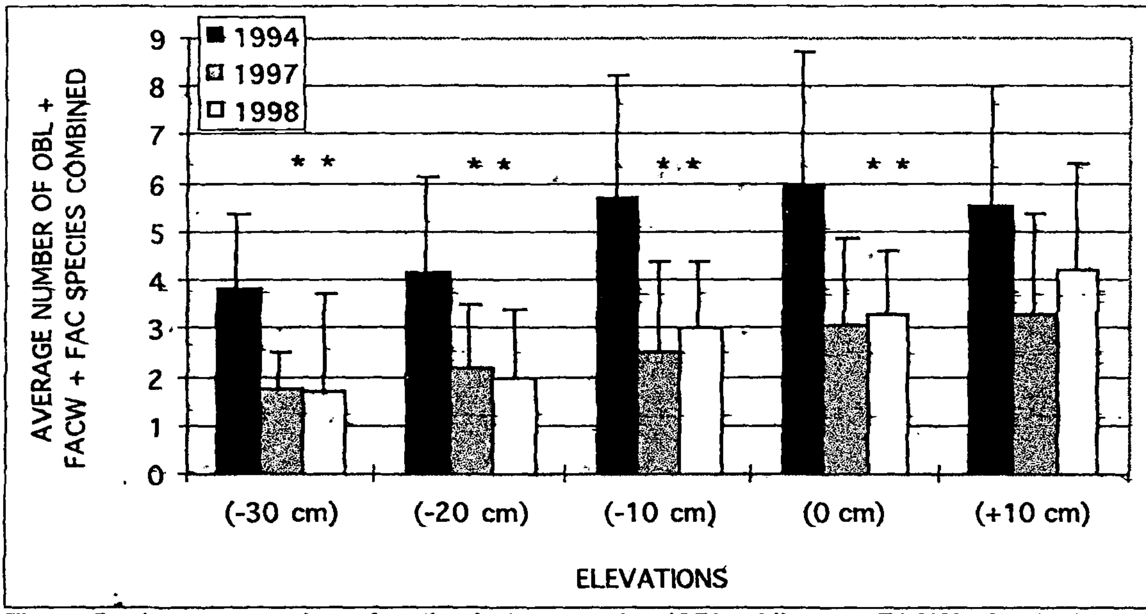

Figure 5. Average number of wetland plant species (OBL=obligate + FACW= facultative wetland + FAC=facultative) per elevation per restoration (n=10). **=p≤.01 One-Way ANOVA; df=2,27. Error bars show +1 standard deviation.

Table 8. Summary of F values and significance levels (p) for the average number of wetland plant species (OBL=obligate + FACW=facultative wetland + FAC= facultative) per elevation per restoration (n=10). One-Way ANOVA; df=2,27.

SPECIES CLASS		-30 cm	-20 cm	-10 cm	0 cm	+10 cm
OBL + FACW + FAC						
	F Value	6.33	5.53	7.37	5.73	2.50
	Significance Level (p)	0.006	0.010	0.003	0.008	0.101

Changes in Species Composition at Each Elevation Among Years

There were noticeable changes in plant community composition at each elevation among years. In general, OBL species comprised the largest percentage of total plant species at -30 cm, -20 cm, -10 cm and 0 cm in all years (Figures 6a-6d). At the highest elevation (+10 cm) however, the percentage of OBL species increased from 1994 and represented the majority of species at this elevation in 1998 (Figure 6e). The percentage of FACW species remained relatively stable among years at all elevations while FAC species generally comprised a small percentage of total species at all elevations and years (Figures 6a-6e). Percentage of FACU species decreased between 1994 and 1998 at all elevations, and percentage of UPL species increased between 1994 and 1998 at all elevations except +10 cm where the relative percentage of UPL species decreased (Figures 6a-6e).

At -30 cm, the representation of OBL species increased by 7% between 1994 and 1997 and then decreased by 26% between 1997 and 1998. The percentage of FAC species in 1998 was 21% higher than in 1994 and there was an 11% decrease in FACU species between 1994 and 1998. UPL species were not found in 1997; but reestablished in 1998 at 7% higher than 1994 levels (Figure 6a).

At -20 cm the percentage of OBL species remained stable among years (Figure 6b). FACW species increased in 1997 by 8% from 1994, but decreased in 1998 by 13% (Figure 6b). There was an 8% increase in FAC species from 1994 to 1998, and UPL species reestablished in 1998 at 5% higher than 1994 levels (Figure 6b).

At -10 cm there was an increase of 8% in OBL and 11% in UPL species between 1994 and 1998, while FACW and FACU species decreased by 13% and 7%, respectively (Figure 6c). FAC species at this elevation were uncommon in 1997 (Figure 6c).

There was an increase of 19% in OBL and 5% in UPL species at 0 cm from 1994 to 1998; however, FACW species remained stable among years (Figure 6d). There were no FAC species found in 1998 at this elevation, but in 1997 22% of the plot was comprised of this species classification (Figure 6d). Between 1994 and 1998 there was a 14% decrease in FACU species (Figure 6d).

At +10 cm the percentage of OBL species increased from 1994 to 1998 by 26%, and the percentage of FACW and FAC species remained relatively stable among years (Figure 6e). There was a 24% decrease in FACU species between 1994 and 1998 and UPL species also decreased slightly by 6% over the same time period (Figure 6e).

In summary, the average number of all plant species (OBL + FACW + FAC + FACU + UPL) and the average number of wetland plant species (OBL + FACW + FAC) were higher in 1994 than in 1997 or 1998 at all elevations, while the percentage of wetland plant species in the total plant community tended to increase from 1994 to 1998 at all elevations (Table 9). At the five elevations, percentage of the total plant community comprised of wetland species ranged from 55-83% over all restorations in 1994, 77-94% in 1997 and 87-94% in 1998 (Table 9). As the average number of species at each elevation decreased between 1994 and 1998, the percent composition of surviving species represented by wetland plant classifications increased (Table 9).

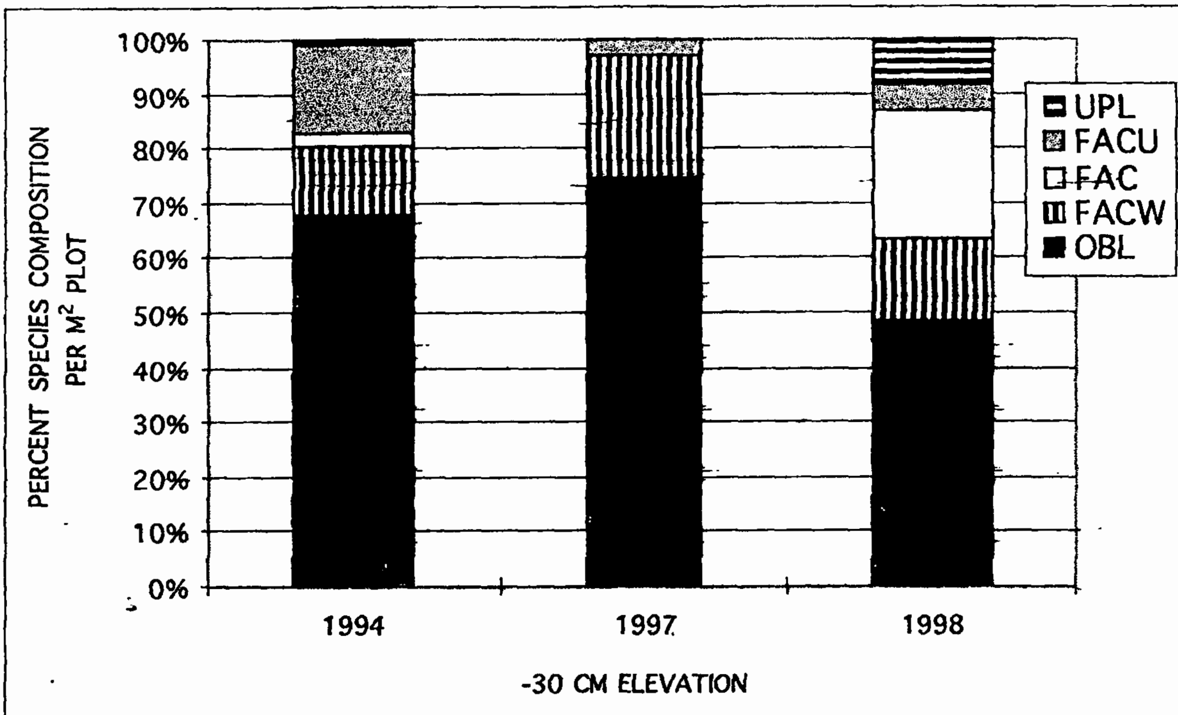

Figure 6a. Average percent species composition of each plant classification for m^2 plots at -30 cm [(number of species in a class / total number of species in all classes) x 100] per restoration (n=10). OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU= facultative upland, UPL=upland.

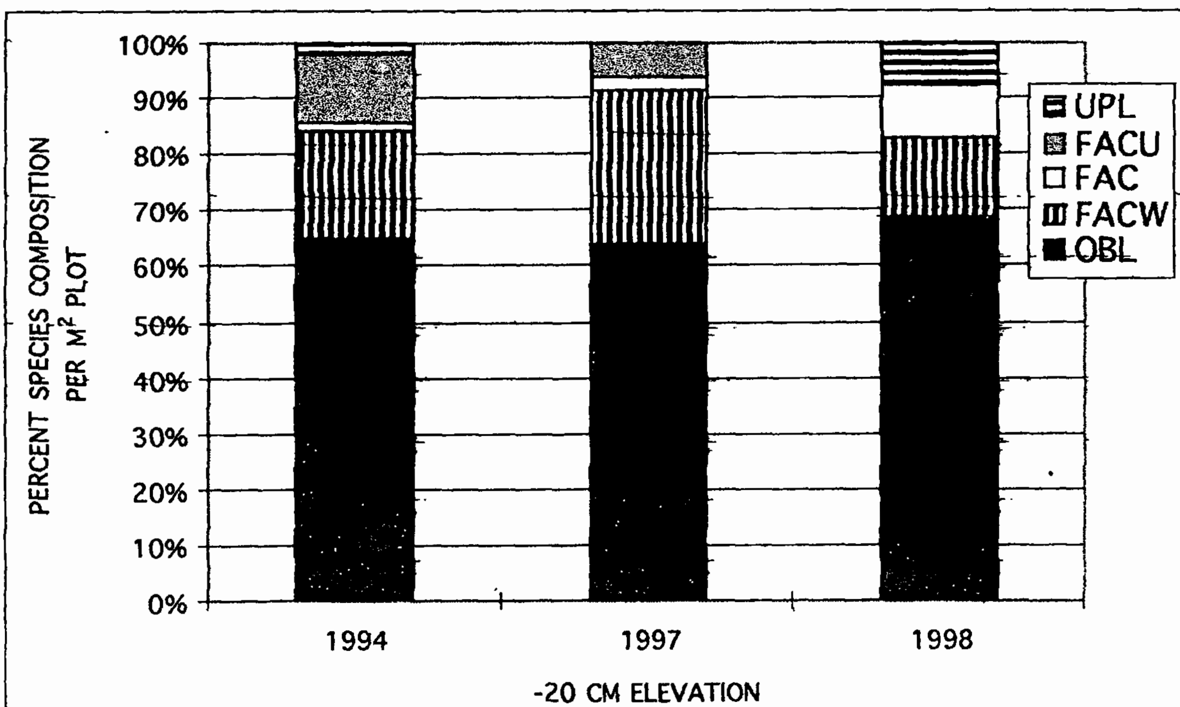

Figure 6b. Average percent species composition of each plant classification for m^2 plots at -20 cm [(number of species in a class / total number of species in all classes) x 100] per restoration (n=10). OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU= facultative upland, UPL=upland.

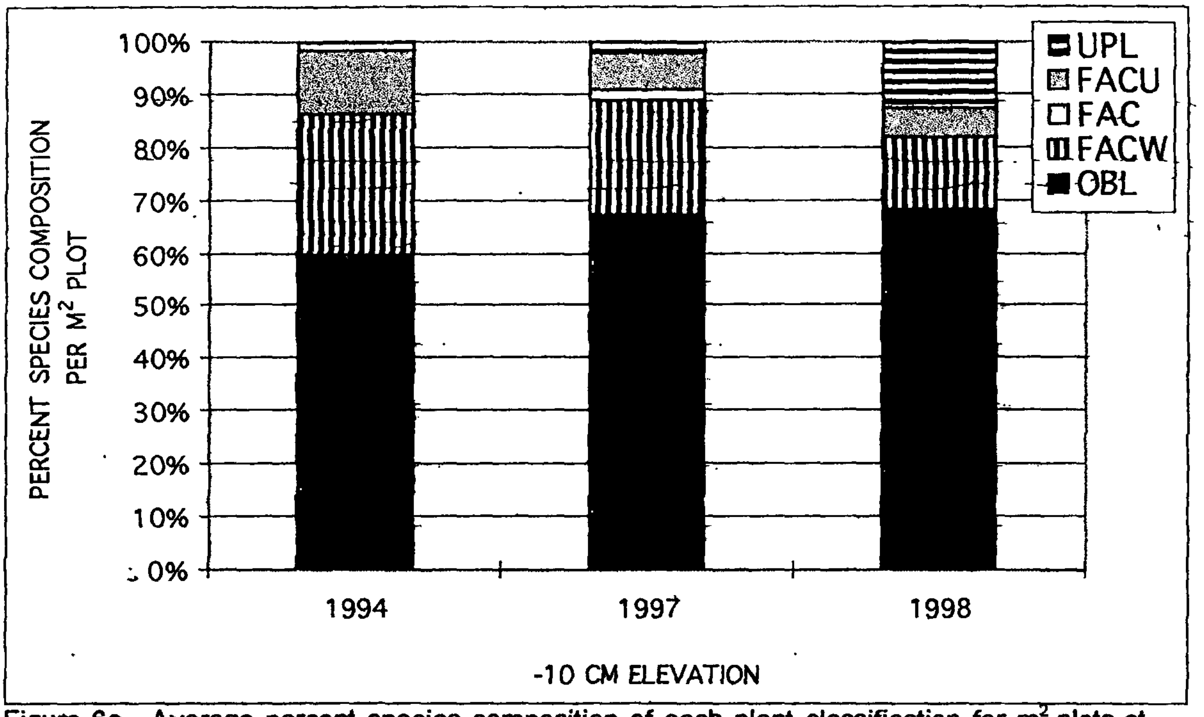

Figure 6c. Average percent species composition of each plant classification for m^2 plots at -10 cm [(number of species in a class / total number of species in all classes) x 100] per restoration (n=10). OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU= facultative upland, UPL=upland.

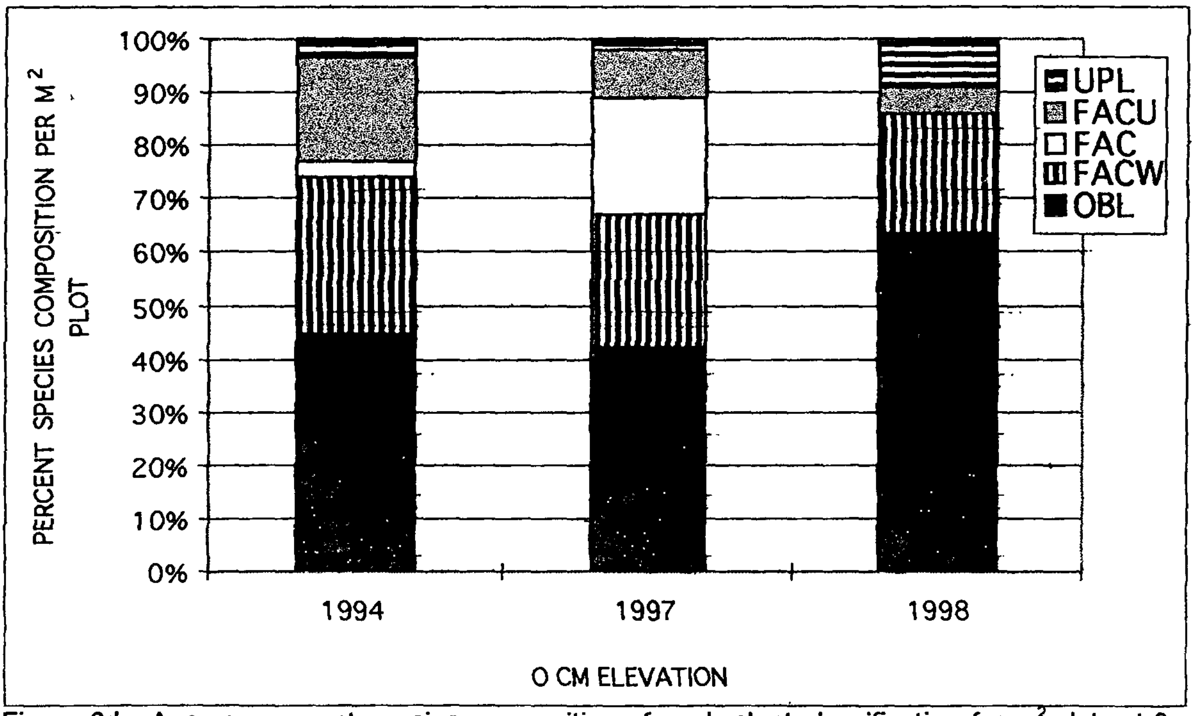

Figure 6d. Average percent species composition of each plant classification for m^2 plots at 0 cm [(number of species in a class / total number of species in all classes) x 100] per restoration (n=10). OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland.

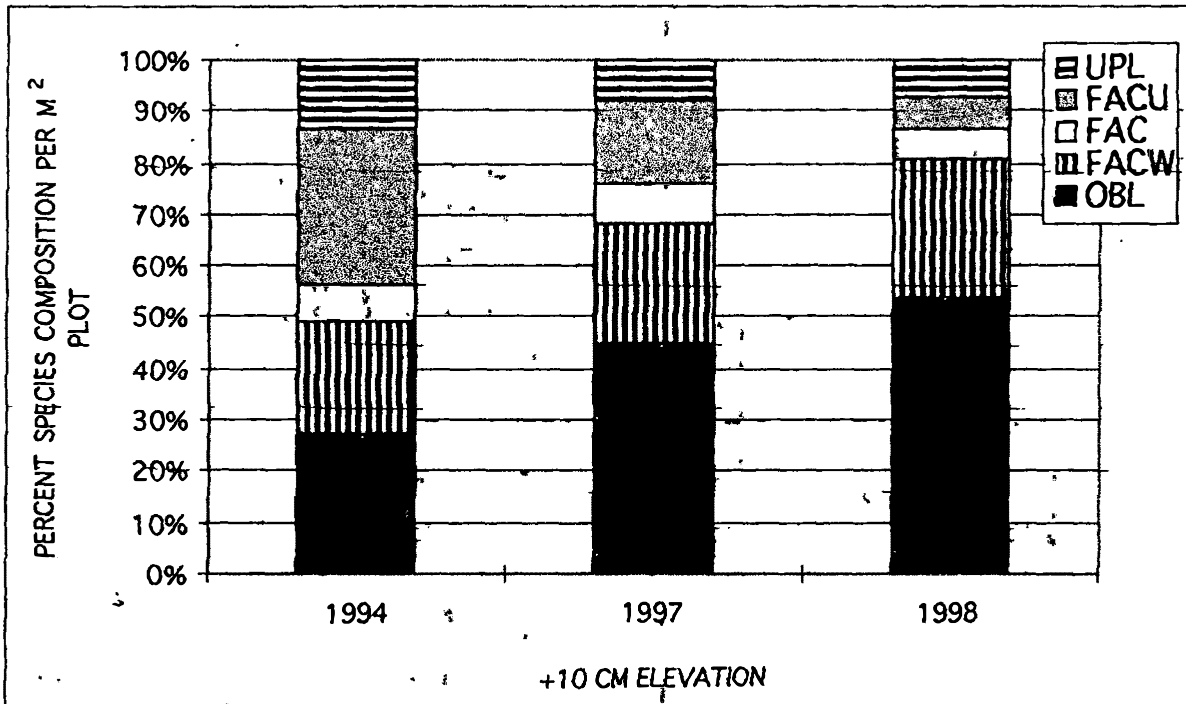

Figure 6e. Average percent species composition of each plant classification for m^2 plots at +10 cm [(number of species in a class / total number of species in all classes) x 100] per restoration (n=10). OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU= facultative upland, UPL=upland.

Table 9. Comparison of the average number of all plant species (A: OBL=obligate + FACW=facultative wetland + FAC=facultative + FACU=facultative upland + UPL=upland) and the average number of wetland plant species (W: (OBL=obligate + FACW=facultative wetland + FAC=facultative) in permanent m^2 plots at each elevation per restoration (n=10). (P) = the percent of wetland plants comprising the total plant community at each elevation per restoration.

	1994 (A)	1994 (W)	1994 (P)	1997 (A)	1997 (W)	1997(P)	1998 (A)	1998 (W)	1998 (P)
ELEVATION	AVE. NO. PLANT SPECIES ALL CLASSES	AVE. NO. WETLAND SPECIES OBL+ FACW+ FAC	% OF 1994 (A) THAT ARE 1994 (W)	AVE. NO. PLANT SPECIES ALL CLASSES	AVE. NO. WETLAND SPECIES OBL+ FACW+ FAC	% OF 1997 (A) THAT ARE 1997 (W)	AVE. NO. PLANT SPECIES ALL CLASSES	AVE. NO. WETLAND SPECIES OBL+ FACW+ FAC	% OF 1998 (A) THAT ARE 1998 (W)
-30 cm	4.6	3.8	83	1.8	1.7	94	1.8	1.7	94
-20 cm	4.8	4.1	85	2.3	2.2	96	2.0	1.9	95
-10 cm	6.6	5.7	86	2.7	2.5	92	3.3	3.0	91
0 cm	4.0	2.8	70	3.6	3.1	86	3.6	3.3	92
+10 cm	10.0	5.5	55	4.3	3.3	77	4.8	4.2	87

Differences in Vegetation Cover at Each Elevation Among Years

There were no significant differences in percent cover of OBL or FACW species at any elevation among years (Figure 7, see Table 10 for ANOVA results). However, variances (standard deviations) in percent cover were high and probably reflect the varying hydrological capability of each restoration to support plants in these classifications.

The percent cover of FAC species at +10 cm was significantly higher in 1994 than in 1997 or 1998 (Figure 7, see Table 10 for ANOVA results).

At 0 cm the percent cover of FACU species was significantly higher in 1994 than in 1997 or 1998, and at +10 cm percent cover of FACU species was significantly higher in 1997 than in 1994 or 1998 (Figure 7, see Table 10 for ANOVA results).

There were no significant differences in UPL species cover among years at any elevation (Figure 7, see Table 10 for ANOVA results).

Between 1994 and 1998, the percent cover for all plant species (OBL + FACW + FAC + FACU + UPL) (Figure 8) and for wetland plant species (OBL + FACW + FAC) (Figure 9) tended to increase at higher elevations (-10 cm, 0 cm, +10 cm) and decrease at lower elevations (-20 cm and -30 cm) where open water dominated and emergent vegetation was not well established. There were no significant differences in the percent cover of all plant species at any elevation among years (Figure 8, see Table 11 for ANOVA results); however, percent cover for wetland plant species was significantly higher at +10 cm in 1998 than in 1994 or 1997 (Figure 9, see Table 11 for ANOVA results).

