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# Development of vegetation in wetlands restored on Ozaukee County Conservation Reserve Program Lands

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## Abstract

We studied the natural revegetation of six wetlands created in 1988 and six wetlands created in 1989 in Ozaukee County, Wisconsin. By describing the flora and vegetation of these two sets of wetlands we could compare the development of plant communities in one- and two-year old wetlands. Of the 119 species found in the 12 wetlands, 64% were native, 62% were wetland plants, and 65% were perennials. More species were found in two-year old than in one-year old wetlands. There was also a strong correlation between wetland size and the number of species present during the first year after construction.

Two-year old wetlands had a higher percentage of native plants and of wetland plants and a much higher total plant cover than did one-year old wetlands. However, while species richness increased, evenness declined from one- to two-year old wetlands so overall species diversity did not change. Evenness declined because of a dramatic increase in the dominance of two-year old wetlands by cattails (*Typha* spp.). Our results lead us to predict that the wetlands will become surrounded by willow shrub "rings", and they may develop into near monocultures of cattail in the future. Continuance of the study will compare naturally colonized wetlands with wetlands seeded with native wetland species.

## Introduction

Tiner (1984) estimated that 30-40% of the original wetlands in the United States have been lost and that destruction continues at a rate of about 350,000 acres per year. Interest in wetland creation and restoration has increased dramatically over the last decade at all levels of governmental agencies and in the private sector (Kusler and Kentula, 1990a). Wetland restoration and creation have been advocated as a mitigation for the loss of all of the known functions of wetlands including enhancement of water quality and wildlife habitat.

Experience in the restoration of wetlands, and the evaluation and reporting of success, varies greatly with region and with wetland types. For example, coastal and estuarine mitigation projects along the eastern seaboard are relatively well known and well reported, whereas very little is known about restoring or creating inland, freshwater wetlands. Thousands of inland wetlands have been created or restored over the past 50 years in the United States but there has been very little short-term, and almost no long-term, monitoring of these projects. Monitoring of wetland projects and comparison with natural wetlands could provide information on rates of revegetation,

use by wildlife, development of soils, patterns of succession and evidence of persistence of the wetland systems (Kusler and Kentula, 1990b). In particular, knowledge of vegetation development in created, isolated kettle wetlands (those having no inlet or outlet streams) is practically non–existent.

Kusler and Kentula's (1990b) list of topics of study particularly critical to filling gaps in knowledge of wetland restoration includes: 1) systematic monitoring, 2) hydrologic needs and requirements of various plants including their minimum and maximum tolerated water levels, and 3) characteristics and rates of natural revegetation in contrast with various types of planting methods.

Over 100 small wetlands areas (0.1 to 4.0 acres) have been restored or created on Conservation Reserve Program (CRP) Lands in Ozaukee County during 1988, 1989 and 1990. The wetlands that have been restored fall roughly into two major categories:

1) Wetlands on organic soils where the groundwater table is at or near the surface. These wetlands often require only a tile break to restore water levels and often have some existing, although degraded, wetland vegetation present at the time of their restoration.

2) Wetlands created on impermeable clay soils by constructing an impoundment with a small dam across a local surface water drainageway. These wetlands typically have no existing wetland vegetation at the time of their construction and are mostly located in abandoned hay fields.

The primary goals of these wetland restoration projects are to provide wildlife habitat and to encourage the establishment of a diverse native wetland vegetation. These wetlands may partially restore some of the wetland functions lost in Ozaukee County through historical loss of wetland acreage. In addition the wetlands may serve some function as pulse control storage basins for local streams.

The major objectives of this study are to describe the natural revegetation of these wetlands when no intentional plantings or introductions are made, and to compare this natural revegetation with vegetation development in wetlands where a variety of native wetland species are intentionally introduced. In the process of introducing native wetland species, the study is also designed to compare some methods for low cost and low effort introduction through seeding techniques.

This paper is a report after one year of study in the wetlands. More results will be available over the next two seasons. All aspects of the studies have been designed so that they will be amenable to the long-term monitoring of the studied sites.

## Methods

Twelve wetlands, 6 established in 1988, and 6 established in 1989 (Table 1) were chosen for study. From 3 to 7 permanently marked transects were established perpendicular to the water depth gradient in each wetland. Five, equally spaced, $1m^2$ quadrats were arranged along each transect line extending from the edge of the wet soil to the open water. Within each quadrat we recorded the cover of each plant species present in five categories: present (<5% cover); 5-25%; 26-50%; 51-75%; and 76-100% cover.

Table 1. Ozaukee County wetlands sampled for this study of the revegetation of restored wetlands.

| Wetland # in this report | SCS Wetland # | Year Estab. | Size Acres | Perimeter (meters) |
|---|---|---|---|---|
| 1 | 2-1 | 88 | 0.3 | 155 |
| 2 | 2-2 | 88 | 0.4 | 164 |
| 3 | 4-1 | 88 | 0.5 | 193 |
| 4 | 4-2 | 88 | 0.2 | 113 |
| 5 | 8-1 | 88 | 0.1 | 90 |
| 6 | 8-2 | 88 | 0.7 | 217 |
| 7 | 7-1 | 89 | 4.0 | 524 |
| 8 | 11-1 | 89 | 0.2 | 102 |
| 9 | 11-3 | 89 | 0.1 | 84 |
| 10 | 11-4 | 89 | 0.2 | 105 |
| 11 | 11-6 | 89 | 1.0 | 247 |
| 12 | 14-1 | 89 | 0.1 | 76 |

We also compiled a complete list of species present in each wetland whether or not they occurred in one of our sampled quadrats. The ends of each transect were marked with metal or PVC pipe. Species were identified using the nomenclature of Voss (1972, 1985) and Fernald (1970). Voucher specimens of species were collected and deposited in the herbarium of the UWM Field Station.

Wetland size, measured as area or as total length of wetland perimeter, was found to be significantly correlated with several statistics summarizing the vegetation and flora of wetlands. Wetland perimeter was positively correlated with number of species, species richness, percent annual species, number of native species, number of wetland species, and number of perennial species. All statistical tests of significant differences between one- and two-year old wetlands were therefore calculated as one way analyses of covariance with wetland perimeter used as a covariate. In this way, the effects of wetland size were removed before comparing the means of one- and two-year old wetlands.

## Results

The results obtained to date are preliminary, allowing a comparison