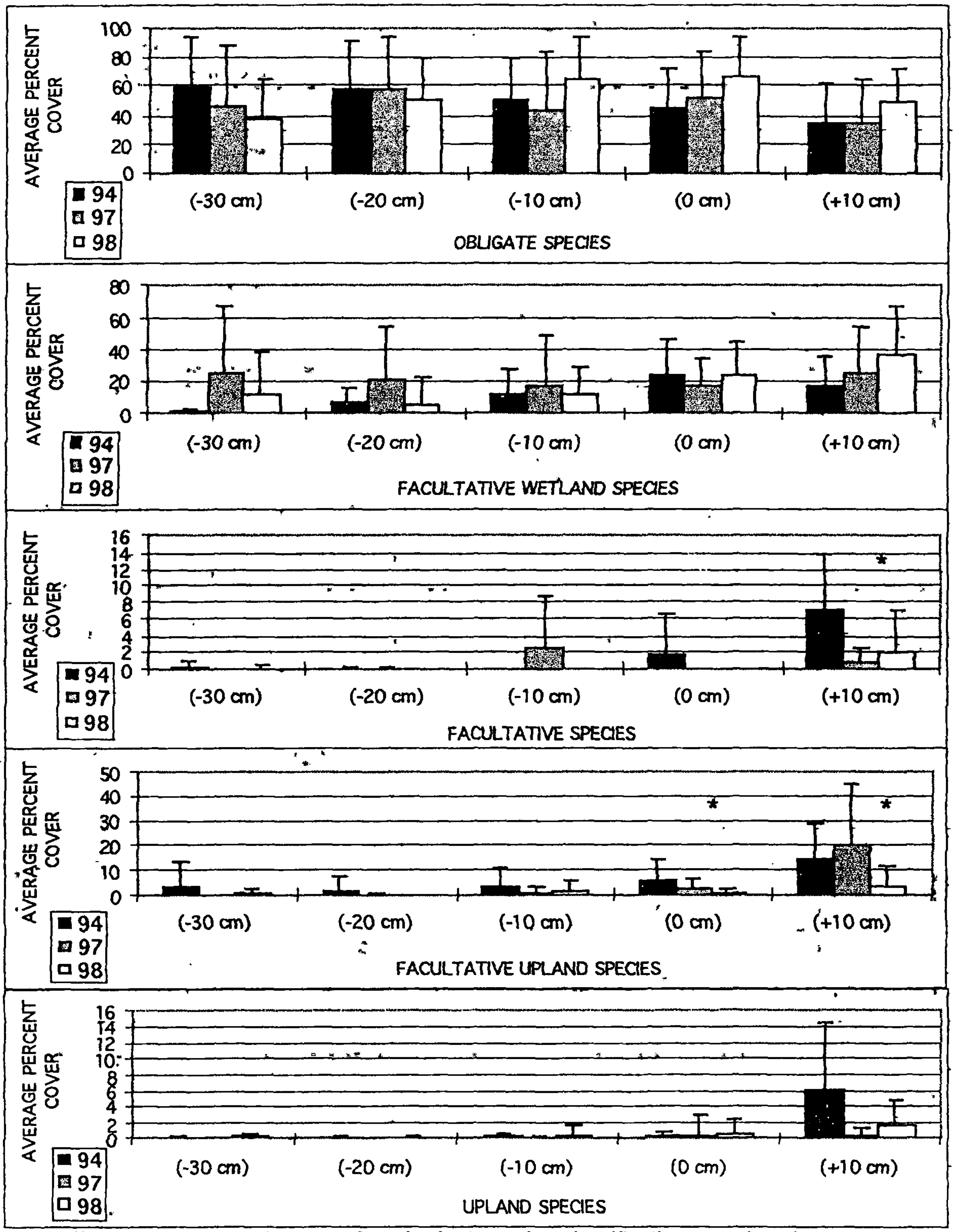

Figure 7. Average percent cover of each plant species classification per elevation per restoration (n=10). *=p≤.05 One-Way ANOVA; df=2,27. Error bars show +1 standard deviation.

Table 10. Summary of F values and significance levels (p) for the average percent cover of each plant species classification per elevation per restoration (n=10). ANOVA One-Way; df=2,27. Arcsin transformed data were used in the ANOVA analysis.

SPECIES CLASS		-30 cm	-20 cm	-10 cm	0 cm	+10 cm
OBLIGATE						
	F Value	1.06	0.16	1.21	1.79	1.11
	Significance Level (p)	0.359	0.857	0.312	0.186	0.344
FACULTATIVE WETLAND						
	F Value	1.26	1.89	0.28	0.35	0.92
	Significance Level (p)	0.301	0.170	0.762	0.711	0.412
FACULTATIVE						
	F Value	0.53	0.50	1.00	1.89	4.50
	Significance Level (p)	0.595	0.612	0.381	0.171	**0.021**
FACULTATIVE UPLAND						
	F Value	0.97	0.97	0.36	3.94	4.13
	Significance Level (p)	0.390	0.392	0.704	**0.031**	**0.027**
UPLAND						
	F Value	0.57	0.50	0.25	0.01	2.62
	Significance Level (p)	0.574	0.612	0.778	0.993	0.092

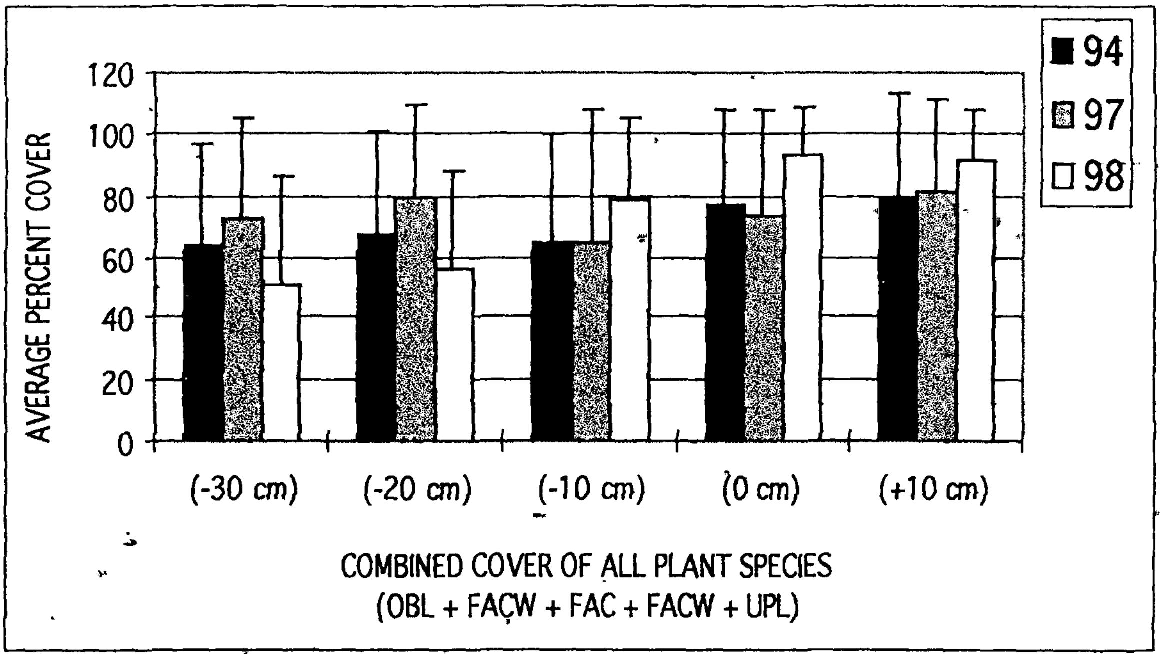

Figure 8. Average percent cover of all plant species (OBL=obligate + FACW=facultative wetland + FAC=facultative + FACU=facultative upland + UPL=upland) per elevation per restoration (n=10). One-Way ANOVA; df=2,27. Error bars show +1 standard deviation.

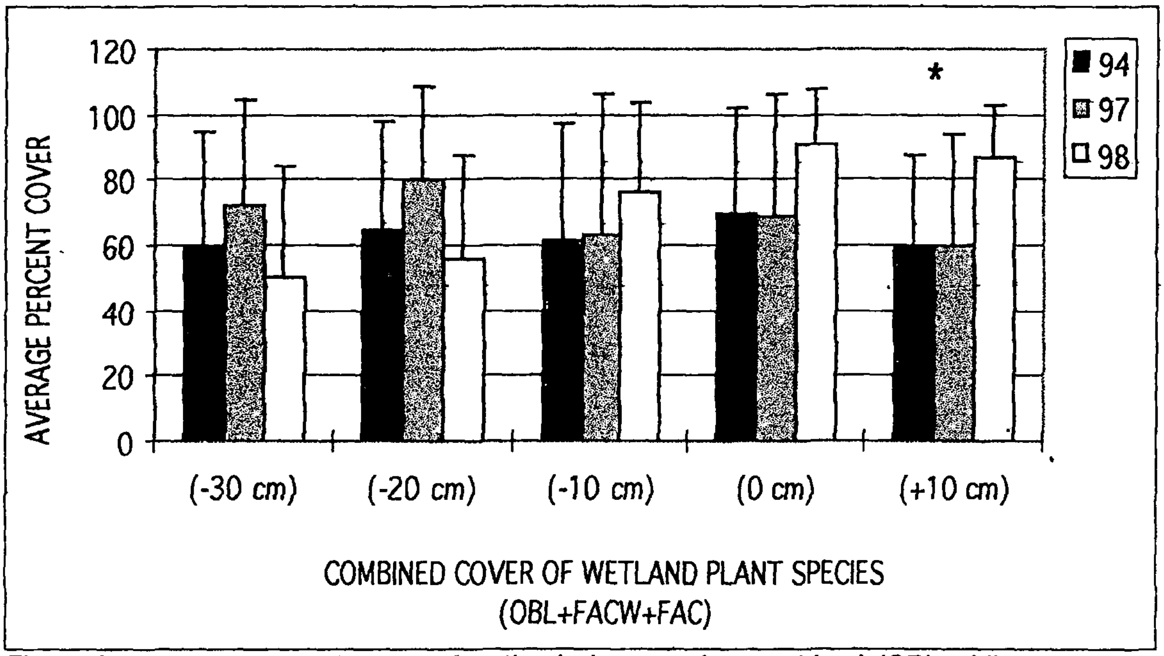

Figure 9. Average percent cover of wetland plant species combined (OBL=obligate + FACW=facultative wetland + FAC=facultative) per elevation per restoration (n=10). *=p≤.05 One-Way ANOVA; df=2,27. Error bars show +1 standard deviation.

Table 11. Summary of F values and significance levels (p) for the average percent cover of all plant species (OBL=obligate + FACW=facultative wetland + FAC=facultative + FACU= facultative upland + UPL=upland) and wetland plant species (OBL=obligate + FACW= facultative wetland + FAC=facultative) per elevation per restoration (n=10). ANOVA One-Way; df=2,27. Arcsin transformed data were used in the ANOVA analysis.

SPECIES CLASS		-30 cm	-20 cm	-10 cm	0 cm	+10 cm
OBL+FACW + FAC+FACU+ UPL						
	F Value	1.52	1.80	0.47	1.12	0.62
	Significance Level (p)	0.236	0.185	0.628	0.341	0.544
OBL+FACW+ FAC						
	F Value	1.70	1.79	0.66	1.99	3.44
	Significance Level (p)	0.201	0.187	0.524	0.157	**0.047**

Changes in Cover Composition at Each Elevation Among Years

In general, OBL and FACW plant species represented the majority of cover at all elevations in all years (Figures 10a-10e). At the highest elevation (+10 cm) however, percent cover of OBL and FACW plants increased steadily from 1994 levels and by 1998 comprised nearly all cover at that elevation by displacing "borderline" wetland species (FAC) and more upland species types (FACU and UPL) (Figure 10e). The percent cover represented by FAC, FACU and UPL plant classes did not represent a majority of cover at any elevation in any year (Figures 10a-10e).

At -30 cm there was a 27% decrease in OBL species cover between 1994 and 1997; however, between 1997 and 1998 cover increased by 10% (Figure 10a). FACW species increased at -30 cm by 33% between 1994 and 1997, but decreased by 12% between 1997 and 1998 (Figure 10a). Percent cover of FAC, FACU and UPL species at this elevation was very low and remained relatively unchanged among years (Figure 10a).

Percent cover of OBL species at -20 cm dropped by 14% between 1994 and 1997, but increased again between 1997 and 1998 by 15% (Figure 10b). FACW species cover increased between 1994 and 1997 by 17% and then dropped to 15% between 1997 and 1998 (Figure 10b). As at -30 cm, percent cover of FAC, FACU and UPL species were very low at this elevation and remained relatively unchanged among years (Figure 10b).

In 1994, OBL species cover was 9% higher at -10 cm than in 1997, but cover increased between 1997 and 1998 by 15% (Figure 10c). FACW species cover was higher in 1997 than in 1994 by 10%, but dropped by 13% between 1997 and 1998 (Figure 10c). As at -30 cm and -20 cm, percent cover of FAC, FACU and UPL species was very low at this elevation and remained relatively unchanged among years (Figure 10c).

Between 1994 and 1998 at 0 cm, OBL species cover increased by 8% and FACW species increased by 9% while FAC species were not recorded in any year (Figure 10d). As at -30 cm, -20 cm and -10 cm, percent cover of FACU and UPL species were very low at this elevation and remained relatively unchanged among years (Figure 10d).

There was an increase of 10% OBL and 16% FACW species cover at +10 cm between 1994 and 1998 (Figure 10e). FAC species cover decreased by 7% between 1994 and 1998, while cover of FACW species increased by 7%

between 1994 and 1997 and then dropped by 22% between 1997 and 1998 (Figure 10e). UPL species cover decreased by 6% between 1994 and 1998 (Figure 10e).

The percent cover of all plant species (OBL + FACW + FAC + FACU + UPL) and wetland plant species (OBL + FACW + FAC) changed very little among years at each elevation, but the percent cover represented by wetland plant species comprised ≥ 74% of the total cover at all elevations in all years (Table 12). The largest percent increases in the cover of wetland plant species were 11% between 1997 and 1998 at 0 cm and 21% at +10 cm between 1994 and 1998 (Table 12).

In 1997, a generally dry summer, the average number of wetland plant species decreased at -30 cm and -20 cm by 2 species from 1994 while the percent cover increased by 12% and 15%, respectively (Tables 9 and 12). In 1998, the growing season was much wetter and even though the average number of wetland species was similar to that in 1997, the increased prevalence of open water at lower elevations resulted in a decrease in cover of wetland species by 22% at -30 cm and by 24% at -20 cm (Tables 9 and 12).

In general, between 1994 and 1998 at higher elevations (-10 cm, 0 cm, +10 cm), the average number of wetland plant species decreased, and the percent cover of these species increased (Tables 9 and 12). At -10 cm, the average number of wetland species decreased by 2 between 1994 and 1998, while the percent cover increased by 15% (Tables 9 and 12).

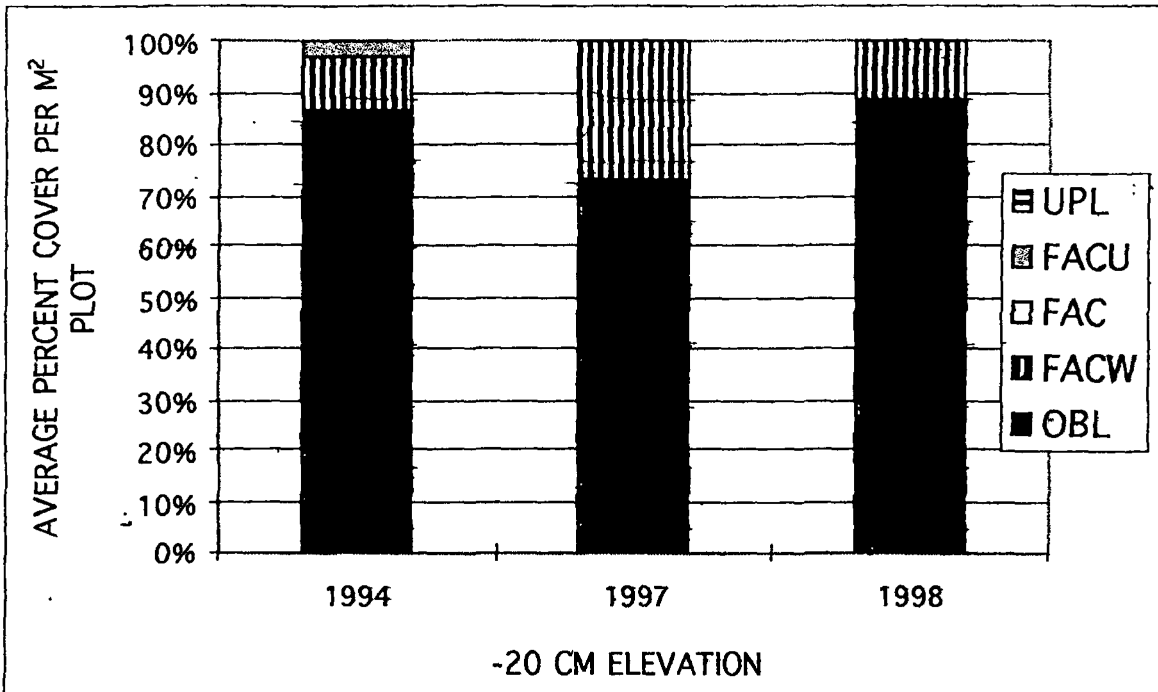

Figure 10b. Average percent cover composition of each plant classification for m^2 plots at -20 cm [(cover for a class / total cover of all classes) x 100] per restoration (n=10). OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland.

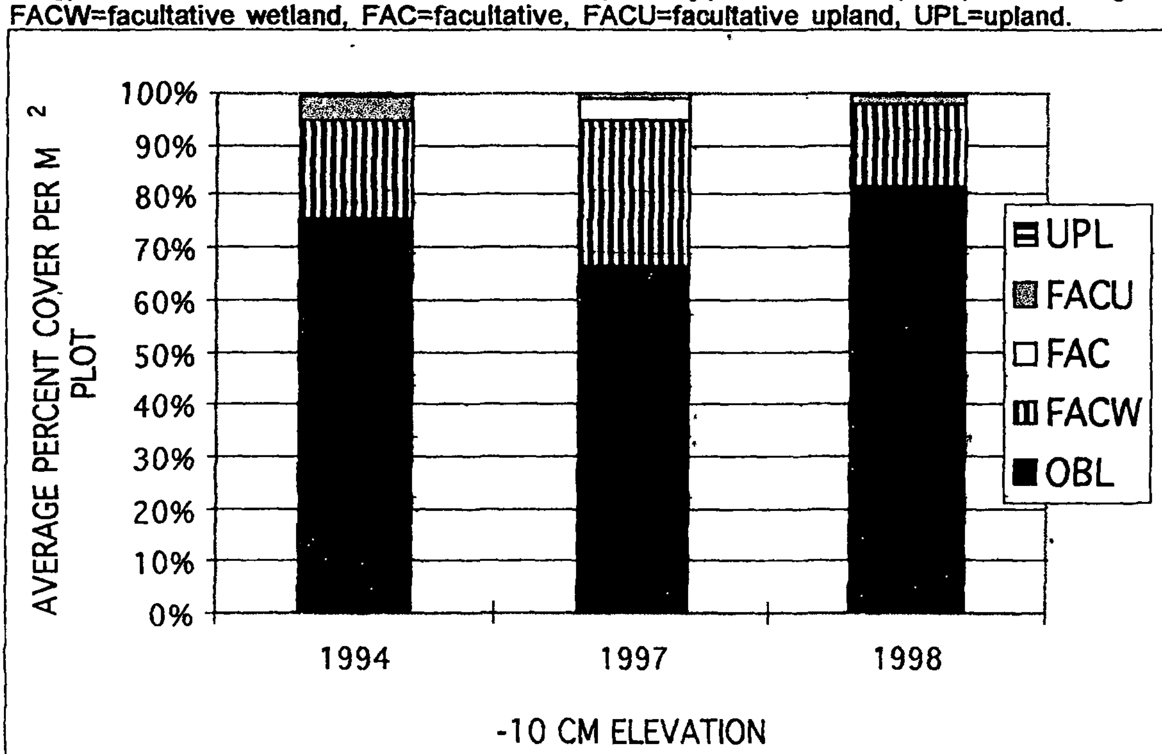

Figure 10c. Average percent cover composition of each plant classification for m^2 plots at -10 cm [(cover for a class / total cover of all classes) x 100] per restoration (n=10). OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland.

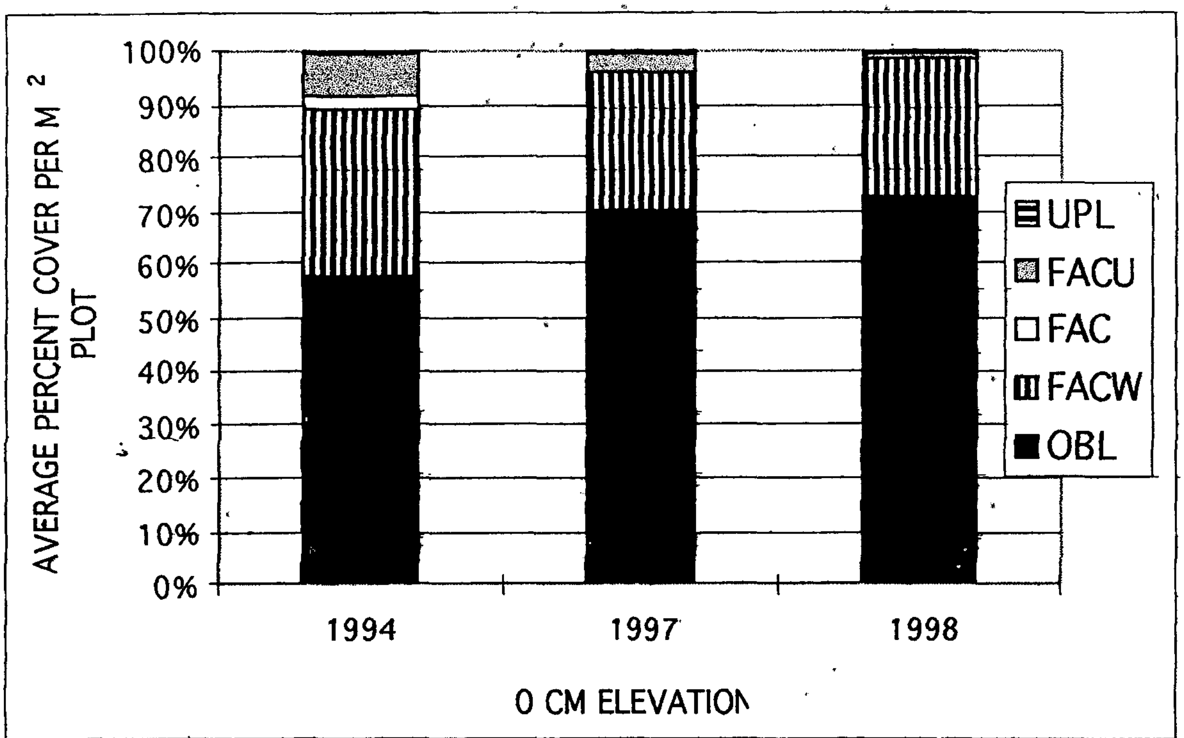

Figure 10d. Average percent cover composition of each plant classification for m^2 plots at 0 cm [(cover for a class / total cover of all classes) x 100] per restoration (n=10). OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland.

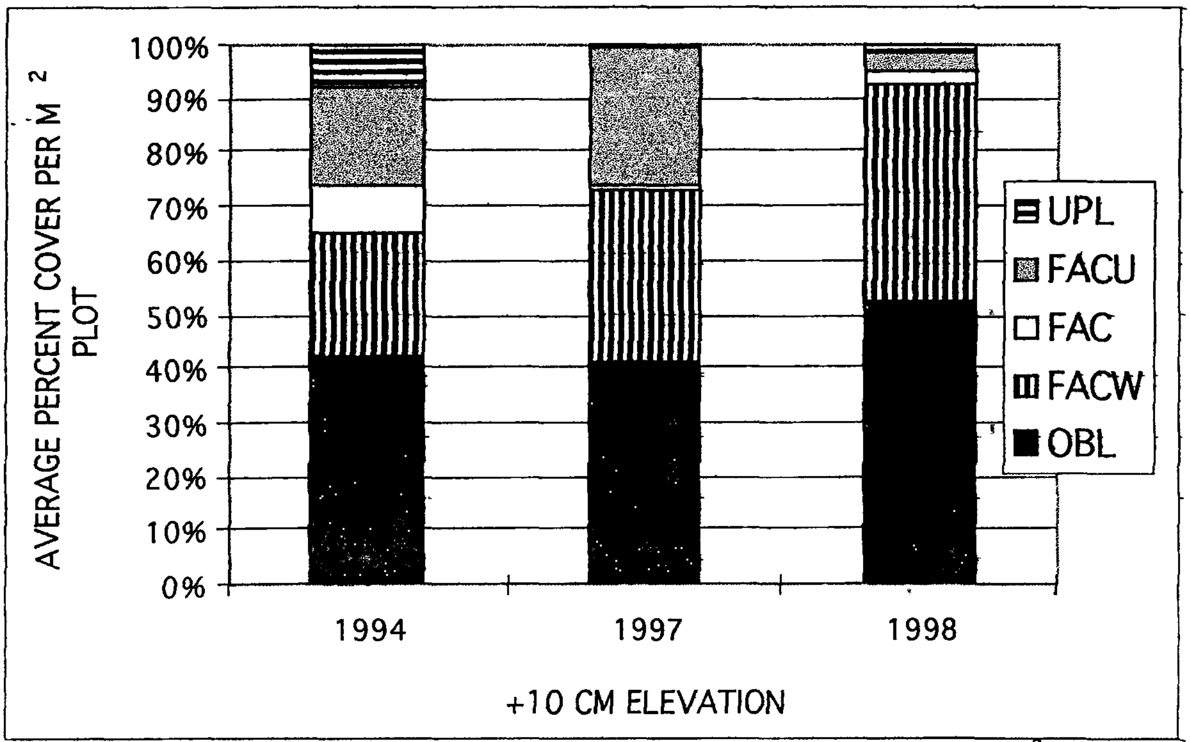

Figure 10e. Average percent cover composition of each plant classification for m^2 plots at +10 cm [(cover for a class / total cover of all classes) x 100] per restoration (n=10). OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland.

Table 12. Comparison of the average cover of all plant species (A: OBL=obligate + FACW=facultative wetland + FAC=facultative + FACU=facultative upland + UPL=upland) and the average cover of wetland plant species (W: (OBL=obligate + FACW= facultative wetland + FAC=facultative) in permanent m^2 plots at each elevation per restoration. (P) = the percent of wetland plant cover comprising the total plant community at each elevation per restoration (n=10).

	1994 (A)	1994 (W)	1994 (P)	1997 (A)	1997 (W)	1997 (P)	1998 (A)	1998 (W)	1998 (P)
ELEVATION	**% COVER ALL CLASSES**	**% COVER OBL+ FACW+ FAC**	**% COVER OF 1994 (A) THAT IS 1994 (W)**	**% COVER ALL CLASSES**	**% COVER OBL+ FACW+ FAC**	**% COVER OF 1997 (A) THAT IS 1997 (W)**	**% COVER ALL CLASSES**	**% COVER OBL+ FACW+ FAC**	**% COVER OF 1998 (A) THAT IS 1998 (W)**
-30 cm	64.0	60.4	94	72.7	72.2	100	50.8	49.9	98
-20 cm	66.7	64.7	97	79.9	79.7	100	56.1	56.0	100
-10 cm	65.1	61.5	94	64.2	63.3	98	78.3	76.5	98
0 cm	76.4	69.8	91	72.8	63.5	87	92.8	91.4	98
+10 cm	79.7	59.1	74	81.0	59.9	74	91.5	86.7	95

Differences in Wildlife Food Plant Species Richness and Cover Among Years

In 1997 and 1998 there were significantly fewer preferred wildlife food plant species per transect [all elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] per restoration (n=10) than in 1994 (One-Way ANOVA; df=2,27, p≤.001) (Figure 11). Preferred wildlife food plant species are summarized in Appendix F.

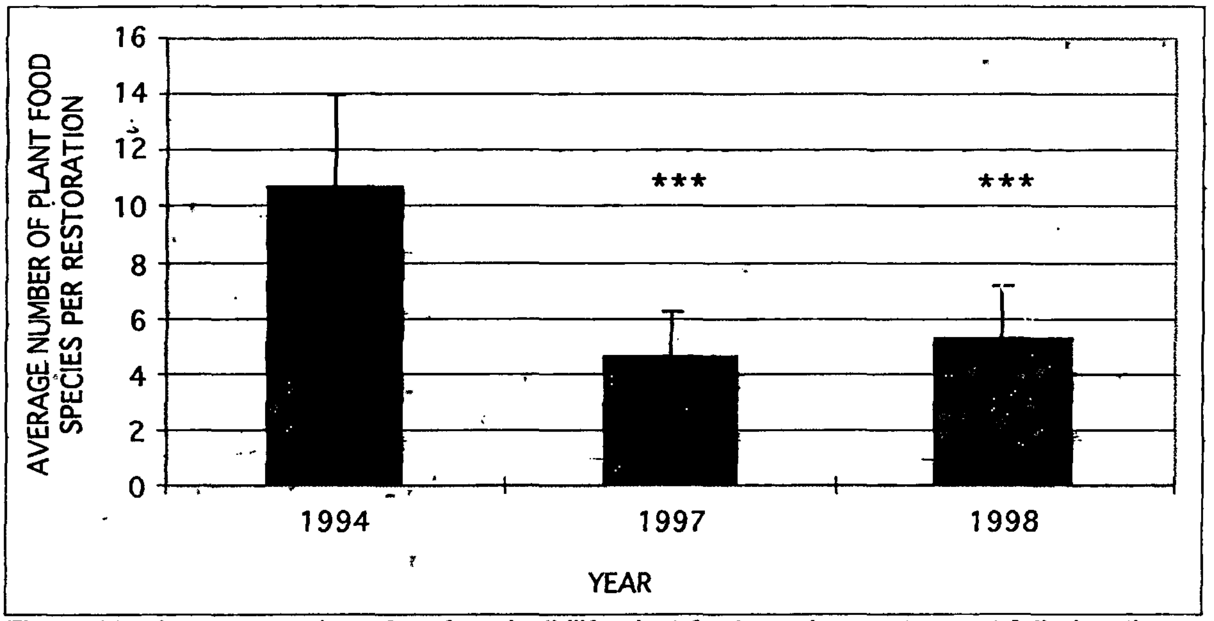

Figure 11. Average number of preferred wildlife plant food species per transect [all elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] per restoration (n=10). ***p≤.001 One-Way ANOVA; df=2,27 Error bars show +1 standard deviation.

There were no significant differences in the percent cover of preferred wildlife food plant species per transect [(all elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] per restoration (n=10) among years (Wilcoxon paired sample signed-rank test, p≤0.05) (Figure 12).

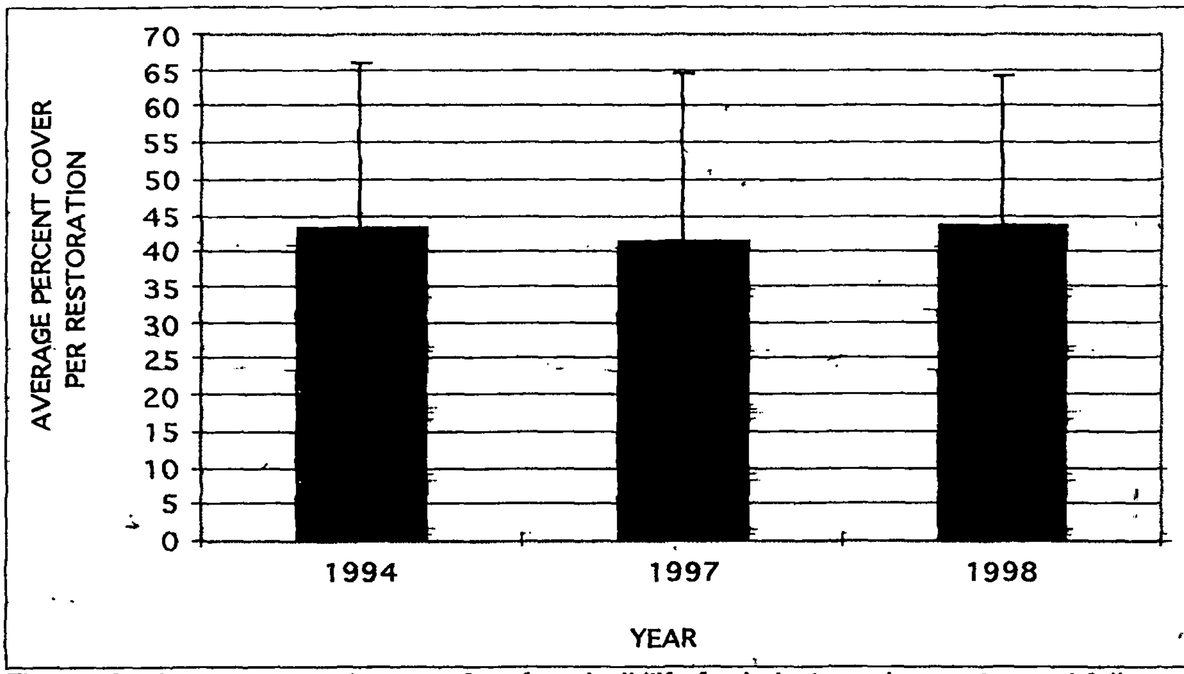

Figure 12. Average percent cover of preferred wildlife food plant species per transect [all elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] per restoration (n=10). Wilcoxon paired sample signed-rank test, p≤0.05. Error bars show +1 standard deviation.

Within Restoration Changes in Wildlife Food Plant Species Richness and Cover Among Years

I did not perform statistical analyses on among-year differences in the total number or percent cover of preferred wildlife food plant species per transect [all elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] for each restoration due to the small sample size for each wetland (average of two transects/site/year). Therefore, the total number and percent cover of preferred wildlife food plant species are presented only as a general indicator of changes among years for each restoration.

Between 1994 and 1998, the total number of preferred wildlife food plant species remained the same at site D, but tended to decrease at all other restorations (Figure 13).

Between 1994 and 1998, there was a trend toward increased percent cover of preferred wildlife plant food species at sites D, N-1, N-2, N-3, S-1 and W-2; while percent cover at sites S-2, S-3, S-4 and V tended to decrease (Figure 14).

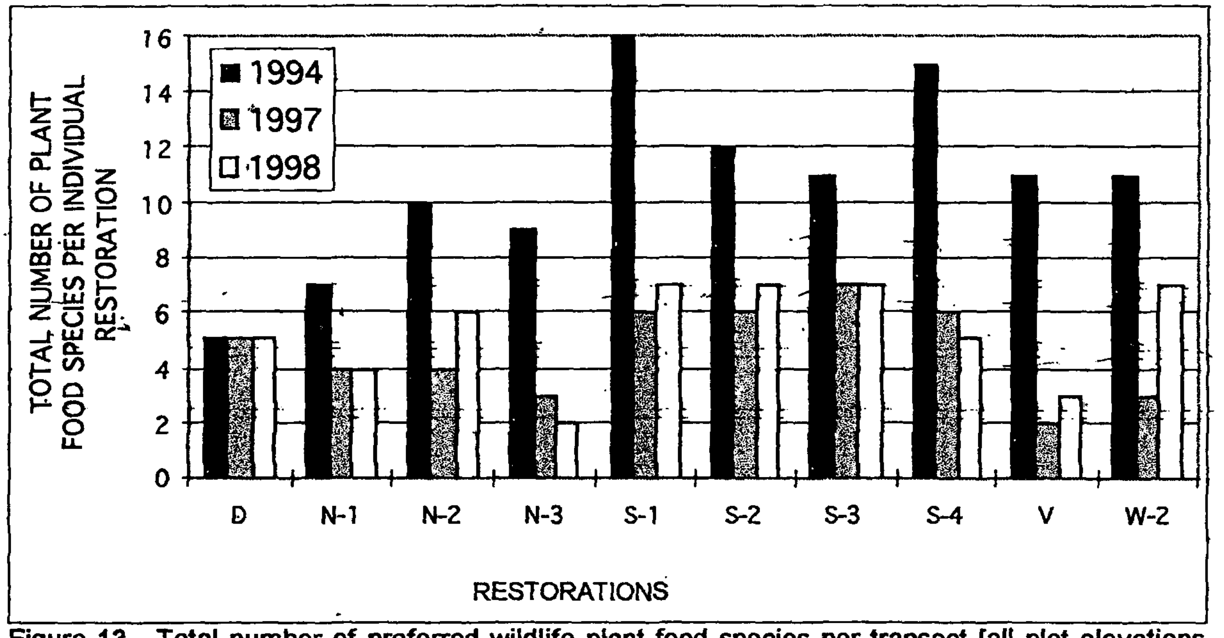

Figure 13. Total number of preferred wildlife plant food species per transect [all plot elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] for each restoration.

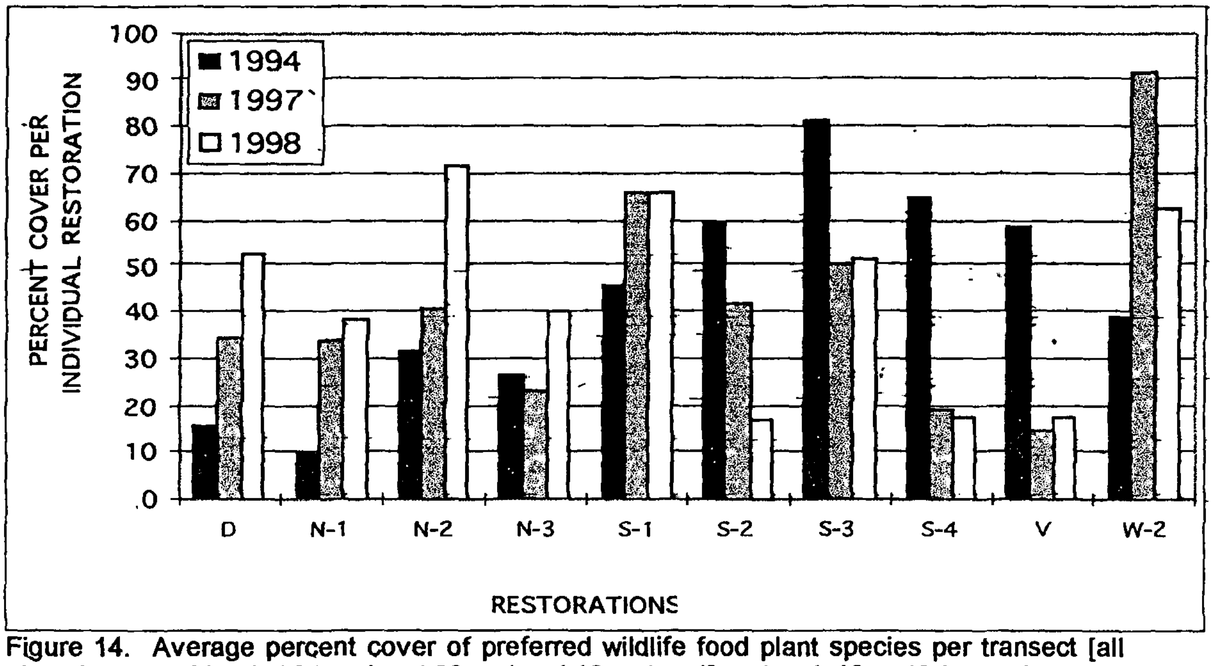

Figure 14. Average percent cover of preferred wildlife food plant species per transect [all elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] for each restoration.

Weighted Wetland Indicator (WI)

Among Year Differences in the Wetland Index (WI) Value

There were no significant differences in WI values per transect [all elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] per restoration (n=10) among years (ANOVA; F=2.68, df=2,27, p=0.087). However, the data do show a trend toward decreasing WI values between 1994 and 1998 as the WI value approached significance, suggesting that restorations are moving towards increased wetland status (Figure 15).

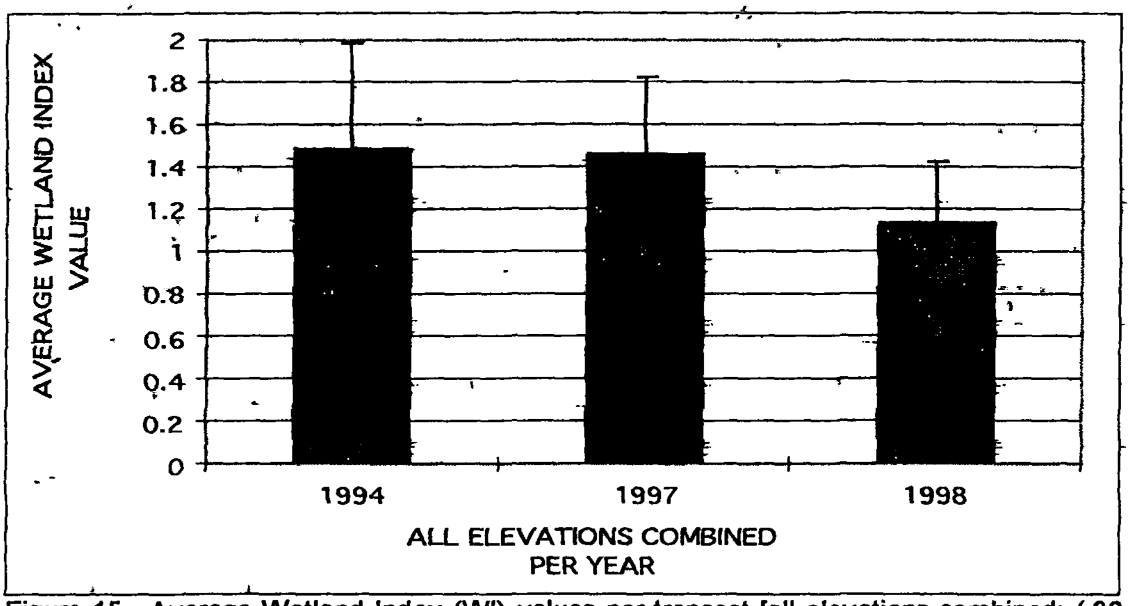

Figure 15. Average Wetland Index (WI) values per transect [all elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] per restoration (n=10). ANOVA One-Way; df=2,27. Error bars show +1 standard deviation.

Although there were no significant among-year differences in WI values per restoration at any elevation, results show a general trend towards increased wetland status, indicated by decreasing WI values at each elevation. In addition, the WI value at +10 cm approached significance between 1994 and 1998 at p=0.067 (Figure 16, see Table 13 for ANOVA results).

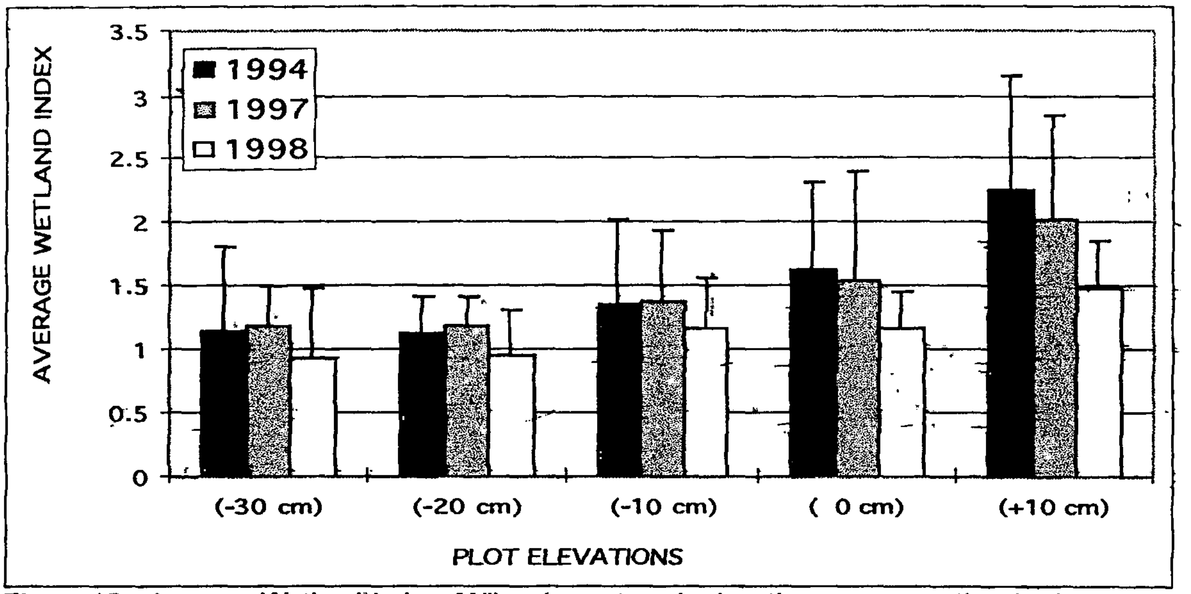

Figure 16. Average Wetland Index (WI) values at each elevation per restoration (n=10). ANOVA One-Way; df=2,27. Error bars show +1 standard deviation.

Table 13. Summary of F values and significance levels (p) for the average Wetland Index value (WI) at each elevation per restoration (n=10). ANOVA One-Way; df=2,27

AVERAGE WETLAND INDEX	-30 cm	-20 cm	-10 cm	0 cm	+10 cm
F Value	0.73	1.53	0.45	1.40	3.00
Significance Level (p)	0.490	0.235	0.643	0.264	0.067

Although there was a general decrease in WI values per transect [all elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] at each restoration, indicating a transition towards improved wetland status between 1994 and 1998, decreases were significant only at sites D and V (Figure 17, see Table 14 for ANOVA results). The WI value for site N-2 increased significantly between 1994 and 1997, indicating decreased wetland status in that year, but there was no significant difference in WI values between 1994 and 1998 (Figure 17, see Table 14 for ANOVA results).

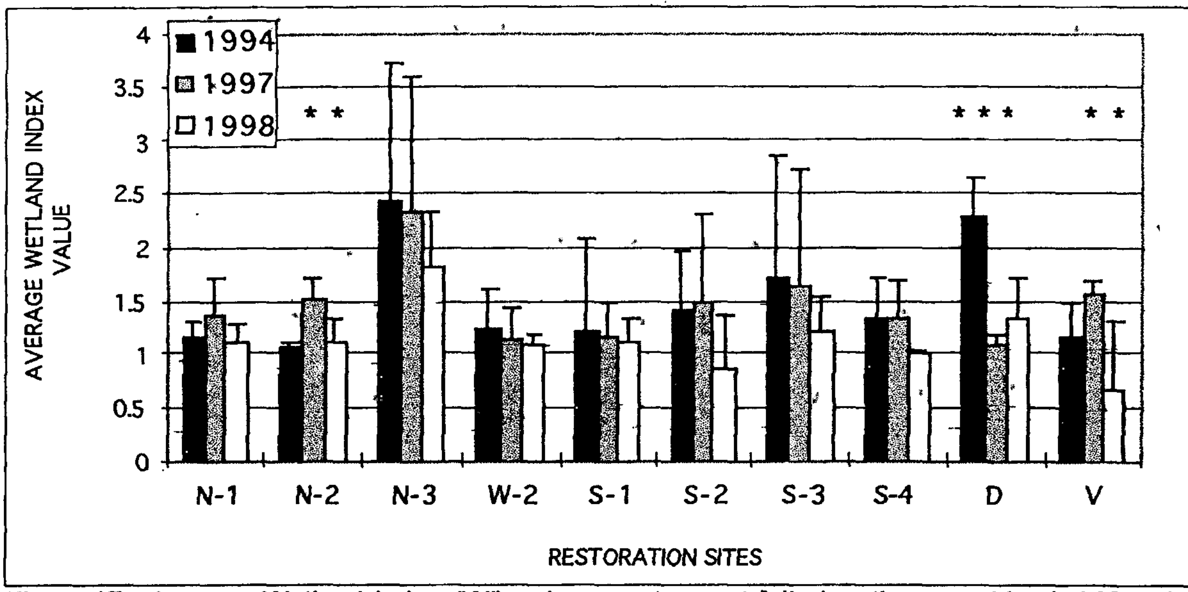

Figure 17. Average Wetland Index (WI) values per transect [all elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] for each restoration. **=p≤.01 ***=p≤.001 ANOVA One-Way; df=2,27. Error bars show +1 standard deviation.

Table 14. Summary of F values and significance levels (p) for the average Wetland Index (WI) value per transect [all elevations combined: (-30 cm) + (-20 cm) + (-10 cm) + (0 cm) + (+10 cm)] for each restoration (n=10). ANOVA One-Way; df=2,27.

Site	F Value	Significance Level (p)
N-1	1.54	0.254
N-2	10.69	**0.002**
N-3	0.52	0.608
W-2	0.48	0.632
S-1	0.03	0.969
S-2	1.39	0.287
S-3	0.40	0.682
S-4	1.83	0.202
D	21.27	**0.000**
V	4.53	**0.034**

Statistical analysis was not performed on among-year differences in Wetland Index (WI) values per elevation at each restoration due to small sample size (average of two plots/elevation/site/year). Therefore, average WI values are presented only as a general history for the years 1994, 1997 and 1998 for each restoration (Figures 18 and 19).

Wetland status increased or remained relatively unchanged at all elevations for sites N-1, W-2, S-1, S-2, S-3, S-4, D and V (Figures 18 and 19) between 1994 and 1998, as WI values decreased.

WI values for site N-2 remained nearly unchanged between 1994 and 1998 for all elevations except +10 cm, where the WI value increased steadily since 1994. In addition, all elevations at site N-2 had an increase in WI values in 1997, decreasing that site's wetland status (Figure 18).

Site N-3 had slight WI value increases between 1994 and 1998 at -30 cm and -20 cm, but WI values decreased at the three higher elevations, increasing the wetland status of those plots. At 0 cm, the WI value was higher in 1997 than in 1994 or 1998 (Figure 18).

Between 1994 and 1997, the WI values for site V increased at all elevations except +10 cm, decreasing wetland status at the four lower elevations (Figure 19). Between 1997 and 1998, wetland status increased as WI values decreased at all elevations, and open water prevailed at -30 cm and -20 cm (Figure 19).

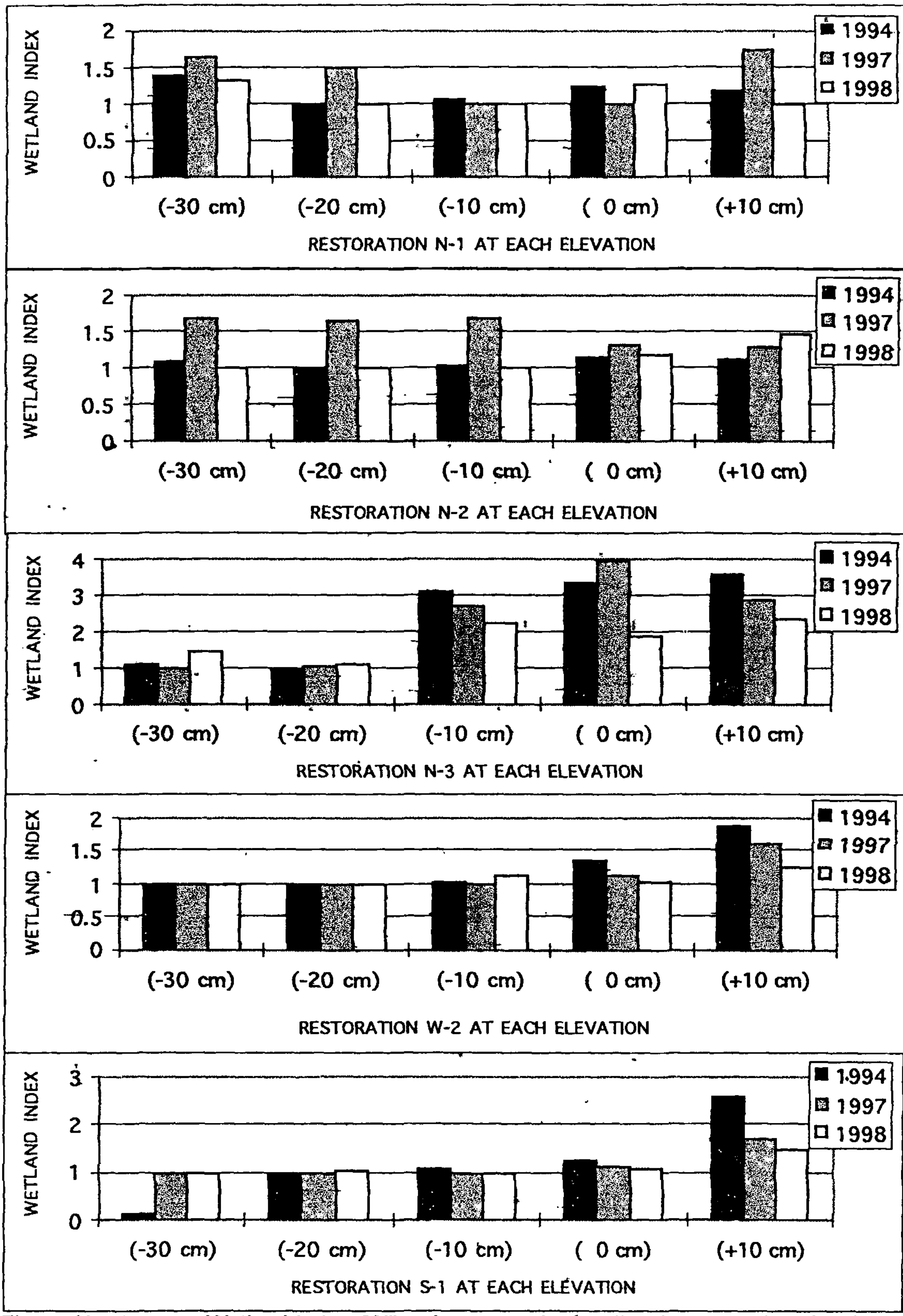

Figure 18. Average Wetland Index (WI) values at each elevation for restoration sites N-1, N-2, N-3, W-2 and S-1. Standard deviations and significance levels (p) were not calculated due to small sample size (two plots/elevation/year).

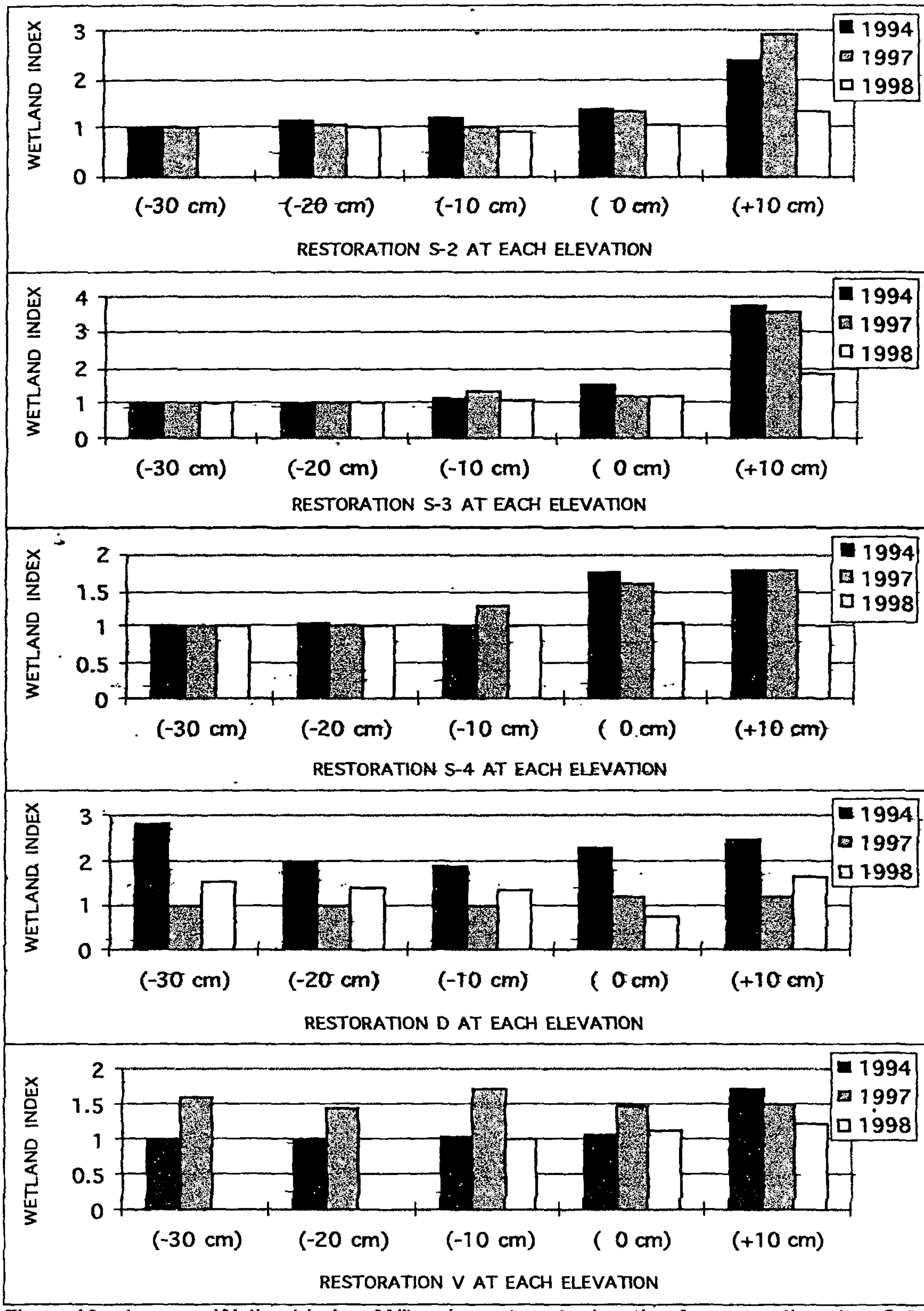

Figure 19. Average Wetland Index (WI) values at each elevation for restoration sites S-2, S-3, S-4, D, and V. Standard deviations and significance levels (p) were not calculated due to small sample size (two plots/elevation/year). NOTE: Elevations lacking a value bar = 0 vegetation cover = open water = highest WI status.

SUMMARY OF DIFFERENCES IN VEGETATION BETWEEN 1994-1998

Differences in Plant Species Richness Among Years

* There was a significant decrease in the average number of all plant species per transect per restoration between 1994 and 1998 (Figure 3, Table 6).

* There were significant decreases in plant species richness among elevations per restoration between 1994 and 1998 (Figure 4, Table 7).

* Between 1994 and 1998, there were significant decreases in the average number of wetland plant species at each elevation (Figure 5, Table 8).

* At all elevations, the average number of wetland plant species was greater than half of all plant species identified (Table 9). The percent of wetland plant species comprising the plant community at each elevation ranged from 55-86% for all wetlands in 1994, 77-96% in 1997 and 87-95% in 1998 (Table 9).

Differences in Vegetation Cover Among Years

* Between 1994 and 1998, there was a significant decrease in the percent cover of FAC species per restoration at +10 cm. Percent cover of FACU species was significantly lower at 0 cm between 1994 and 1998, and at +10 cm between 1997 and 1998 (Figure 7, Table 10).

* There were no significant differences among years in the percent cover of all plant species at any elevation per restoration (Figure 8, Table 11).

* The percent cover of wetland plant species per restoration was significantly higher only at +10 cm (Figure 9, Table 11).

* Wetland plant species comprised the dominant cover at all elevations, ranging from 74-97% for all restorations in 1994, 74-100% in 1997 and 95-100% in 1998 (Table 12).

Differences in Wildlife Food Plant Species Among Years

* In 1997 and 1998, there were significantly fewer preferred wildlife food plant species per transect per restoration than in 1994 (Figure 11).

* There were no significant among-year differences in the percent cover of preferred wildlife food plant species per transect across all restorations (Figure 12).

* Between 1994 and 1998, the total number of preferred wildlife food plant species per transect remained the same at site D, but tended to decrease at all other restorations (Figure 13). Note that these are not statistically significant differences, but reflect only the change in the actual number of preferred food plant species per transect at each restoration.

* Between 1994 and 1998, there was a trend toward increased percent cover of preferred wildlife plant food species per transect at sites D, N-1, N-2, N-2, S-1 and W-2; while percent cover at sites S-2, S-3, S-4 and V tended to decrease (Figure 14). Note that these are not statistically significant differences, but reflect only the change in the actual percent cover per transect at each restoration.

Differences in Wetland Index (WI) Values Among Years

* There were no significant differences in the WI value per restoration among years; however, there was a trend toward decreased WI values that suggests an increase in wetland status (Figure 15).

* There were no significant among year differences in the WI value at any elevation across all restorations, but there was a trend toward decreased WI values that suggests an increase in wetland status (Figure 16, Table 13).

* Between 1994 and 1997, there was a significant increase in the WI value for site N-2, however differences were not significant between 1994 and 1998. The WI value at site D decreased significantly between 1994 and 1998, and site V had a significant decrease in the WI value between 1997 and 1998 (Figure 17, Table 14).

* Between 1994 and 1998, there were no significant differences in the WI value for sites N-1, N-2, W-2, S-1, S-2, S-3 or S-4; however, these sites show a trend toward decreased WI values that suggests an increase in wetland status (Figure 17, Table 14).

* Changes in the WI value for each site varied among elevations between 1994 and 1998; however, there was a strong trend towards decreased WI values that suggests an overall increase in wetland status at all restorations (Figures 18 and 19). Note that these are not statistically significant differences, but reflect only the change in WI value per elevation at each restoration.

In summary, the average number of plant species at restorations decreased between 1994 and 1998; however, in all years the percentage of total species represented by wetland plant species increased (Table 9). The percent cover of all plant species per elevation per restoration was not significantly different among years, but the percentage of cover represented by wetland plant species at each elevation increased between 1994 and 1998 (Table 12). In 1997 and 1998, there were significantly fewer preferred wildlife food plant species per restoration than in 1994 (Figure 11), and there were no significant differences among years in the percent cover of preferred wildlife food plant species per restoration (Figure 12). Between 1994 and 1998, the total number of preferred wildlife food plant species decreased at nine sites, and remained unchanged at one (Figure 13). There was no clear trend in the percent cover of these species at individual restorations. Six sites showed increases in percent cover, and four sites exhibited decreases that may reflect an increase in open water at lower elevations (Figure 14). Between 1994 and 1998, WI values tended to decrease both among restorations and within sites, suggesting a trend toward increased wetland status (Figures 15, 16, 17, 18, 19).

Wetland Birds

Differences in Species Richness and Community Composition Among Years

Species Richness

Overall, the average number of bird species in each habitat preference group per restoration did not differ significantly among years; however, an increase in UPL birds between 1997 and 1998, and a decrease in all bird species between 1994 and 1997, approached significance (Figure 20, see Table 15 for ANOVA results). The only significant difference in species richness was a decline in the average number of facultative (FAC) species from 4 to 2 species per restoration between 1994 and 1998 (Figure201, see Table 15 for ANOVA results). Bird species observed at restored wetlands are summarized in Appendix G.

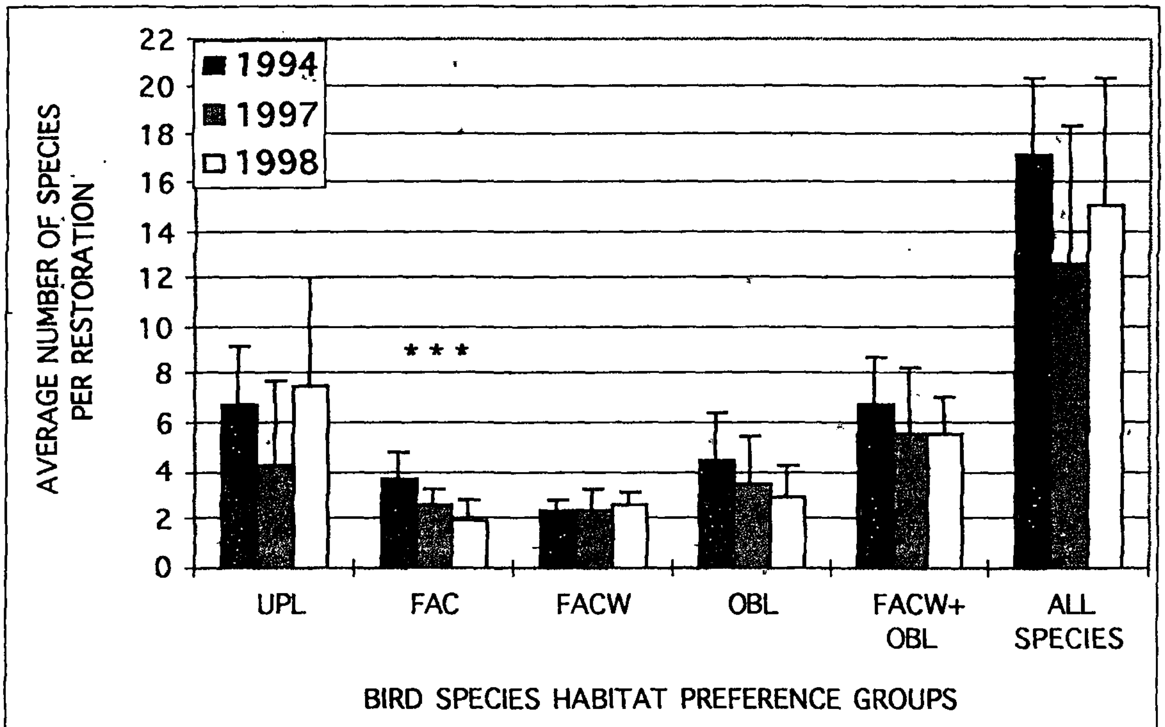

Figure 20. Average number of bird species in each habitat preference group (UPL=upland, FAC=facultative, FACW=facultative wetland, OBL=obligate) per restoration (n=13). ***=p≤.001 One-Way ANOVA; df=2,36. Error bars show +1 standard deviation.

Table 15. Summary of F values and significance levels (p) for the average number of bird species in each habitat preference group (UPL=upland, FAC=facultative, FACW= facultative wetland, OBL=obligate) per restoration (n=13)., One-Way ANOVA; df=2,36

	UPL	FAC	FACW	OBL	FACW+ OBL	ALL GROUPS
F Value	2.90	10.90	0.89	2.37	1.32	2.83
Significance Level (p)	0.068	**0.000**	0.420	0.108	0.280	0.072

Species Composition

Avian community composition by habitat preference groups [(number of species in a group / total species in all groups) x 100] at restorations differed very little among years. Between 1994 and 1998, percentage of the UPL bird group increased by 8% per restoration and comprised nearly half (47%) of the species recorded in 1998 (Figure 21). Percent composition of the FAC group decreased between 1994 and 1998 from 21% to 14% per restoration, while the FACW group increased between 1994 and 1998 from 14% to 18% (Figure 21). Percentage of the OBL group per restoration dropped between 1994 and 1998 from 25% to 20% (Figure 21).

Percent composition of wetland habitat preference groups (OBL + FACW) increased slightly between 1994 and 1997 from 40% to 43%, but decreased between 1997 and 1998 from 43% to 38% (Figure 21).

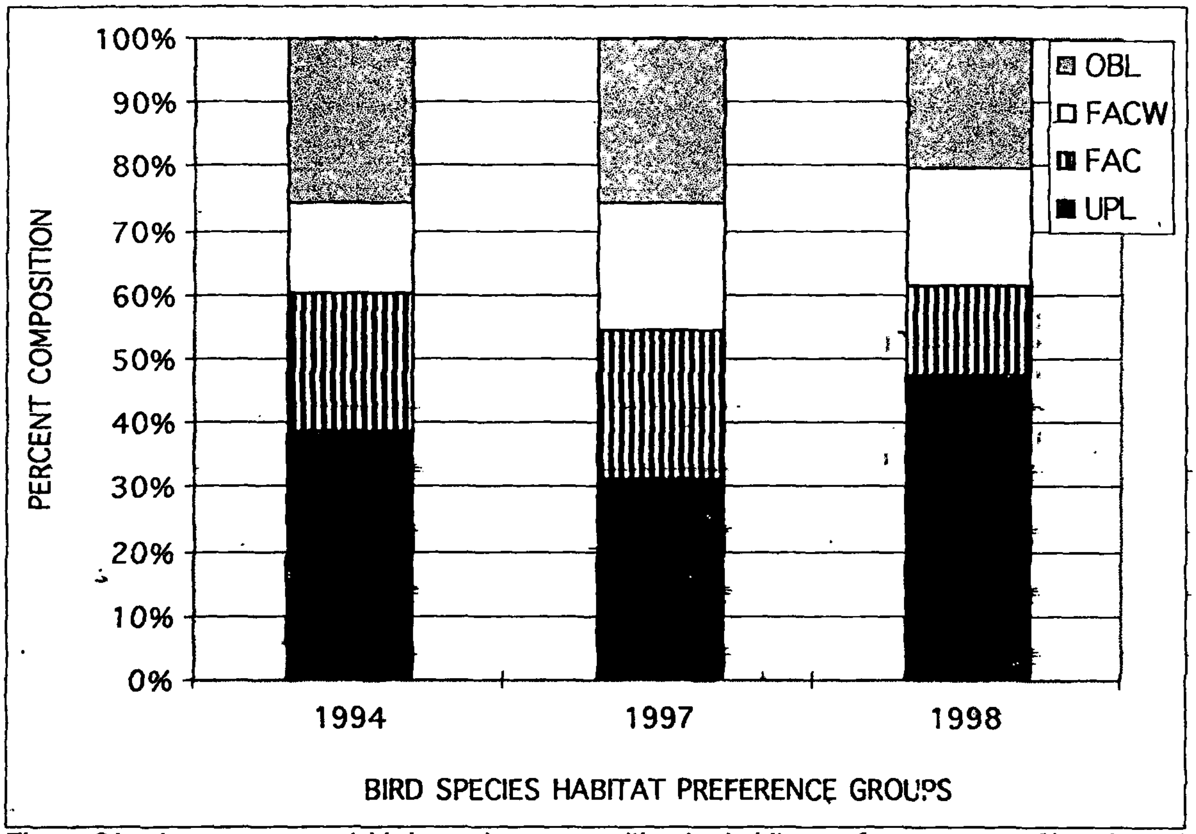

Figure 21. Average percent bird species composition by habitat preference group [(number of species in a group / total species in all groups) x 100]. (UPL=upland, FAC=facultative, FACW= facultative wetland, OBL=obligate) per restoration (n=13).

Differences in Abundance Among Years

Number of Individuals

The average number of individuals per census per restoration in the UPL habitat preference group decreased significantly between 1994 and 1997 from 8 to 3 individuals, and between 1994 and 1998 from 8 to 5 individuals (Figure 22, see Table 16 for ANOVA results). In addition, the OBL group decreased significantly from 5 to 2 individuals per census per restoration between 1994 and 1997 (Figure 22 see, Table 16 for ANOVA results).

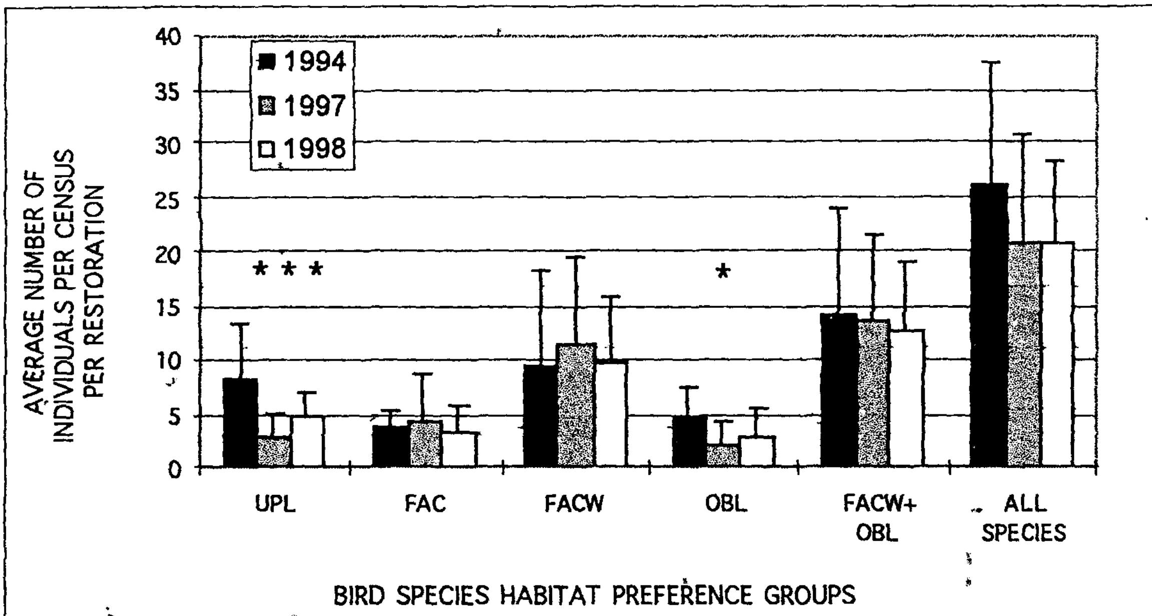

Figure 22. Average number of individuals per census in each habitat preference group (UPL= upland, FAC=facultative, FACW=facultative wetland, OBL=obligate) per restoration (n=13). *=p≤.05 ***=p≤.001 One-Way ANOVA; df=2,36. Error bars show +1 standard deviation.

Table 16. Summary of F values and significance levels (p) for the average number of individuals per census in each habitat preference group (UPL=upland, FAC=facultative, FACW=facultative wetland, OBL=obligate) per restoration (n=13). One-Way ANOVA; df=2,36.

	UPL	FAC	FACW	OBL	FACW+ OBL	ALL GROUPS
F Value	8.64	0.20	0.24	3.52	0.14	1.47
Significance Level (p)	**0.001**	0.822	0.790	**0.040**	0.871	0.243

Differences in Avian Community Composition Among Years

There was a significant decrease in the percentage of UPL and OBL groups in the total avian community [(number of individuals in a habitat preference group / total number of individuals in all habitat preference groups) x 100] between 1994 and 1997 (Figure 23, see Table 17 for ANOVA results). Over this time period, percentage of the UPL group decreased significantly from 32% to 25%, and the

OBL group decreased significantly from 18% to 10% (Figure 23, see Table 17 for ANOVA results).

Between 1994 and 1997, there was a significant increase in the percentage of FACW species from 35% to 54% (Figure 23, see Table 17 for ANOVA results).

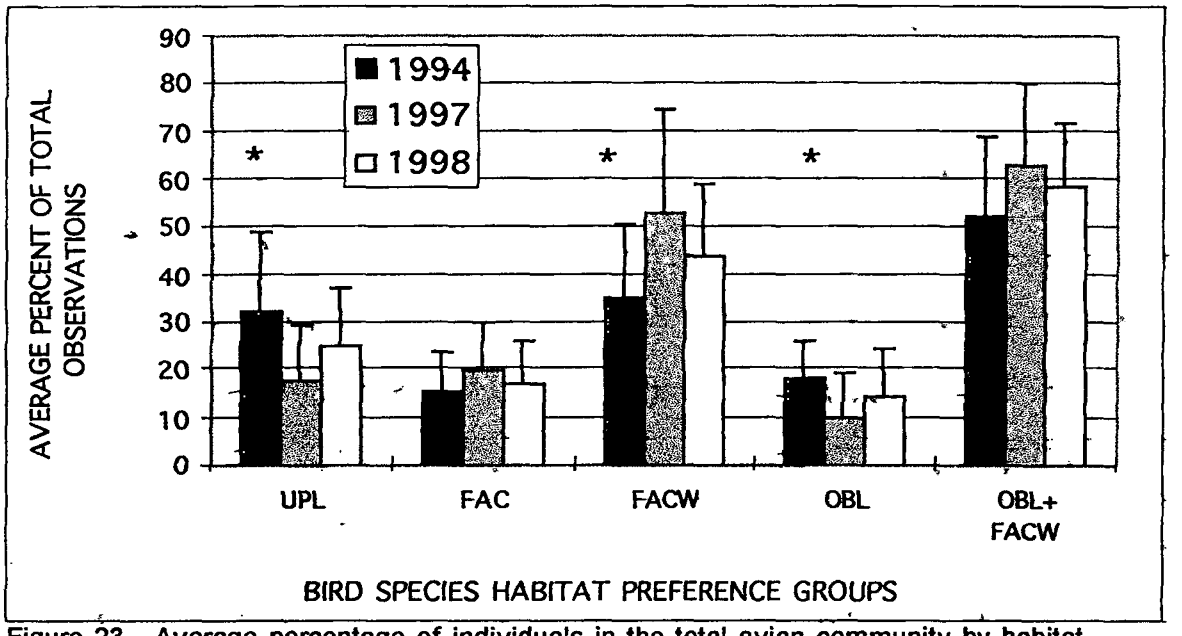

Figure 23. Average percentage of individuals in the total avian community by habitat preference group [(number of individuals in a group / total number of individuals in all groups) x 100]. (UPL=upland, FAC=facultative, FACW=facultative wetland, OBL=obligate) per restoration (n=13). *=p≤.05 One-Way ANOVA; df=2,36. Error bars show +1 standard deviation.

Table 17. Summary of F values and significance levels (p) for the average percentage of individuals in the total avian community by habitat preference group [(number of individuals in a group / total number of individuals in all groups) x 100]. (UPL=upland, FAC=facultative, FACW=facultative wetland, OBL=obligate) per restoration (n=13). One-Way ANOVA; df=2,36. Arcsin transformed data were used in the ANOVA analysis.

	UPL	FAC	FACW	OBL	FACW+OBL
F Value	3.70	0.58	3.45	3.31	0.48
Significance Level (p)	**0.034**	0.566	**0.043**	**0.048**	0.625

Differences in Abundance in the Number of Obligate Individuals Among Years

Statistical analyses were not performed on these data due to the absence of OBL individuals (zero values) on many of the restorations; therefore, only the total number of OBL individuals recorded on all restorations (Figure 24) and the total number of restorations having each species (Figure 25) are reported for each year.

Abundance of OBL individuals across all restorations increased only for the pied-billed grebe (*Podilymbus podiceps*) and belted kingfisher (*Ceryle alcyon*) between 1994 and 1998 (Figure 24). Over the same time period, I observed decreases in the number of individuals for the American bittern (*Botaurus lentiginosus*), great blue heron (*Ardea herodias*), green heron (*Butorides virescens*), Virginia rail (*Rallus limicola*), blue-winged teal (*Anas discors*), Canada goose (*Branta canadensis*), green-winged teal (*Anas crecca*), mallard (*Anas platyrhynchos*), wood duck (*Aix sponsa*), double-crested cormorant (*Phalacrocorax auritus*), belted kingfisher (*Ceryle alcyon*), lesser yellowlegs (*Tringa flavipes*) and spotted sandpiper (*Actitis macularia*) (Figure 24). The number of marsh wrens (*Cistothorus palustris*), swamp sparrows (*Melospiza georgiana*) and soras (*Porzana carolina*) increased between 1994 and 1997, then decreased in 1998 (Figure 24). In 1997, I observed one black-crowned night heron (*Nycticorax nycticorax*) and one hooded merganser (*Lophodytes cucullatus*), but neither species was recorded in 1994 or 1998 (Figure 24).

The number of sites at which a species was observed increased between 1994 and 1998 for the great blue heron, Virginia rail, blue-winged teal, pied-billed grebe and belted kingfisher (Figure 25). Between 1994 and 1998, the number of sites at which a species was observed decreased for the American bittern, green heron, Canada goose, green-winged teal, mallard, wood duck, double-crested cormorant, lesser yellowlegs and spotted sandpiper (Figure 25, Table 19). The number of sites supporting marsh wrens, swamp sparrows and soras increased between 1994 and 1997, then decreased in 1998. In 1997, I observed one black-crowned night heron at one site and one hooded merganser at another, but neither species was observed in 1994 or 1998 (Figure 25).

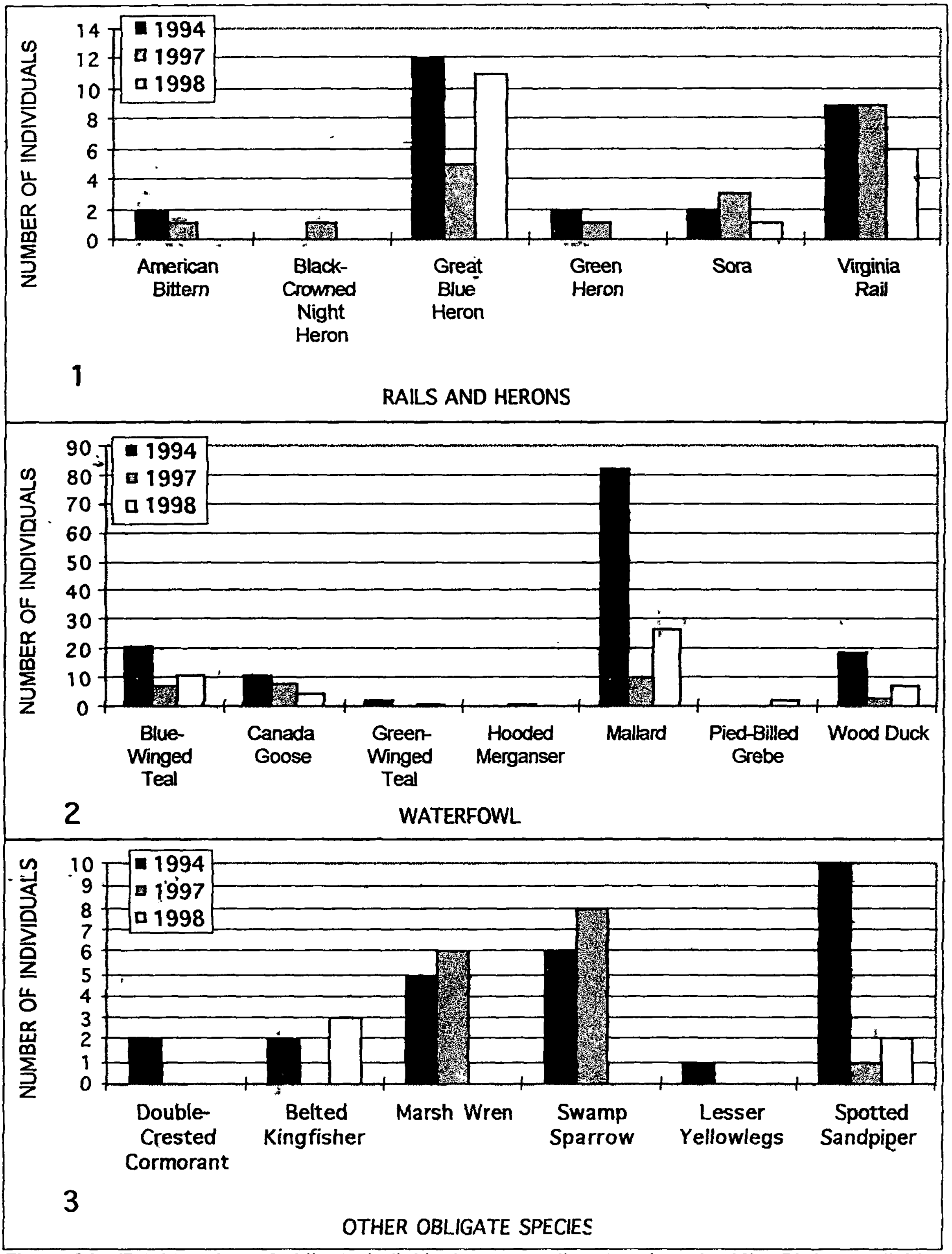

Figure 24. Total number of obligate individuals across all restorations (n=13). Birds are divided into three categories: 1) rails and herons; 2) waterfowl; and 3) other obligate species. Absence of a value bar indicates zero individuals recorded in a year.

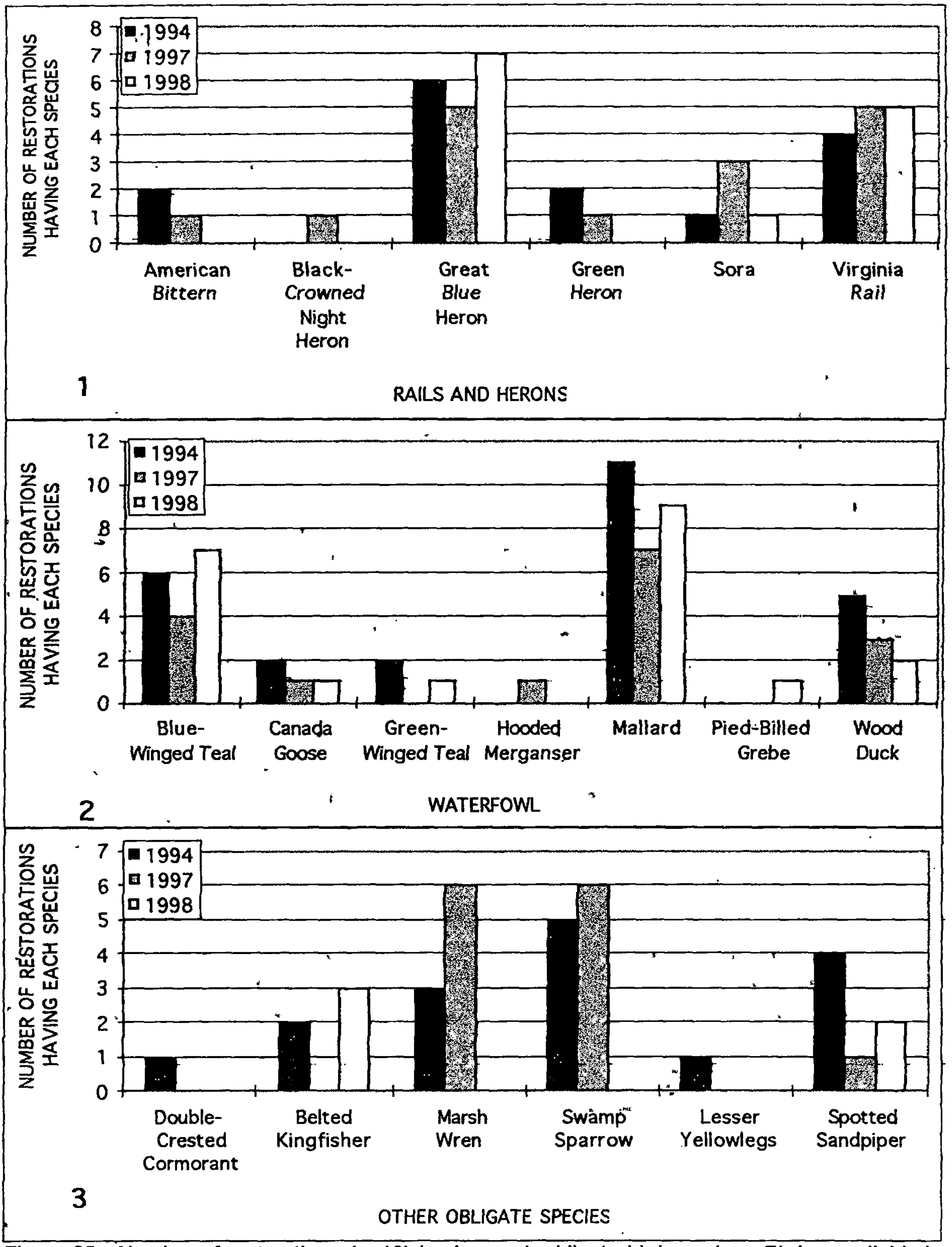

Figure 25. Number of restorations (n=13) having each obligate bird species. Birds are divided into three categories: 1) rails and herons; 2) waterfowl; and 3) other obligate species. Absence of a value bar indicates zero species recorded in a year.

Shannon-Wiener Index for Species Diversity

The only significant difference in bird species diversity per restoration was a decrease in the diversity of the UPL habitat preference group between 1994 and 1997 (Figure 26, see Table 18 for ANOVA results).

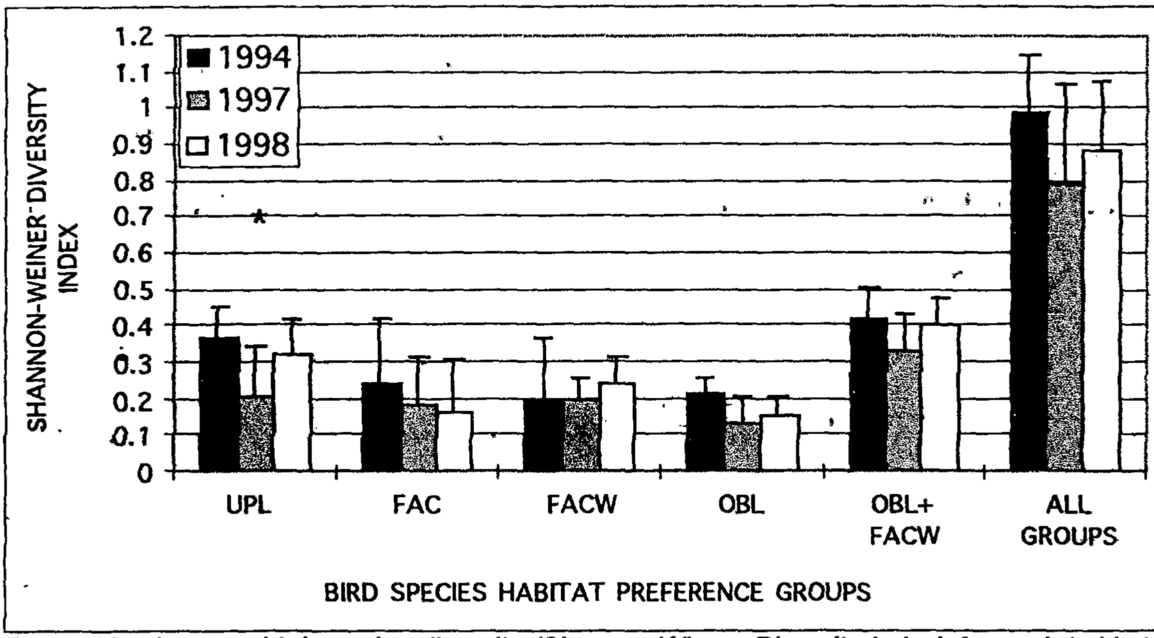

Figure 26. Average bird species diversity (Shannon-Wiener Diversity Index) for each habitat preference group (UPL=upland, FAC=facultative, FACW=facultative wetland, OBL=obligate) per restoration (n=13). *=p≤.05 ANOVA One-Way; df=2,36. Error bars show +1 standard deviation.

Table 18. Summary of F values and significance levels (p) for the average bird species diversity (Shannon-Wiener Diversity Index) in each habitat preference group (UPL=upland, FAC=facultative, FACW=facultative wetland, OBL=obligate) per restoration (n=13). ANOVA One-Way; df=2,36.

	UPL	FAC	FACW	OBL	OBL+ FACW	ALL GROUPS
F Value	3.85	1.94	2.55	2.93	2.37	2.66
Significance Level (p)	**0.031**	0.158	0.092	0.066	0.108	0.084

Summary of Bird Species Richness and Abundance

Number of Species

Between 1994 and 1998, the only significant difference in bird species habitat preference groups was a decrease in the average number of FAC species (Figure 20). Species richness tended to be highest in UPL and OBL habitat preference groups (Figure 20), although the average number of species and percent species representation of the UPL group dominated in all years (Figures 20 and 21). In 1994 and 1997, wetland preference groups (OBL + FACW) tended to be highest in the average number of species and percent species representation, but these groups decreased in both categories in 1998 (Figures 20 and 21). For the FACW group, the average number of species and percent species representation were lowest in 1994 and 1997 (Figures 20 and 21), and in 1998, the average number of species and percent species representation tended to be lower for the FAC group than for all other classes in all years (Figures 20 and 21).

Number of Individuals per Census

There were significant decreases in the average number of UPL and OBL individuals per census per restoration between 1994 and 1998. In all years, FACW birds tended to have the highest average number of individuals and the highest percent species representation, while the average number and percent species representation of FAC individuals remained relatively steady among years (Figures 22 and 23). The UPL group tended to be higher in the average number and percent representation of individuals in 1994 than in 1997 or 1998, and the OBL group was lower than all other groups in the average number and percent representation of individuals in 1997 and 1998 (Figures 22 and 23). However, when wetland habitat preference groups (OBL + FACW) were combined, they tended to be dominant in the average number of individuals and percent individual representation in all years (Figures 22 and 23).

Number of Obligate Individuals at All Restorations

Between 1994 and 1998, the abundance of OBL individuals increased for two species, and decreased for 13 species. Three species increased in the number of individuals between 1994 and 1997, but decreased in 1998, and individuals of two species were observed in 1997, but not in 1994 or 1998 (Figure 24).

The number of sites at which OBL species were observed increased for five species, and decreased for eight species between 1994 and 1998 (Figure 25). For three OBL species, the number of sites increased between 1994 and 1997, then decreased in 1998, and the number of sites increased in 1997 for two species that were not found in 1994 or 1998 (Figure 25).

Shannon-Wiener (S-W) Species Diversity Index

The only significant difference in avian species diversity (S-W) was a decrease in the diversity of UPL species between 1994 and 1997 (Figure 26). Although not significant, between 1994 and 1998 there was a trend toward decreased avian diversity in all habitat preference groups except the FACW group which had a slight increase in species diversity (Figure 26).

Summary of Correlation Coefficients for Relationships Between Site Habitat and Bird Variables

1997

In 1997, the average number of 1) all individuals per census, and 2) OBL + FACW individuals per census per restoration increased significantly with wetland area, with this variable explaining between 46.2 and 34.8% of the variation in response variables (Table 19).

The average number of OBL birds per census per restoration increased significantly with distance to the nearest wetland in 1997, with this variable explaining 29% of the response variation (Table 19).

The average species diversity (S-W) of OBL + FACW species decreased significantly with percent emergent vegetation in 1997, explaining 36% of the response variation (Table 19). In addition, average species diversity for OBL species approached a significant decrease with percent emergent vegetation at p=0.064 (Table 19).

1998

In 1998, the average number of 1) all individuals per census, and 2) OBL + FACW individuals per census per restoration increased significantly with wetland area, with this variable explaining 56.2 and 60.8%, respectively, of the variation in response variables (Table 20). In addition, average number of OBL individuals per census approached a significant increase with wetland area at p=0.065 (Table 20).

The average 1) number of all bird species; 2) bird diversity (S-W) of all species; and 3) number of OBL individuals per census per restoration in 1998, increased with distance to the nearest wetland, with this variable explaining between 33.6 and 56.2% of the variation in the response variables (Table 20). In addition, average bird diversity of FACW + OBL species approached a significant increase with distance to the nearest wetland at p=0.08 (Table 20).

Table 19. Summary of correlation coefficients (r) and significance levels (p) for relationships between site habitat and bird variables per restoration (n=13) for 1997. Birds: OBL=obligate, FACW=facultative wetland, FAC=facultative, UPL= upland. Plants: OBL=obligate, FACW=facultative wetland, FAC=facultative, FAGU=facultative upland, UPL=upland. Significant r values are reported with shaded areas indicating relationships approaching significance. Bold-type indicate negative values.

VARIABLE	AVERAGE NUMBER OF ALL BIRD SPECIES 1997	AVERAGE NUMBER OF OBL+ FACW BIRD SPECIES 1997	AVERAGE NUMBER OF OBL BIRD SPECIES 1997	AVERAGE BIRD DIVERSITY (S-W) ALL SPECIES 1997	AVERAGE BIRD DIVERSITY (S-W) OBL+FACW SPECIES 1997	AVERAGE BIRD DIVERSITY (S-W) OBL SPECIES 1997	AVERAGE NUMBER OF ALL BIRDS PER CENSUS 1997	AVERAGE NUMBER OF OBL+ FACW BIRDS PER CENSUS 1997	AVERAGE NUMBER OF OBL BIRDS PER CENSUS 1997
WETLAND AREA							r=0.68 p=0.001	r=0.59 p=0.03	
DISTANCE TO NEAREST WETLAND									r=0.54 p=0.05
PERCENT EMERGENT COVER					**r= - 0.60 p=0.03**	**r= - 0.53 p=0.064**			

Table 20. Summary of correlation coefficients (r) and significance levels (p) for relationships between site habitat and bird variables per restoration (n=13) for 1998. Birds: OBL=obligate, FACW=facultative wetland, FAC=facultative, UPL= upland. Plants: OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland. Significant r values are reported with shaded areas indicating relationships approaching significance.

VARIABLE	AVERAGE NUMBER OF ALL BIRD SPECIES 1998	AVERAGE NUMBER OF OBL+ FACW BIRD SPECIES 1998	AVERAGE NUMBER OF OBL BIRD SPECIES 1998	AVERAGE BIRD DIVERSITY (S-W) ALL SPECIES 1998	AVERAGE BIRD DIVERSITY (S-W) OBL+FACW SPECIES 1998	AVERAGE BIRD DIVERSITY (S-W) OBL SPECIES 1998	AVERAGE NUMBER OF ALL BIRDS PER CENSUS 1998	AVERAGE NUMBER OF OBL +FACW BIRDS PER CENSUS 1998	AVERAGE NUMBER OF OBL BIRDS PER CENSUS 1998
WETLAND AREA							r=0.75 p=0.003	r=0.78 p=0.002	r=0.53 p=0.065
DISTANCE TO NEAREST WETLAND	r=0.67 p=0.01			r=0.58 p=0.04	r=0.26 p=0.08				r=0.75 p=0.003
PERCENT EMERGENT COVER									

Summary of Correlation Coefficients for Relationships Between Vegetation and Bird Variables

<u>1994</u>

The average number of 1) all bird species, and 2) all individuals per census increased significantly with the average number of OBL + FACW + FAC plant species per restoration, with this variable explaining 67 and 77% of the variation in response variables, respectively (Table 21). In addition, the average number of 1) OBL bird species, and 2) OBL individuals per census approached a significant increase with the average number of OBL + FACW + FAC plant species per restoration both at p=0.082 (Table 21).

Although not significant, the average number of all individuals per census approached a significant increase with average percent cover of all plant species per restoration at p=0.054 (Table 21).

<u>1997</u>

Per restoration in 1997, the average number of 1) all bird species; 2) OBL + FACW bird species; 3) OBL bird species; 4) all individuals per census; and 5) OBL + FACW individuals per census increased significantly with the average number of all plant species per restoration, with this variable explaining between 62.4 and 81% of the variation in response variables (Table 22). In addition, average bird diversity of OBL species approached a significant increase with the average number of all plant species combined per restoration at p=0.063 (Table 22).

Also in 1997, the average number of 1) all bird species combined; 2) OBL + FACW bird species; 3) OBL bird species; and 4) OBL individuals per census increased significantly with the average number of OBL + FACW + FAC plant species per restoration, with this variable explaining between 56.2 and 79% of the variation in response variables (Table 22). In addition, the average number of all individuals per census approached a significant increase with the average number of OBL + FACW + FAC plant species at p=0.067 (Table 22).

1998

Only two relationships were significant in 1998. The average species diversity (S-W) of all bird species increased significantly with the average percent cover of all plant species per restoration, explaining 84.6% of the response variability (Table 23).

Also in 1998, the average species diversity (SW) for all bird species increased significantly with the average percent cover of OBL + FACW + FAC plant species per restoration, explaining 77% of the response variability (Table 23).

Table 21. Summary of correlation coefficients (r) and significance levels (p) for relationships between vegetation and bird variables per restoration (n=7) for 1994. Birds: OBL=obligate, FACW=facultative wetland, FAC=facultative, UPL=upland. Plants: OBL=obligate, FACW=facultative wetland, FAC= facultative, FACU=facultative upland, UPL=upland. Significant r values are reported with shaded areas indicating relationships approaching significance.

VARIABLE	AVERAGE NUMBER OF ALL BIRD SPECIES 1994	AVERAGE NUMBER OF OBL+FACW BIRD SPECIES 1994	AVERAGE NUMBER OF OBL BIRD SPECIES 1994	AVERAGE BIRD DIVERSITY (S-W) ALL SPECIES 1994	AVERAGE BIRD DIVERSITY (S-W) OBL+FACW SPECIES 1994	AVERAGE BIRD DIVERSITY (S-W) OBL SPECIES 1994	AVERAGE NUMBER OF ALL BIRDS PER CENSUS 1994	AVERAGE NUMBER OF OBL +FACW BIRDS PER CENSUS 1994	AVERAGE NUMBER OF OBL BIRDS PER CENSUS 1994
AVERAGE NUMBER OF ALL PLANT SPECIES									
AVERAGE NUMBER OF OBL+ FACW+FAC PLANT SPECIES	r=0.82 p=0.025		r=0.70 p=0.082				r=0.87 p=0.010		r=0.70 p=0.082
AVERAGE PERCENT COVER OF ALL PLANT SPECIES							r=0.75 p=0.054		
AVERAGE PERCENT COVER OF OBL+ FACW+FAC PLANT SPECIES									

Table 22. Summary of correlation coefficients (r) and significance levels (p) for relationships between vegetation and bird variables per restoration (n=7) for 1997. Birds: OBL=obligate, FACW=facultative wetland, FAC=facultative, UPL= upland. Plants: OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland. Significant r values are reported with shaded areas indicating relationships approaching significance.

VARIABLE	AVERAGE NUMBER OF ALL BIRD SPECIES 1997	AVERAGE NUMBER OF OBL+FACW BIRD SPECIES 1997	AVERAGE NUMBER OF OBL BIRD SPECIES 1997	AVERAGE BIRD DIVERSITY (S-W) ALL SPECIES 1997	AVERAGE BIRD DIVERSITY (S-W) OBL+FACW SPECIES 1997	AVERAGE BIRD DIVERSITY (S-W) OBL SPECIES 1997	AVERAGE NUMBER OF ALL BIRDS PER CENSUS 1997	AVERAGE NUMBER OF OBL +FACW BIRDS PER CENSUS 1997	AVERAGE NUMBER OF OBL BIRDS PER CENSUS 1997
AVERAGE NUMBER OF ALL PLANT SPECIES	r=0.81 p=0.026	r=0.86 p=0.013	r=0.84 p=0.017			r=0.72 p=0.063	r=0.79 p=0.033	r=0.90 p=0.006	
AVERAGE NUMBER OF OBL+ FACW+FAC PLANT SPECIES	r=0.89 p=0.007	r=0.88 p=0.008	r=0.78 p=0.038				r=0.72 p=0.067		r=0.75 p=0.05
AVERAGE PERCENT COVER OF ALL PLANT SPECIES									
AVERAGE PERCENT COVER OF OBL+ FACW+FAC PLANT SPECIES									

Table 23. Summary of correlation coefficients (r) and significance levels (p) for relationships between vegetation and bird variables per restoration (n=7) for 1998. Birds: OBL=obligate, FACW=facultative wetland, FAC=facultative, UPL= upland. Plants: OBL=obligate, FACW=facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland. Significant r values are reported.

VARIABLE	AVERAGE NUMBER OF ALL BIRD SPECIES 1998	AVERAGE NUMBER OF OBL+FACW BIRD SPECIES 1998	AVERAGE NUMBER OF OBL BIRD SPECIES 1998	AVERAGE BIRD DIVERSITY (S-W) ALL SPECIES 1998	AVERAGE BIRD DIVERSITY (S-W) OBL+FACW SPECIES 1998	AVERAGE BIRD DIVERSITY (S-W) OBL SPECIES 1998	AVERAGE NUMBER OF ALL BIRDS PER CENSUS 1998	AVERAGE NUMBER OF OBL +FACW BIRDS PER CENSUS 1998	AVERAGE NUMBER OF OBL BIRDS PER CENSUS 1998
AVERAGE NUMBER OF ALL PLANT SPECIES									
AVERAGE NUMBER OF OBL+ FACW+FAC PLANT SPECIES									
AVERAGE PERCENT COVER OF ALL PLANT SPECIES				r=0.92 p=0.003					
AVERAGE PERCENT COVER OF OBL+ FACW+FAC PLANT SPECIES				r=0.88 p=0.01					

Amphibians

Differences in the Number of Amphibian Species Found at Each Restoration

There was no significant difference in the number of amphibian species found at each restoration between 1997 and 1998 ($t_{0.05,(2),14}$ = 0.47, P=0.65) (Figure 27).

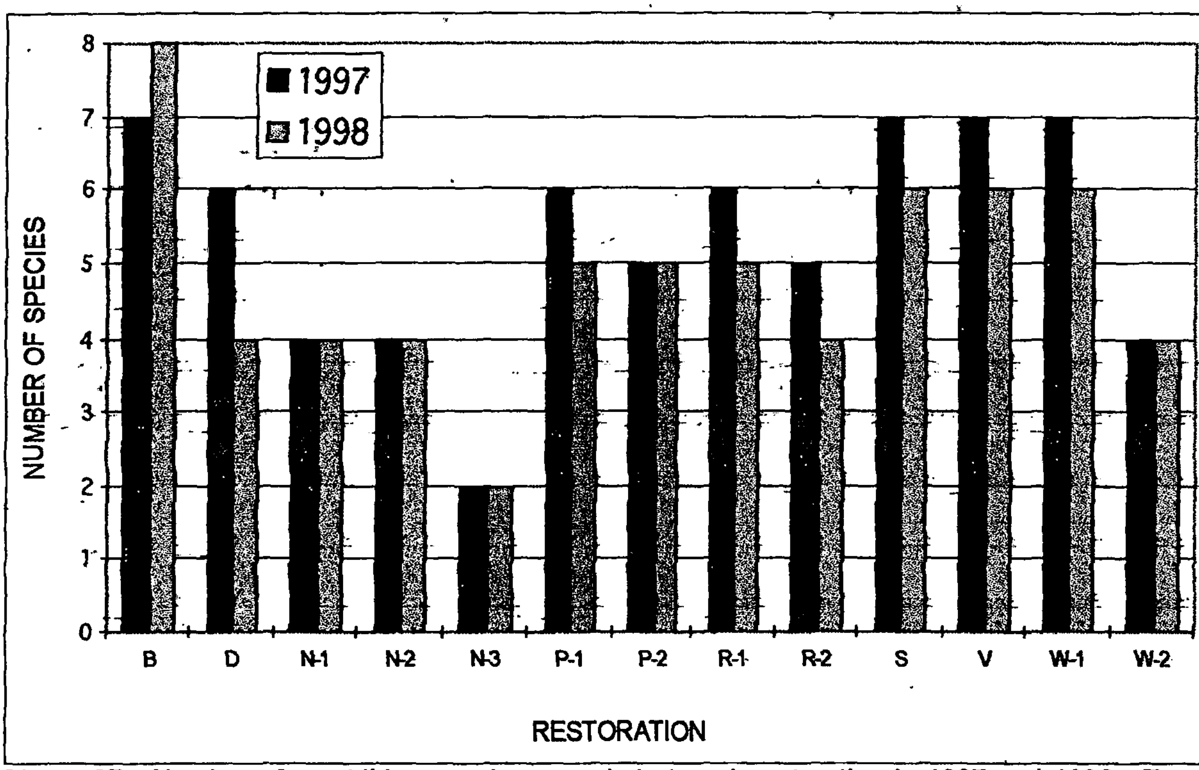

Figure 27. Number of amphibian species recorded at each restoration in 1997 and 1998. Two-tailed t-test, p≤0.05.

Differences in the Number of Restorations Having Each Species

The number of restorations at which American toads were found decreased by 5 in 1998, and wood frogs were reported at one site in 1997, but were not found at any site in 1998 (Figure 28). Amphibian species found at each restoration are summarized in Appendix H.

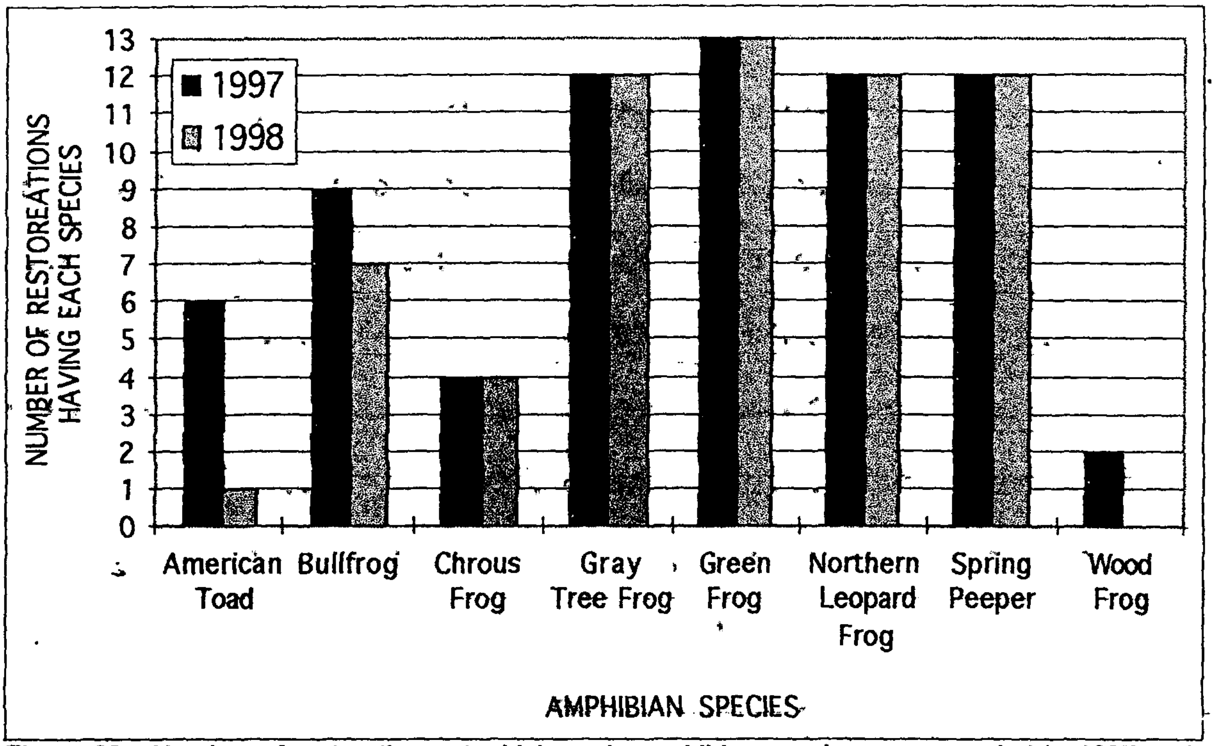

Figure 28. Number of restorations at which each amphibian species was recorded in 1997 and 1998.

DISCUSSION

Vegetation

Comparing data on vegetation and avifauna at restored and natural (reference) wetlands will probably lead to the conclusion that many restorations have "failed" if we expect that the restored or created wetland will eventually "become" the natural wetland (Erwin 1990b). Vegetative response to reflooding will vary from basin to basin (Hemesath and Dinsmore 1993). Therefore, it seems more prudent to assess "success" according to the scope of the project goal, within limits of variables such as wetland size, isolation, and basin morphology. Niering (1990) stated that a major goal in wetland creation should be "the persistence of the wetland as a self-perpetuating oscillating system. . . achieved by a sound hydrologic regime." Extrinsic and intrinsic variables influence the dynamics unique to each wetland (Erwin 1990b, Willard and Hiller 1990, Willard et al. 1990). Wetlands dynamically respond to changes in the surrounding landscape in which they exist and, in turn, vegetation responds to those changes according to the genetic tolerance of each species (Gleason 1917 and 1927, Whittaker 1967, Willard and Hiller 1990, Niering 1990). Wildlife respond to changes in vegetation within the confines of their habitat and feeding needs, and so on throughout the food chain (Niering 1990, Mitsch and Gosselink 1993, Hemesath and Dinsmore 1993, National Research Council 1995). Willard and Hiller (1990) suggest that "all wetlands naturally change in size, in community structure and locality. . . they get bigger and smaller; they become different sorts of habitats; and they may disappear and reappear within the landscape." Niering

(1990) suggests that the terms "vegetation development" or "biotic change" are preferable to the orderly, predictable concept inferred by the term "succession," and that "relative stability" or "equilibrium state" are more realistic terms than that conveyed by "climax community".

Nevertheless, vegetation responses to changes in hydrology are most often used to assess wetlands in terms of their function as wildlife habitat (Willard and Hiller 1990, Niering 1990, Mitsch and Gosselink 1993, National Research Council 1995). Erwin (1990b) suggested that faunal requirements or goals are usually attainable if a wetland "contains the desired hydrology and satisfactory coverage of preferred plant species".

Brown (1995) stated that the primary criterion for site selection in this study was to minimize variability among sites with regard to soil characteristics and landscape settings. Over time, however, changes in land use and landscape variables due to activities of humans and other animals may reduce the degree of similarity among sites. I include the following observations as a summary of site conditions in 1997 and 1998 that have likely affected the degree of similarity among sites since Brown's study (1991-1994).

I did not observe breaches in any of the dams, and landowners did not report concerns in that respect, but muskrat burrowing damage was responsible for poor water retention at two sites (N-1 and N-2). Agricultural run-off from surrounding fields has probably historically affected six of the 13 sites (S-1, S-2, S-3, S-4, D and B). Erosion from the surrounding cultivated field has probably compromised basin slope and water depth at site D, and the fire management regime employed by the landowner at the four "S" sites is not confined to upland areas and may be responsible for maintaining some wetland plant communities in an arrested state of development (Odum 1971).

In the discussion that follows, differences in vegetation and avifaunal variables are analyzed in terms of hydrology changes along the wetland-upland continuum (Mitsch and Gosselink 1993) following the concept that even slight changes in hydrologic conditions will result in substantial changes in wetland flora and fauna species richness and diversity (Weller and Spatcher 1965, Erwin 1990b).

Vegetation 1997 to 1998

The summer of 1997 was very hot and dry, and by mid-July through August, when surveys were conducted, many restorations had very low water levels and some had been reduced entirely or partially to dry, mud-cracked bottoms. Wet meadows and surrounding areas that had been inundated in the spring were also dry by mid-July. Some restorations developed dense *Lemna* spp. or algal mats, due to the lack of adequate "flushing" from hydrological sources supplying the wetland, and others had nearly total cover of the invasive common frog's bit (*Hydrocharis morus-ranae).* WI values were higher in 1997 than in 1998 and reflected the decrease in wetland plant species composition along the wetland-upland gradient in response to the dry conditions.

Rainfall in the summer of 1998 was more frequent, and restorations and wet meadows tended to retain water into the fall months. In addition, algal and *Lemna* spp. mats were less prevalent. When adequate hydrology was maintained, the shift in wetland species composition and percent cover along the wetland-upland gradient was evident. Less adapted species were not able to survive deeper water at lower elevations, and prolonged saturation at higher elevations facilitated an increase in the number and percent cover of wetland plants (Dane 1959, Mitsch and Gosselink 1993).

In response to increased rainfall in 1998, the average WI value per restoration decreased at all elevations, increasing wetland status. On a site-specific level, the WI value decreased at each restoration except the smallest (D, 0.20 ha), which was located at the corner of a cultivated corn field and a woodland edge. Erosion from the adjacent field probably compromised the basin slope and water depth, allowing upland grass species to dominate within the fixed plots. Open water remained primarily in the deeper "take out" area below the berm.

Vegetation 1994 to 1998

Brown (1995) found that after three years, restored sites were significantly lower in the number and percent cover of wetland plant species than at reference sites, and that this condition was "characteristic of drained wetlands before restoration began." He speculated that wetland plant species richness and diversity would increase in the future and wildlife habitat value would improve as the sites matured and woody shrub layers established. Delphey and Dinsmore (1993) suggested that the lack of a developed vegetation structure depressed bird species richness at recently restored wetlands. Dane (1959) stated that "early plant invasion is only part of succession as it gives no indication of quantitative successional changes and can give little indication of the value of the marsh for waterfowl."

Flooding is expected to "bring about the transposition of wetland plant species up the slope to the vicinity of the full pond level" (Dane 1959). Further, the extent and species composition of the new communities depends upon physical attributes of the wetland such as basin slopes, bottom soils, water transparency, depth of flooding, and seasonality and extent of the hydrologic pulse (Hall et al. 1946, Dane 1959, Loucks 1990, Willard and Hiller 1990, Niering 1990, Mitsch and Gosselink 1993, National Research Council 1995).

After seven years of flooding, the average number of plant species per restoration decreased in all classifications, with the loss of wetland plant species predominantly in the OBL group. Loss of species can be attributed to sustained water depths at lower elevations and species displacement by monotypic stands of *Juncus* spp., *Carex* spp., *Scirpus* spp., or *Bidens* spp. as wetland species established at higher elevations along the wetland-upland gradient (Bellrose 1941, Dane 1959, Andrewartha and Birch 1984, Willard and Hiller 1990, Niering 1990, Mitsch and Gosselink 1993, National Research Council 1995).

Long-term flooding did not affect total vegetation cover between 1994 and 1998, but flooding did affect the composition of total cover as interspecific competition among species "adjusted" in response to prevailing conditions. (Willard and Hiller 1990, Niering 1990, Confer and Niering 1992, Mitsch and Gosselink 1993). Brown (1995) reported that in 1994, total cover for wetland plants was significantly lower at restored sites than at natural sites, but in 1998 the percent of the plant community and percent cover represented by wetland plant species was higher at each elevation than in 1994. By 1998, the percent cover of wetland plant species was higher than 1994 levels at -10 cm, 0 cm and +10 cm where wet or saturated conditions persisted, but lower at -30 cm and -20 cm where open water prevailed. These results suggest that the percent cover of wetland plant species is likely shifting towards cover values recorded at natural wetlands referred to by Brown (1995), at least at higher elevations.

Brown (1995) predicted that both the high percent cover and number of food plant species that had established by 1994 would probably be reduced in future years as shrub layers developed within the wetland. However, despite the continued absence of shrubby species at the majority of sites, the average number of wildlife food plant species decreased significantly in the sixth and seventh years after restoration, but the average percent cover of these species remained relatively unchanged. As previously discussed, interspecific competition resulted in the cover dominance of plant food species adapted to prolonged flooded conditions (Willard and Hiller 1990, Niering 1990, Confer and Niering 1992, Mitsch and Gosselink 1993).

Although the number of wildlife plant food species decreased at all restorations, the percent cover of these species increased at six sites. However, at Site V, there was a decrease in the number of plant food species that was not compensated for by increased percent cover of these species as was the trend at the six sites discussed above. This difference may have been due to muskrat activity at the site that eliminated emergent vegetation at lower elevation plots or water depths too deep for vegetation to establish.

Sites S-2, S-3 and S-4 also had decreases in the number and percent cover of wildlife plant food species between 1994 and 1998. These sites comprise a series of restorations connected by spillway overflows. Dense mats of algae and *Hydrocharis morus-ranae*, unique to these sites, likely prohibited seed germination of other species due to the combination of cover and decomposition of dying plant material that can limit oxygen levels and light penetration (Brown 1995). In addition, the landowner of the "S" restorations manages the land by yearly burning that is not confined to upland areas surrounding the wetlands. Although this is an effective method for controlling invasive species and encouraging upland grasses (Willard et al. 1990, Cole et al. 1996), it may confine the progression of wetland plant species to an arrested or intermediate state of development (Odum 1971).

Brown (1995) reported that WI values at restorations had reached significantly lower values than at natural sites by 1994, the third year after restoration. Although the differences were not significant, between 1994 and 1998 long-term flooding resulted in a continued trend toward decreased WI. Notably, the WI value at the highest elevation approached a level of significant decrease in 1998 ($p=0.067$).

Vegetation responses are interesting on a site-specific level because they offer short-term "snapshots" of on-going species adaptation along the wetland-upland gradient at three, six and seven years after restoration. The significant increase in the 1998 WI value over the 1994 value at site N-2 was predictable because of muskrat damage to the berm that prevented sustained water levels.

Higher WI values in 1997 than in 1998 at three sites (N-1, S-2 and V) in response to the dry summer of 1997 were also predictable. Why then, didn't six sites show increased WI index values in 1997? The smallest (D) and the largest (V) restorations had significantly lower WI values in 1998 than in 1994, and the WI value for D actually decreased in 1997. Why did the most significant decreases in WI values occur at sites on opposite ends of the restoration size range? Erwin (1990b) and Gleason (1927) may offer the most plausible explanations as to why wetlands respond differently to seemingly "predictable" conditions: that even slight changes in hydrologic conditions will result in substantial changes in wetland plant species richness and diversity; and because every environment has its own biotic potential in which plants establish according to their own genetic tolerance limits.

<u>**Invasive Plant Species**</u>

The establishment of aggressive, invasive species such as cattail (*Typha latifolia, T. angustifolia*), common frog's bit (*Hydrocharus morus-ranae*), common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), rice cutgrass (*Leersia oryzoides*) and others can be problematic in the early development of new restorations, especially in areas disturbed during construction (Dane 1959, Erwin 1990b, Levine and Willard 1990, Sleggs 1997). Brown (1995) reported that by 1994, cattail covered a greater area at restorations than at natural sites, predominantly where it was necessary to disturb the soil for dike construction, but at sites where flooding was the only "disturbance," plant community development and species richness was comparable to that found at natural wetlands.

Galatowitsch et al. (1999) reviewed the historical spread of five invasive taxa (purple loosestrife, common reed, cattail, reed canary grass [*Phalaris arundinacea*], watermilfoil [*Myriophyllum spicatum*]) and their "morphological plasticity" to colonize disturbed areas in response to altered hydrology. In addition, dense monotypical stands of invasive species diminish the quality of existing wetlands and reduce the effectiveness of restoration efforts with regard to wildlife habitat (Weller and Spatcher 1975, Cutright 1978, Barrett 1989, Confer and Niering 1992, Cole et. al. 1996).

Optimal marsh bird and waterfowl diversity has been reported when the ratio of open water to emergent vegetation is 50:50, and there is diverse interspersion of plant species to provide appropriate food, cover and nest sites (Weller and Spatcher 1965, Weller and Fredrickson 1974, Cole et. al 1996). Hemesath and Dinsmore (1992) refer to this as the "hemi-marsh" stage. Wetland management practices often use this ratio as the standard when managing undesirable plant species at wildlife refuges and other natural or created wetlands, where water levels historically fluctuate or can be manipulated to drown or dry-out undesirable vegetation species (Weller and Spatcher 1965, Fredrickson and Taylor 1982, Keddy 1990, Weller 1990, Cole et. al. 1996). Millar (1972), determined that high water periods greater than two years were required for marsh successional patterns to reestablish.

Control of invasive species using water manipulation methods is not possible at the 13 study sites because wetland flood flows were designed to pass through dike spillways (Brown 1995). Consequently, at sites where invasive species become problematic, more aggressive methods such as herbicide use, periodic cutting or burning may be necessary (Beule 1979, Linde 1983, Kantrud 1986, Weller 1990, Cole et al. 1996). Muskrats may also indirectly "manage" cattail as they harvest the plants for food and lodge construction (Cole et al. 1996, Errington et al. 1963). However, muskrat populations can damage the marsh, as the animals cyclically "eat out" emergent vegetation and convert the wetland to an open water state (Errington et al. 1963, Weller and Spatcher 1965). Further, burrowing activities can damage berms and affect the restoration's capability to sustain water.

For example, in October 1997, one of the largest sites (R-1, 1.24 ha) had a substantial muskrat population that reduced emergent vegetation to the extent that open water was the dominant habitat. The landowner trapped a total of 48 animals and reduced the population considerably (pers. comm. Rathbun 1998). In 1998 I observed only two active muskrat lodges, and estimated that the open water to emergent vegetation ratio was approximately 85:15. In the future, cattail abundance at site R-1 will likely increase until muskrats once again increase their numbers. Although fluctuating water levels are not available to control unwanted vegetation, it is possible that the desired ratio of open water to emergent vegetation, and the persistence of other preferred plant species, can be maintained through the cycle of cattail expansion, muskrat invasion and subsequent feeding and nest building activities, and control of muskrat populations.

Stands of cattail were present at all restorations except N-2 and N-3, where muskrat damage to both dams prevented sustained water retention; however, there were remnant stalks of cattail at these two sites, suggesting that they had previously supported emergent vegetation. Five sites had only negligible to low cattail cover (1-25%), two had reached "optimal" cover (40-55%) and four had high (>55%) cattail abundances that ranged from 75 to 95% cover. The standard ratio of 50:50 open water to emergent vegetation is probably not appropriate for the small (0.12 - 1.4 ha) restorations in this study because these sites are predominantly shallow marshes that have the potential to completely fill with emergent vegetation except in the deeper "take-out" area near the berm (Brown 1995). Subsequently, there would be little interspersion of open water and emergent vegetation, which is the "key factor in the relationship between vegetation structure and habitat quality" (Brown 1995). For smaller wetlands such as these, it may be more suitable for the landowner to "customize" water to cover ratios to optimally suit the size of each wetland. Percent open water for each wetland is summarized in Methods, Table 5.

Common frog's bit formed dense mats at four sites (S-1, S-2, S-3, S-4) and adjacent marsh areas were also densely matted; however, this species was sparse or absent from all other sites. Duckweed and algal mats were also evident at these sites, possibly the result of agricultural run-off from surrounding farms and the lack of "flushing" by fluctuating water sources. Rice cutgrass was the dominant species on slopes surrounding this complex of restorations. These were the only sites at which I observed purple loosestrife, with approximately 10-12 plants scattered throughout the property. This was surprising because dense stands are common throughout wetlands in Jefferson County. This landowner manages vegetation by burning the area each year and it is unlikely that upland invasive species will become problematic. Since it is not possible to manipulate water levels to facilitate vegetation control by flooding or drying, mats of aquatic vegetation may require physical removal or chemical treatment if conditions persist.

Although rice cutgrass is present at other sites, density is low to moderate. *Phragmites spp.* was not present at any of the restorations.

Avifauna

Shifts in the number of species and individuals are "directed" by the dynamics that operate within an avian community. These include genetically controlled habitat specificity, dispersal and recruitment, and inter- and intraspecific competition for food, nesting sites, and cover (Willard and Hiller 1990). How these interactions "play out" over time depend, in part, on prevailing wetland conditions in terms of vegetation type and abundance, open water:cover ratio, wetland size and proximity to other wetlands, and the impacts of predation (Willard and Hiller 1990, Niering 1990, Confer and Niering 1992, Mitsch and Gosselink 1993, Hemesath and Dinsmore 1993).

Wetlands continually change in response to extrinsic and intrinsic forces and may be desirable for some bird species only while certain conditions exist. The absence of a species should not be interpreted as a restoration's "failure" in terms of wildlife habitat value because undesirable conditions for one species may provide desirable conditions for another (Andrewartha and Birch 1984, Willard and Hiller 1990).

Many wetlands and streams of varying sizes exist throughout the study area. The presence or absence of a bird species in a restored wetland may reflect the variety of habitat choices available to satisfy that species' needs (Willard and Hiller 1990, Hemesath and Dinsmore 1993). Wetlands in this study are relatively small, and some still lack a developed shrub layer important in attracting many bird species (Dane 1959, Delphey and Dinsmore 1993). In addition, as discussed in <u>Vegetation</u>, the inability to retain flood waters or manipulate water levels limits the abundance and diversity of preferred avian wetland food plant species at restorations that might otherwise be found at reference or natural wetlands (Weller and Spatcher 1965, Millar 1972, Fredrickson and Taylor 1982, Keddy 1990, Weller 1990, Cole et al. 1996).

Avifauna 1997 to 1998

Between the sixth and seventh years of the study, the total number of bird species and species diversity (S-W) increased for UPL species, but remained relatively unchanged for other habitat preference groups. Rainfall patterns in 1998 likely increased the abundance of food and density of meadow grasses that were probably more desirable for nesting and cover of UPL birds than in 1997. In addition, the increase in UPL species in 1998 is probably directly attributed to my improved ability to identify these species. Increases in the total number of UPL and OBL individuals in 1998 may suggest more desirable conditions with regard to specific habitat needs of species at extreme limits of the wetland-upland gradient.

In a two-year study, Hemesath and Dinsmore (1993) suggested that drought probably accounted for lower species richness in the year that preceded higher species richness in the following wet year. Dry conditions limited the availability of preferred wetland habitat and forced birds to crowd onto larger wetlands or disburse to alternative sites (Hemesath and Dinsmore 1993). Delphey and Dinsmore (1993) suggested that greater wetland availability during years of higher rainfall may enable duck pairs to be more selective in breeding site selection, and Willard and Hiller (1990) suggested that "opportunistic habitat switching may lead to fluctuating population levels on a given wetland."

Avifauna 1994 to 1998

Brown (1995) found that in 1992, 1993, and 1994 natural and restored wetlands were similar in the total number of avian species and individuals, but that the specific species and number of individuals comprising the avian community differed among years. After seven years, only the number of UPL species increased, while the number of individuals decreased in every group except FAC. These results suggest that there was less similarity in the avifaunal community between natural and restored wetlands in 1998 than Brown (1995) observed in 1992, 1993, and 1994. Changes in avian community composition show that UPL species were more prominent, and that OBL species comprised less of the community in 1998, than in other years.

An example of one group's shift in community composition in response to changing wetland conditions is illustrated in RESULTS, ***Avifauna***, Figures 24 and 25. These graphs show the number of OBL individuals for each species found across all restorations in each year, and the number of restorations at which a particular species was reported. The decrease in the number of shorebirds [(lesser yellowlegs (*Tringa flavipes*) and spotted sandpiper (*Actitis macularia*)] and the number of restorations at which they occurred can be attributed to the absence of unvegetated mud flats. The number of mallards (*Anas platyrhynchos*) also dropped dramatically and they were not observed at several restorations where they had been observed in the past. Mallards are dabbling ducks and are considered generalists or opportunists in terms of habitat utilization. They are commonly seen foraging in many wetland types and sizes, including flooded agricultural fields and roadside ditches. There were prolonged dry periods between 1994 and 1998 that may have caused the decrease in mallard numbers due to early drying of wet meadow habitat. Even though the total number of blue-winged teals (*Anas discors*) decreased in 1998 to one-half the number observed in 1994, the number of restorations at which this species occurred increased. Great blue heron (*Ardea herodias*) numbers decreased notably between 1994 and 1997, but increased in 1998. This shift may have been due to the dry conditions in 1997 that affected feeding success in some wetlands. Reasons for the "disappearance" of both marsh wren and swamp sparrow is not known.

Analysis of each species in the context of variables known to affect a species' "decision" to utilize one wetland over another are well beyond the scope of this study. However, individual wetlands in this study probably vary in their ability to support a high diversity and abundance of wetland avian species in any given year. Interaction of the many variables that "control" vegetation and avifaunal community dynamics limit avian richness and diversity to those species that find prevailing conditions desirable (Andrewartha and Birch 1984, Willard and Hiller 1990, Niering 1990, Confer and Niering 1992, Mitsch and Gosselink 1993, Hemesath and Dinsmore 1993).

Wetland area may also limit avian species diversity. Brown and Dinsmore (1986) reported that of 24 avian species found in wetlands ranging from 0.2 - 182.0 ha, 12 species were not found in marshes <1 ha, 10 were not found in marshes ≤5 ha, 4 were not found in marshes < 11 ha, and 2 were not found in marshes <20 ha. In addition to area limitations, avian species diversity at restorations in this study was also constrained by alternate choices of wetland habitat (Willard and Hiller 1990), restricted capability to flood (Brown 1995), and the inability to manipulate water levels to control abundance of preferred plant species, emergent vegetation cover and open water ratio (Weller and Spatcher 1965, Millar 1972, Fredrickson and Taylor 1982, Keddy 1990, Weller 1990, Cole et. al. 1996). Further, vegetation response to water availability and other internal and external influences may change the amount of available habitat required by each species from year to year (Willard and Hiller 1990, Niering 1990, Confer and Niering 1992, Mitsch and Gosselink 1993).

Site Habitat and Avian Response Variables 1997 to 1998

In both 1997 and 1998 the number of all individuals and wetland individuals were positively correlated with wetland area, but unlike results of other species-area relationship studies (cited below), there was no correlation between the number of avian species and area. Larger wetlands had the capacity to support more individuals of certain species, but did not support higher numbers of species. Average species diversity (S-W) was also not affected. In both years of a two-year study, Hemesath and Dinsmore (1993) found that there was a significant log linear relationship between bird species richness and marsh area, even though the average number of avian species recorded in the dry first year was one-half the number recorded in the second year with normal rainfall patterns.

Researchers are exploring possibilities of predicting the minimum marsh size necessary to support a given number of bird species. Two methods of predicting minimum marsh size are suggested by McCoy (1983). Using the first method, calculated by extrapolation of a species-area equation, McCoy (1983) estimated that a 379 ha marsh would be required to support 24 avian species. In the second method, bird species lists are combined from study sites (smallest to largest) until the desired number of species is reached. The sum of the study site areas is the estimated minimum wetland size required to support the desired number of avian species (McCoy 1983).

Brown and Dinsmore (1986) identified 24 breeding avian species in 30 Iowa marshes (average 10 species per restoration) that ranged from 0.2 - 182.0 ha, and reported that marshes 20-30 ha were "more efficient in preserving bird species than larger marshes." In contrast to McCoy (1983), by extrapolation of the species-area equation, Brown and Dinsmore (1986) calculated that on average, 236 ha could support 24 marsh bird species, and they found that by selectively choosing wetland study sites from which to compile the desired species list, an average of 90 ha could support 24 marsh bird species. In addition, Brown and Dinsmore (1986) identified a total of 14 avian species in marshes <5 ha.

The total combined area for all restorations in this study is approximately 7.8 ha (range 0.08 to 1.48 ha). I did not conduct breeding studies; however, the total number of wetland bird species identified in 1994, 1997, and 1998 were 19 (average 7/restoration), 18 (average 6/restoration), and 16 (average 6/restoration), respectively. In addition, the number of wetland bird species found at individual sites ranged from 3 to 10 in 1994, 3 to 11 in 1997, and 3 to 8 in 1998. These data suggest that substantial numbers of avian species are utilizing the small restorations in this study even though small size probably excluded most area-dependent species, and explains the lack of a significant species-area relationship (Brown and Dinsmore 1986, Hemesath and Dinsmore 1993).

Brown and Dinsmore (1986) found that the swamp sparrow, Virginia rail, pied-billed grebe, and green-winged teal bred on wetlands no smaller than between 6 and 10 ha, and that the marsh wren was rarely found in wetlands less than 2 ha. Although I did not conduct surveys of breeding pairs, all of these species have been observed at the study sites, none of which were over 1.50 ha.

The average number of OBL individuals was positively correlated with distance between wetlands in both 1997 and 1998. However, each restoration was within 0.60 km of another wetland, and it is probably better to consider the sites as part of larger complexes rather than as isolated wetlands. Brown and Dinsmore (1986) measured distance to the nearest marsh for three marsh size categories (<5, 5-20, >20 ha) and the number of marshes and total area of marshland within 1, 3, and 5 km of each study site (n=30). They found that the total area of marshland within 5 km explained the most variation in species richness, suggesting that smaller sites within wetland complexes (area of marshland within 5 km) held more species than larger, isolated marshes (farther than 5 km), even though smaller sites were half the size of larger marshes.

Diversity of wetland bird species was negatively correlated with percent emergent cover in 1997. Species diversity was highest at sites B, S, V and P-1, which varied widely in size and percent cover (0.72 ha and 5%, 0.6 ha and 5%, 1.20 ha and 10%, 1.48 ha and 85%, respectively). The diversity found at B, S and V may be attributable to the grassland, upland forest, and rocky ledges found adjacent to the sites. The P-1 restoration lies within grassland habitat; however, it is one of the few wetlands that has a developing shrub layer, consisting predominantly of *Salix* spp. and *Cornus* spp.

Although not significant, in 1997 species diversity for all species and for OBL species also had negative relationships with percent emergent cover. In 1998 all avian variables were negatively correlated (but not significantly) with percent emergent cover.

Bird species diversity is highest on wetlands with 30-50% emergent cover (Weller and Spatcher 1965, Weller and Fredrickson 1974). Hemesath and

Dinsmore (1993) found that wetlands with >30% emergent cover had significantly greater avian species richness than wetlands with <30% emergent cover. A diverse interspersion of open water and emergent cover provides more opportunity for nesting, cover, and preferred food for many bird species (Weller and Fredrickson 1974, Brown and Dinsmore 1986, Cole et al. 1996). Voights (1976) suggested that wetlands in the "hemi-marsh" stage supported more invertebrate species.

Only two restorations in this study were within the "preferred" range of emergent vegetation, both at 50%. However, 50% cover for these small restorations (0.40 ha and 0.08 ha) was excessive as the vegetation approached monotypical stands of cattail with little interspersion of open water. Open water was mainly in the deeper "take-out" areas below the berm. Six of the 13 wetlands (four of which are <0.50 ha) had >50% emergent cover (range 50-95%). Areas of the other two sites were 1.00 and 1.48 ha, with 85 and 90% cover, respectively. The high percent of emergent vegetation in the majority of restorations is probably excluding marsh bird species that require expanses of open water habitat. Conversely, two of the larger restorations (each at 1.20 ha) had only 15 and 10% emergent vegetation, and probably exclude species that require more vegetation cover. Emergent vegetation was absent at two sites (N-1 and N-2). In addition to small wetland size, the uneven distribution of emergent vegetation and open water at many of the restorations seems to be limiting optimal avifaunal species diversity (Weller and Fredrickson 1974, Brown and Dinsmore 1986, Brown 1995, Cole et al. 1996).

Vegetation and Avian Response Variables 1994 to 1998

In 1994, there were positive, significant relationships between the average number of all bird species and all individuals with the average number of wetland plant species. These relationships suggest that the overall avian community responded to the re-establishment of wetland vegetation that included many preferred wildlife food plant species that had established by 1994.

The number of significant correlations increased in 1997. The average number of OBL individuals was correlated with the average number of wetland plant species, and the remaining avian groups were correlated with the average number of all plant species. No correlations existed between any avian variables and percent vegetation cover, which is interesting because the amount and type of vegetative cover is often considered the basis for avian habitat selection (Weller and Spatcher 1965, Weller and Fredrickson 1974, Hemesath and Dinsmore 1993). The number of plant species decreased between 1994 and 1997 at the study sites, but because general weather conditions were dry, we can assume that this was also the trend at similar wetlands in the area. These relationships suggest that the wetlands in this study maintained a variety of plant species attractive to avian species and individuals across all habitat preference groups.

Correlations in 1998 were dissimilar to any found in 1994 or 1997. The only significant correlations was the average diversity (S-W) for all avian species with the average percent cover of all plant species, and with wetland plant species.

Vegetation and avian communities were probably stressed more in 1997 than in 1994 or 1998 due to the lack of rainfall during the summer months. Brown

(1995) stated that there were few existing wetlands in the area that had not been stressed directly or indirectly by human activities. The additional stress of drought may have caused wetlands already adversely affected to become less desirable to wildlife (Delphey and Dinsmore 1993). Correlations between plant species and avian variables suggest that restorations increased in their value to birds in 1997, the most stressful of the three years studied, at least in terms of preferred plant species. The number and type of plant species available at the study sites became important to avian species across all habitat preference groups. Weller (1979) found that "periods of great species richness. . . coincided with low water levels in other parts of the prairie pothole region" and that water availability. . . "may influence the abundance and diversity of marsh birds in an area."

Researchers make predictions regarding which avian species "should" be found in a particular wetland, based on variables such as vegetation composition and structure, food sources, water depth, area, isolation and open water to cover ratios. Predictions are based on selected criteria, while other variables are assumed to "remain equal" (Brown and Dinsmore 1986). Few, if any, variables are "equal" when the unique dynamics that operate within a wetland environment, surrounding landscape, and associated avian community are considered (Delphey and Dinsmore 1993, Hemesath and Dinsmore 1993, Brown 1995). We have learned much about some of the pieces, but the function of the system in totality leaves researchers with many more questions than answers.

Amphibians

Over the past decade the world-wide decline and extinctions of amphibian populations, particularly frogs and toads, has caused alarm throughout the scientific community (Stebbens and Cohen 1995, Chabot and Helferty 1995). The magnitude, rapidity and extent of population declines suggests "some far-reaching, damaging environmental cause or causes, rather than simply natural fluctuations in population densities" (Stebbens and Cohen 1995).

Amphibian characteristics that make these species good "indicators" of relative ecosystem health are that: 1) the amphibious life cycle utilizes both terrestrial and aquatic habitats; 2) exposure to ultra-violet light affects egg and larvae development; 3) feeding habits expose them to contaminants that may be sequestered in plant or animal foods (bio-magnification); and 4) the glandular skin of amphibian adults and larvae is specialized for gas and water exchange. Because of the skin's constant contact with the environment, amphibians are especially sensitive to pollution impacts by wide-ranging chemical contaminants such as pesticides, herbicides, industrial waste, acid rain, etc. (Blaustein et al. 1994, Stebbens and Cohen 1995, Jones [no date]).

Baseline information regarding amphibian life histories is scarce, yet amphibians total approximately 4550 vertebrate species, comprised of 390 salamanders, 4000 frogs and toads, and 163 caecilians (Heyer et al. 1994, Stebbens and Cohen 1995). Collection of data on amphibian populations is difficult because many variables can influence effective sampling efforts. For example: 1) most amphibian species are secretive by nature; 2) some species are found in fossorial habitats; 3) many species are active at times when survey attempts are difficult; 4) habitat requirements may be very specific and not easily accessible; 5) reproduction and activity may vary with temperature and precipitation; and 6) the natural population fluctuation of amphibian species may not be discernible from declines due to negative environmental impacts. Further, non-standardized sampling methodology may make integration of population data difficult (Pechmann et al. 1991, Heyer et al. 1994, Stebbens and Cohen 1995). Jones (no date) suggested that in a given survey area, only a small percentage of amphibian species are verified during routine searches, and that sampling efforts often take months or years to verify actual populations. Subsequently, short-term monitoring to determine amphibian species presence / absence and population estimates are probably misleading and may result in highly underestimated amphibian populations (Heyer et al. 1994, Stebbens and Cohen 1995).

The call count surveys that I conducted on the study sites produced only rudimentary presence/absence information regarding frog and toad species. I recorded a total of eight species; however, sampling protocol by Chabot and Helferty (1995) suggests that 14 species are common to the Great Lakes region. Concerns regarding sampling effort are discussed in METHODS. In 1997 and 1998, the gray tree frog, green frog, northern leopard frog, and spring peeper were found at the most number of restorations. The number of restorations at which the American toad was recorded had the largest decrease (from 6 to 1 site), and the absence of wood frogs from all but one site was most likely due to the lack of preferred habitat adjacent to restorations, as well as ill-timed surveys at sites with preferred habitat. The number of amphibian species (based on the eight species recorded) decreased or remained the same for all sites except B, which had all 8 species in 1998.

It is possible that future presence/absence surveys can become more accurate and comprehensive at these restorations if adjustments are made to the sampling protocol (see METHODS). Even though more thorough, labor-intensive survey methods would be required to conduct a complete amphibian survey, long-term collection of these data are important as regional and local indicators of potential species declines (Heyer et al. 1994, Chabot and Helferty 1995, Stebbens and Cohen 1995).

Summary

The U.S. Fish and Wildlife Service has "succeeded" in its efforts to enhance wildlife habitat on the 13 restored wetlands in this study. Although data show fluctuating populations and shifts in avifaunal community composition, the absence of a species should not be interpreted as a restoration's "failure" in terms of wildlife habitat value. A wetland's response to changing environmental cues may mean undesirable conditions for one species while providing desirable conditions for another (Andewartha and Birch 1984, Willard and Hiller 1990).

Since restoration, each site has increased its capacity to provide some important measure of habitat required by a variety of birds, (most notably, wetland-dependent species) and other wildlife species. Eight years post-restoration, vegetation is well established and most wetlands have "integrated" into the landscape. All sites were successful in their ability to sustain water and support wetland flora and fauna (sites with muskrat berm damage were retaining substantial water levels prior to damage).

Managing complexes of small wetlands is labor-intensive and may not be as cost effective as management of larger wetlands; however, some studies suggest that small wetlands may have more important overall benefits to wildlife. Complexes of small wetlands provide specialized habitat types (Weller 1990), increase habitat heterogenity, and in some cases have been found to contain more species than larger, isolated marshes (Brown and Dinsmore 1986). Gibbs (1993) suggested that small wetlands may be important for the persistence of spacially structured populations of wetlands-associated species. Semlitsch and

Bodie (1998) contend that small wetlands are not expendable if the goal is to maintain present levels of biodiversity, and further, they suggest that permitting agencies should regulate protection of wetlands as small as 0.2 ha. Results of this study suggest that these small wetlands are providing habitat for a variety of species and that the "habitat value" of these restorations appears to increase in times of hydrological stress.

Wetlands restored through the FWS Partners for Wildlife program are not part of any agency management regime. Rather, they are in private ownership, and it is assumed that landowners will conduct good stewardship practices under the contract terms. Restoration efforts have reestablished many wetlands across the landscape, "creating" new wetland complexes, and restoring additional wetlands to existing ones. The small restorations in this study are all within one km of another wetland, and can be generally considered as a complex of wetlands across the landscape. These 13 wetland restorations have achieved the main objective of the FWS Partners for Wildlife program by providing enhanced habitat for wildlife.

Recommendations

The FWS now has data that span an eight year period for 13 wetlands restored through the Partners program. These data are valuable as one of the few long-term longitudinal studies on restored wetlands. Further, standardized protocol established in Brown's (1995) original study (1992-1994) were continued in 1997 and 1998. Avifauna and vegetation data were statistically analyzed by species indicator status which provided an in-depth view of changes in development and shifts in species composition in response to environmental conditions.

Most of the stewardship agreements for restorations in this study were 10-year contracts which will end by the year 2000 or 2001. It would be beneficial for the Partners program to solicit renewal contracts with these landowners for an additional 15-20 years. In this way, restoration efforts would be perpetuated, and researchers could continue to monitor restoration development in the future. Securing these wetlands for future monitoring would be an opportunity for the FWS to establish a unique, standardized, long-term study.

Detailed monitoring could be conducted every five years; however, to continue fixed elevation plot surveys, plot markers should be secured at the 13 sites so that no further loss of vegetation data occurs. It may also be possible to increase the data base by reestablishing vegetation plots at four restorations where plot markers were missing.

Monitoring water depth, basic water chemistry, and average rainfall data during the summer months may be useful in future studies. This information could be utilized to develop a more in-depth understanding of wetland changes that affect habitat use by wildlife.

Tracking the progress of these 13 restorations should include up-dates on landownership and yearly contact with owners, to give them an opportunity to express satisfaction or concerns about their wetland, to maintain a good "working" relationship with the stewards, and to acknowledge their continued participation in the Partners program.

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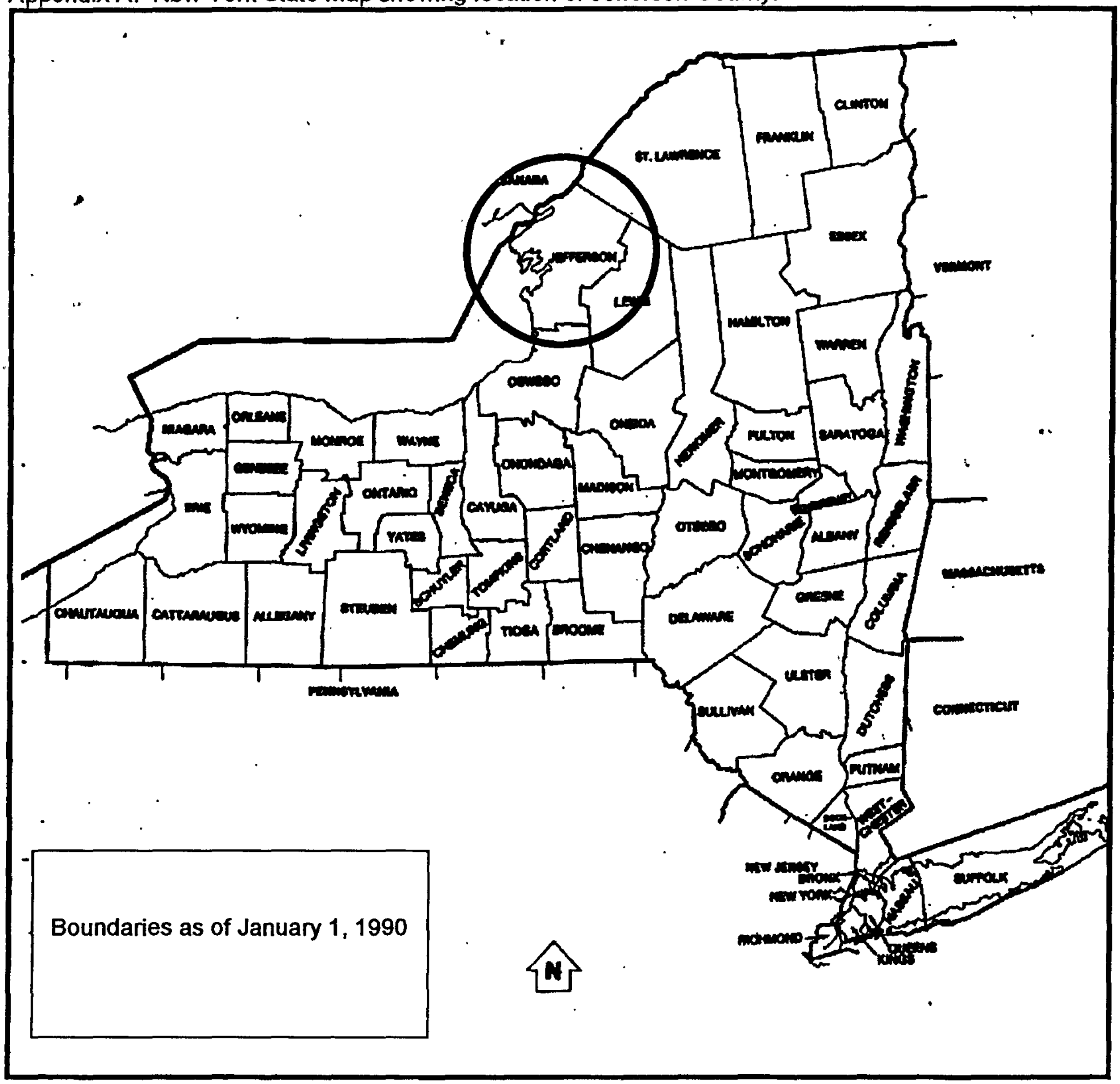
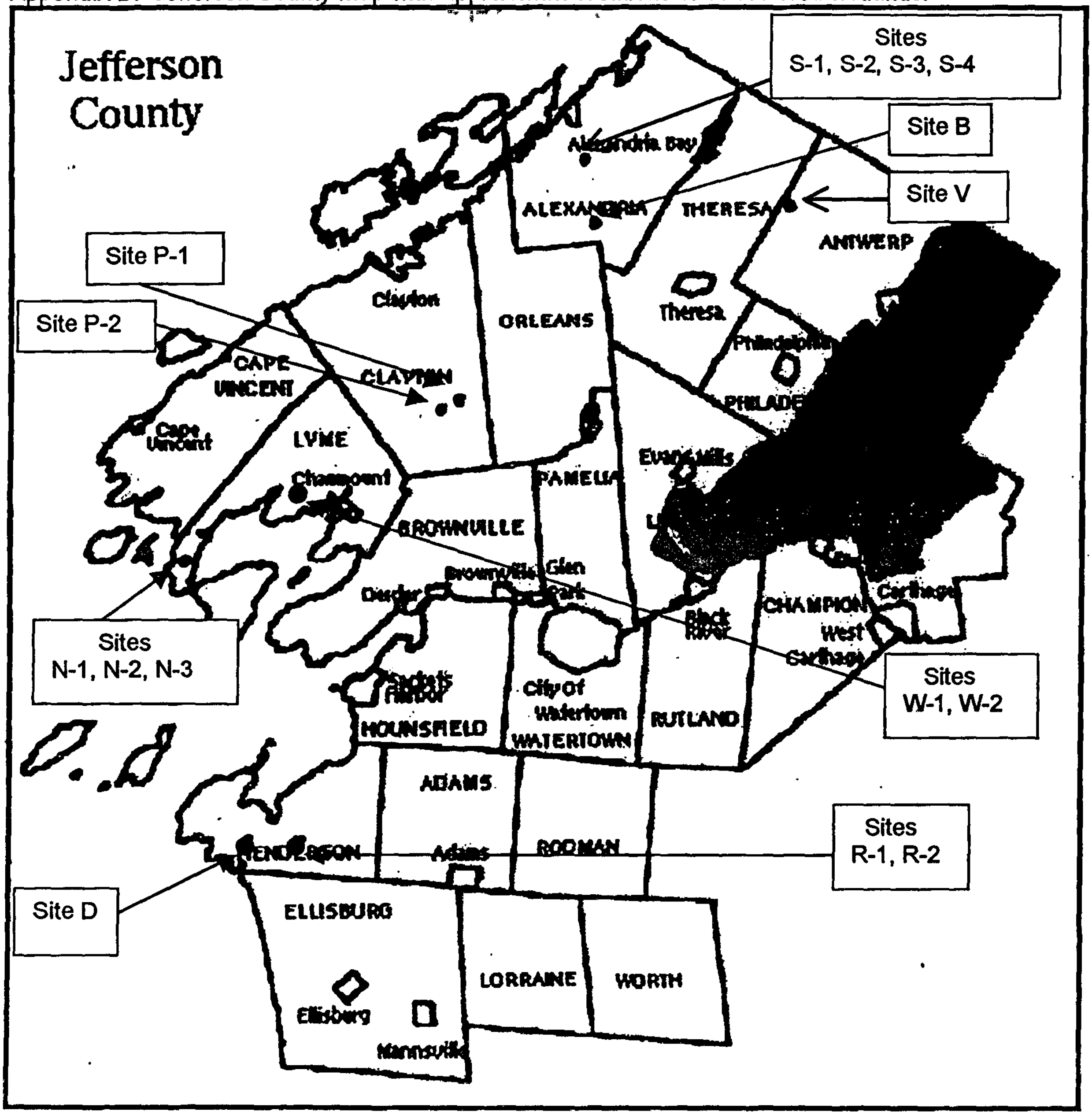
APPENDIX A

Appendix A. New York State Map showing location of Jefferson County.



APPENDIX B

Appendix B. Jefferson County Map with approximate locations of 16 restored wetlands.



APPENDIX C

Appendix C. Beaufort Wind Scale taken from Long Point Bird Observatory Marsh Monitoring Program Guidelines (Chabot and Helferty, 1995)

Number	Wind Speed kph	Wind Speed mph	Indicators
0	0-2	0-1	Calm, smoke rises vertically
1	3-5	2-3	Light air movement, smoke drifts
2	6-11	4-7	Slight breeze, wind felt on face; leaves rustle
3	12-19	8-12	Gentle breeze, leaves and small twigs in constant motion
4	20-30	13-18	Moderate breeze, small branches are moved; raises dust and loose paper
5	31-39	19-24	Fresh breeze, small trees in leaf begin to sway; crested wavelets form
6	40-50	25-31	Strong breeze, large branches in motion; whistling heard in telephone wires

APPENDIX D

Appendix D. Amphibian survey data form provided by the Long Point Bird Observatory Marsh Monitoring Program (Chabot and Helferty, 1995).

AMPHIBIAN DATA FORM

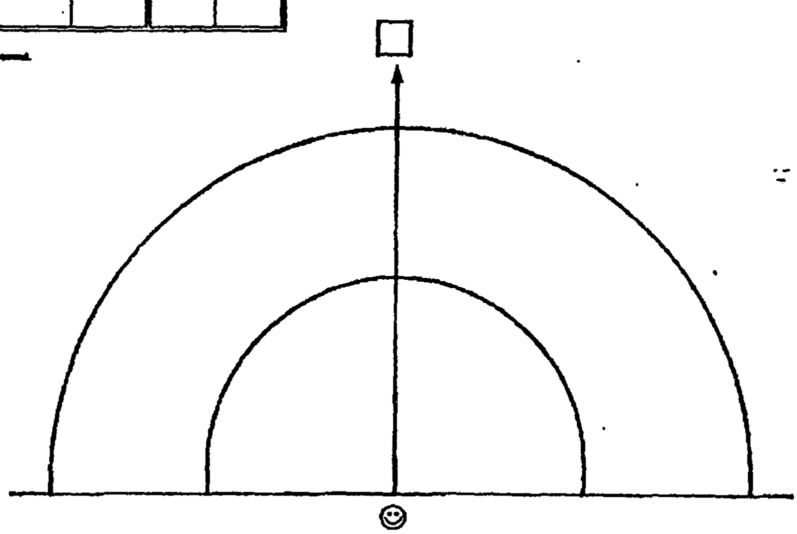
Please write legibly.

Observer:	Route Name:	Date (yr-mm-dd):
Station #: (A-H):	Survey #:	Start time (e.g. 2127 h):
Beaufort Wind Scale:	Cloud Cover (10ths):	Air Temp. (°C or °F):
Water Temp. (°C or °F):	Precip: None/dry ___ Damp ___ Haze ___ Fog ___ Drizzle ___ Rain ___	
Validation studies you are participating in: None ___ Two observers ___ 3-minute & 5-minute surveys ___		
Remarks:		

Species Name	Code	First 3 minutes		Next 2 minutes*	
		Code	Count	Code	Count
American Toad	AMTO				
Fowler's Toad	FOTO				
Gray Treefrog	GRTF				
Cope's Gray Treefrog	CGTF				
Spring Peeper	SPPE				
Chorus Frog	CHFR				
Blanchard's Cricket Frog	BCFR				
Wood Frog	WOFR				
N. Leopard Frog	NLFR				
Pickerel Frog	PIFR				
Green Frog	GRFR				
Mink Frog	MIFR				
Bullfrog	BULL				

* Only record new species, change in code or change in count.

CALL LEVEL CODES	
0 =	None heard (record zeroes, not blanks)
1 =	Males can be counted individually without error
2 =	Calls overlap each other, but numbers can be reliably estimated
3 =	Calls overlap each other too much to estimate numbers



APPENDIX E

Appendix E. Summary of plant species identified at 10 restorations for the years 1994, 1997 and 1998. Species are listed alphabetically by taxon within each plant classification. OBL= obligate, FACW= facultative wetland, FAC=facultative, FACU=facultative upland, UPL=upland.

COMMON NAME	GENUS	SPECIES	CLASS	1994	1997	1998
Common Water Plantain	*Alisma*	*plantago-aquatica*	OBL	X		
Swamp Milkweed	*Asclepius*	*incarnata*	OBL		X	X
Nodding Beggarticks	*Bidens*	*cernua*	OBL	X		
Slough Sedge	*Carex*	*atherodes*	OBL	X	X	X
Fringed Sedge	*Carex*	*crinita*	OBL			X
Graceful Sedge	*Carex*	*gracillima*	OBL	X		
Hop Sedge	*Carex*	*luplina*	OBL	X		X
Bull Sedge	*Carex*	*lanuginosa*	OBL	X		
Lurid Sedge	*Carex*	*lurida*	OBL	X	X	X
Stalk-Grain Sedge	*Carex*	*stipata*	OBL	X		
Fox Sedge	*Carex*	*vulpinoidea*	OBL	X	X	X
Poison Water Hemlock	*Cicuta*	*bulbifera*	OBL	X	X	X
Needle Spikerusk	*Eleocharis*	*acicularis*	OBL	X	X	X
Blunt Spikerush	*Eleocharis*	*obtusa*	OBL			X
Ovate Spikerush	*Eleocharis*	*ovata*	OBL	X		
Purpleleaf Willowweed	*Epilobium*	*coloratum*	OBL	X		
Rough Bedstraw	*Galium*	*asprellum*	OBL		X	X
Marsh Bedstraw	*Galium*	*palustre*	OBL	X		
Dye Bedstraw	*Galium*	*tinctorium*	OBL	X		
Reed Meadow Grass	*Glyceria*	*grandis*	OBL		X	
Common Frogbit	*Hydrocharus*	*morsus-ranae*	OBL	X	X	X
Rice Cutgrass	*Leersia*	*oryzoides*	OBL	X	X	X
Duckweed	*Lemna*	*minor*	OBL	X	X	X
Marsh Purslane	*Ludwigia*	*palustris*	OBL	X		
American Bugleweed	*Lycopus*	*americanus*	OBL	X	X	X
Oneflower Bugleweed	*Lycopus*	*uniflorus*	OBL		X	X
Moneywort Loosestrife	*Lysimachia*	*nummularia*	OBL	X	X	X
Ditch Stonecrop	*Penthorum*	*sedoides*	OBL	X	X	X
Water Smartweed	*Polygonum*	*amphibium*	OBL		X	
Water Pepper	*Polygonum*	*hydropiper*	OBL	X		X
Pondweed	*Potamogeton*	*spp.*	OBL	X	X	X
Broadleaf Arrowhead	*Sagittaria*	*latifolia*	OBL		X	X
Silky Willow	*Salix*	*sericea*	OBL	X		
Green Bulrush	*Scirpus*	*atrovirens*	OBL	X	X	
Softstem Bulrush	*Scirpus*	*validus*	OBL	X		
Roughleaf Goldenrod	*Solidago*	*patula*	OBL			X
Giant Burreed	*Sparganium*	*eurycarpum*	OBL	X	X	X
Big Duckweed	*Spirodela*	*polyrhiza*	OBL	X		
Common Cattail	*Typha*	*latifolia*	OBL	X	X	X
Nannyberry	*Viburnum*	*lentago*	OBL			X

COMMON NAME	GENUS	SPECIES	CLASS	1994	1997	1998
Redtop	*Agrostis*	*alba*	FACW			X
Redtop Bentgrass	*Agrostis*	*gigantea*	FACW	X		X
Many-Flowered Aster	*Aster*	*lanceolatus*	FACW	X		
Calico Aster	*Aster*	*lateriflorus*	FACW	X	X	
New England Aster	*Aster*	*novae-angliae*	FACW	X	X	
Swamp Beggarticks	*Bidens*	*connata*	FACW	X		
Devils Beggarticks	*Bidens*	*frondosa*	FACW	X	X	X
False Nettle	*Boehmeria*	*cylindrica*	FACW			X
Crested Sedge	*Carex*	*cristatella*	FACW	X		X
Meadow Sedge	*Carex*	*granularis*	FACW	X		
Beaded Broom Sedge	*Carex*	*projecta*	FACW	X		
Retrorse Sedge	*Carex*	*retrorsa*	FACW	X		
Broom Sedge	*Carex*	*scoparia*	FACW		X	X
Bristlebract Sedge	*Carex*	*tribuloides*	FACW	X		
Silky Dogwood	*Cornus*	*amomum*	FACW		X	
Red Osier Dogwood	*Cornus*	*stolonifera*	FACW		X	X
Tufted Hairgrass	*Deschampsia*	*cespitosa*	FACW		X	
Large Leaf Avens	*Geum*	*macrophyllum*	FACW			X
Spotted Touch-Me-Not	*Impatiens*	*capensis*	FACW		X	X
Soft Rush	*Juncus*	*effusus*	FACW	X	X	X
Field Mint	*Mentha*	*arvensis*	FACW	X	X	X
Reed Canarygrass	*Phalaris*	*arundinacea*	FACW	X	X	X
Common Elderberry	*Sambucus*	*canadensis*	FACW			X
Woolgrass	*Scirpus*	*cyperinus*	FACW	X	X	X
Late Goldenrod	*Solidago*	*gigantea*	FACW		X	X
Blue Vervain	*Verbena*	*hastata*	FACW	X		X
Riverbank Grape	*Vitis*	*riparia*	FACW		X	
Slender Sedge	*Carex*	*tenera*	FAC	X		
Gray-Twigged Dogwood	*Cornus*	*racemosa*	FAC	X	X	X
Wooly Panicum	*Dichanthelium*	*acuminatum*	FAC	X		
Field Horsetail	*Equisetum*	*arvense*	FAC	X	X	X
Yellow Avens	*Geum*	*aleppicum*	FAC		X	X
Rough Avens	*Geum*	*laciniatum*	FAC	X		
Path Rush	*Juncus*	*tenuis*	FAC	X		
Witchgrass	*Panicum*	*cappalare*	FAC		X	
Tall Buttercup	*Ranunculis*	*acris*	FAC	X		

COMMON NAME	GENUS	SPECIES	CLASS	1994	1997	1998
Rhombic Copperleaf	*Acalypha*	*rhomboidea*	FACU	X		
Quackgrass	*Agropyron*	*repens*	FACU	X		X
Common Ragweed	*Ambrosia*	*artemisiifolia*	FACU	X	X	X
Bitter Wintercress	*Barbarea*	*vulgaris*	FACU	X		
Bull Thistle	*Cirsium*	*vulgare*	FACU	X		
Red Fescue	*Festuca*	*rubra*	FACU		X	
Wild Strawberry	*Fragaria*	*virginiana*	FACU	X	X	X
Birdsfoot Trefoil	*Lotus*	*corniculatus*	FACU	X		
Common Evening Primrose	*Oenothera*	*biennis*	FACU	X	X	
Timothy	*Phleum*	*pratense*	FACU	X	X	X
Common Plantain	*Plantago*	*major*	FACU	X		
Canada Bluegrass	*Poa*	*compressa*	FACU	X		
Kentucky Bluegrass	*Poa*	*pratensis*	FACU	X	X	X
Norwegian Cinquefoil	*Potentilla*	*norvegica*	FACU	X		
Old Field Cinquefoil	*Potentilla*	*simplex*	FACU	X	X	X
Heal-All	*Prunella*	*vulgaris*	FACU	X	X	
Curly Dock	*Rumex*	*crispus*	FACU	X		
Tall Goldenrod	*Solidago*	*altissima*	FACU		X	
Canada Goldenrod	*Solidago*	*canadensis*	FACU	X	X	
Dandilion	*Taraxacum*	*officinale*	FACU	X		
Alsike Clover	*Trifolium*	*hybridum*	FACU	X		
Slimsting Nettle	*Urtica*	*dioica*	FACU		X	
Common Milkweed	*Asclepias*	*syriaca*	UPL	X		
Field Bindweed	*Convolvulus*	*arvensis*	UPL			X
Hedge Bindweed	*Convolvus*	*sepium*	UPL	X		X
Queen Ann's Lace	*Daucus*	*carota*	UPL	X	X	
Wild Madder	*Galium*	*mollugo*	UPL	X		
Black Medick	*Medicago*	*lupulina*	UPL	X		
Yellow Wood Sorrell	*Oxalis*	*europaea*	UPL	X		
Early Goldenrod	*Solidago*	*juncea*	UPL	X		
Cow Vetch	*Vicia*	*cracca*	UPL	X	X	X
Slender Vetch	*Vicia*	*tetrasperma*	UPL	X		

APPENDIX F

Appendix F. Summary of Preferred Wildlife Food Plant species identified at 10 wetland restorations in 1994, 1997 and 1998. Species are listed alphabetically by taxon within each plant classification. OBL=obligate, FACW=facultative wetland, FAC=facultative.

COMMON NAME	GENUS	SPECIES	CLASS	1994	1997	1998
Common Water Plantain	*Alisma*	*plantago-aquatica*	OBL	X		X
Nodding Beggarticks	*Bidens*	*cernua*	OBL	X		
Slough Sedge	*Carex*	*atherodes*	OBL	X	X	X
Fringed Sedge	*Carex*	*crinita*	OBL			X
Graceful Sedge	*Carex*	*gracillima*	OBL	X		
Bull Sedge	*Carex*	*lanuginosa*	OBL	X		
Hop Sedge	*Carex*	*luplina*	OBL	X		X
Lurid Sedge	*Carex*	*lurida*	OBL	X	X	X
Stalk-Grain Sedge	*Carex*	*stipata*	OBL	X		
Fox Sedge	*Carex*	*vulpinoidea*	OBL	X	X	X
Needle Spikerush	*Eleocharis*	*acicularis*	OBL	X	X	X
Blunt Spikerush	*Eleocharis*	*obtusa*	OBL			X
Ovate Spikerush	*Eleocharis*	*ovata*	OBL	X		
Reed Meadow Grass	*Glyceria*	*grandis*	OBL		X	
Rice Cutgrass	*Leersia*	*oryzoides*	OBL	X	X	X
Duckweed	*Lemna*	*minor*	OBL	X	X	X
Water Smartweed	*Polygonum*	*amphibium*	OBL		X	
Water Pepper	*Polygonum*	*hydropiper*	OBL	X		X
Pondweed	*Potamogeton*	*spp.*	OBL	X	X	X
Broadleaf Arrowhead	*Sagittaria*	*latifolia*	OBL		X	X
Giant Burreed	*Sparganium*	*eurycarpum*	OBL	X	X	X
Swamp Beggarticks	*Bidens*	*connata*	FACW	X		
Devils Beggarticks	*Bidens*	*frondosa*	FACW	X	X	X
Crested Sedge	*Carex*	*cristatella*	FACW	X		X
Meadow Sedge	*Carex*	*granularis*	FACW	X		
Beaded Broom Sedge	*Carex*	*projecta*	FACW	X		
Retrorse Sedge	*Carex*	*retrorsa*	FACW	X		
Broom Sedge	*Carex*	*scoparia*	FACW		X	X
Bristlebract Sedge	*Carex*	*tribuloides*	FACW	X		
Silky Dogwood	*Cornus*	*amomum*	FACW		X	
Red Osier Dogwood	*Cornus*	*stolonifera*	FACW		X	X
Soft Rush	*Juncus*	*effusus*	FACW	X	X	X
Slender Sedge	*Carex*	*tenera*	FAC	X		
Gray-Twigged Dogwood	*Cornus*	*racemosa*	FAC	X	X	
Path Rush	*Juncus*	*tenuis*	FAC	X		

APPENDIX G

Appendix G. List of bird species observed at 13 restored wetlands for the years 1994, 1997 and 1998. Species are listed in American Ornithologists Union taxonomic order within each habitat preference classification. OBL=obligate, FACW=facultative wetland, FAC=facultative, UPL=upland.

COMMON NAME	GENUS	SPECIES	CLASS	1994	1997	1998
Pied-Billed Grebe	*Podilymbus*	*podiceps*	OBL			X
Double-Crested Cormorant	*Phalacrocorax*	*auritus*	OBL	X		
Canada Goose	*Branta*	*canadensis*	OBL	X	X	X
Mallard	*Anas*	*platyrhynchos*	OBL	X	X	X
Blue-Winged Teal	*Anas*	*discors*	OBL	X	X	X
Green-Winged Teal	*Anas*	*crecca*	OBL	X		X
Wood Duck	*Aix*	*sponsa*	OBL	X	X	X
Hooded Merganser	*Lophodytes*	*cucullatus*	OBL		X	
Great Blue Heron	*Ardea*	*herodias*	OBL	X	X	X
Green Heron	*Butorides*	*virescens*	OBL	X	X	X
Black-Crowned Night Heron	*Nycticorax*	*nycticorax*	OBL		X	
American Bittern	*Botaurus*	*lentiginosus*	OBL	X	X	
Virginia Rail	*Rallus*	*limicola*	OBL	X	X	X
Sora	*Porzana*	*carolina*	OBL	X	X	X
Lesser Yellowlegs	*Tringa*	*flavipes*	OBL	X		
Spotted Sandpiper	*Actitis*	*macularia*	OBL	X	X	X
Belted Kingfisher	*Ceryle*	*alcyon*	OBL	X		X
Marsh Wren	*Cistothorus*	*palustris*	OBL	X		
Swamp Sparrow	*Melospiza*	*georgiana*	OBL	X	X	
Common Snipe	*Gallinago*	*gallinago*	FACW	X	X	X
Sedge Wren	*Cistothorus*	*platensis*	FACW		X	
Veery	*Catharis*	*fuscescens*	FACW		X	X
Common Yellowthroat	*Geothlypis*	*trichas*	FACW	X	X	X
Red-Winged Blackbird	*Agelaius*	*phoeniceus*	FACW	X	X	X
Ruby-Throated Hummingbird	*Archilochus*	*colubris*	FAC	X		
Red-Bellied Woodpecker	*Melanerpes*	*carolinus*	FAC		X	
Tree Swallow	*Tachycineta*	*bicolor*	FAC	X	X	X
Gray Catbird	*Dumetella*	*carolinensis*	FAC	X	X	X
Yellow Warbler	*Dendroica*	*petechia*	FAC	X	X	X
Bobolink	*Dolichonyx*	*oryzivorus*	FAC	X	X	X
Song Sparrow	*Melospiza*	*melodia*	FAC	X	X	X

COMMON NAME	GENUS	SPECIES	CLASS	1994	1997	1998
Killdeer	*Charadrius*	*vociferus*	UPL	X	X	X
Rock Dove	*Columba*	*livia*	UPL	X		
Mourning Dove	*Zenaida*	*macroura*	UPL	X	X	X
Whipporwill	*Caprimulgus*	*vociferus*	UPL		X	X
Common Flicker	*Colaptes*	*auratus*	UPL	X		
Piliated Woodpecker	*Dryocopus*	*pileatus*	UPL			X
Downy Woodpecker	*Picoides*	*pubescens*	UPL		X	X
Eastern Kingbird	*Tyrannus*	*tyrannus*	UPL	X	X	X
Great-Crested Flycatcher	*Myiarchus*	*crinitus*	UPL			X
Eastern Phoebe	*Sayornis*	*phoebe*	UPL	X		X
Willow Flycatcher	*Empidonax*	*traillii*	UPL		X	X
Eastern Wood Pewee	*Contopus*	*virens*	UPL	X	X	X
Barn Swallow	*Hirundo*	*rustica*	UPL	X	X	X
Purple Martin	*Progne*	*subis*	UPL			X
Blue Jay	*Cyanocitta*	*cristata*	UPL		X	X
American Crow	*Corvus*	*brachyrhynchos*	UPL	X	X	X
Black-Capped Chickadee	*Parus*	*atricapillus*	UPL	X	X	X
White-Breasted Nuthatch	*Sitta*	*carolinensis*	UPL			X
Red-Breasted Nuthatch	*Sitta*	*canadensis*	UPL			X
House Wren	*Troglodytes*	*aedon*	UPL			X
Brown Thrasher	*Toxostoma*	*rufum*	UPL			X
American Robin	*Turdus*	*migratorius*	UPL	X	X	X
Wood Thrush	*Hylocichla*	*mustelina*	UPL			X
Cedar Waxwing	*Bombycilla*	*cedrorum*	UPL	X		X
European Starling	*Sturnus*	*vulgaris*	UPL	X	X	X
Red-Eyed Vireo	*Vireo*	*olivaceus*	UPL		X	X
Eastern Meadowlark	*Sturnella*	*magna*	UPL		X	X
Common Grackle	*Quiscalus*	*quiscula*	UPL	X	X	X
Brown-Headed Cowbird	*Molothrus*	*ater*	UPL		X	X
Northern Oriole	*Icterus*	*galbula*	UPL		X	X
Northern Cardinal	*Cardinalis*	*cardinalis*	UPL		X	X
Rose-Breasted Grosbeak	*Pheucticus*	*ludovicianus*	UPL	X		X
American Goldfinch	*Carduelis*	*tristis*	UPL	X	X	X
Rufous-Sided Towhee	*Pipilo*	*erythrophthalmus*	UPL	X		
Savannah Sparrow	*Passerculus*	*sandwichensis*	UPL			X
American Tree Sparrow	*Spizella*	*arborea*	UPL	X		
Chipping Sparrow	*Spizella*	*passerina*	UPL			X

APPENDIX H

Appendix H. Summary of amphibian species found at each site in 1997 and 1998.

SPECIES	YEAR	B	D	N-1	N-2	N-3	P-1	P-2	R-1	R-2	S	V	W-1	W-2	Total No. of Sites Having Each Species
American Toad	1997	*	*						*		*	*	*		6
(*Bufo americana*)	1998	*													1
Bullfrog	1997	*	*				*	*	*	*	*	*	*		9
(*Rana catesbiena*)	1998	*					*	*	*		*	*	*		7
Chorus Frog	1997	*									*	*	*		4
(*Pseudacris triseriata*)	1998	*									*	*	*		4
Gray Tree Frog	1997	*	*	*	*		*	*	*	*	*	*	*	*	12
(*Hyla versicolor*)	1998	*	*	*	*		*	*	*	*	*	*	*	*	12
Green Frog	1997	*	*	*	*	*	*	*	*	*	*	*	*	*	13
(*Rana clamitans*)	1998	*	*	*	*	*	*	*	*	*	*	*	*	*	13
Northern Leopard Frog	1997	*	*	*	*	*	*	*	*	*	*	*	*	*	12
(*Rana pipiens*)	1998	*	*	*	*	*	*	*	*	*	*	*	*	*	12
Spring Peeper	1997	*	*	*	*		*	*	*	*	*	*	*	*	12
(*Pseudacris crucifer*)	1998	*	*	*	*		*	*	*	*	*	*	*	*	12
Wood Frog	1997	*					*								2
(*Rana sylvatica*)	1998														0
Number of Species Found at Each Site (n=8)	1997	7	6	4	4	2	6	5	6	5	7	7	7	4	
	1998	8	4	4	4	2	5	5	5	4	6	6	6	4	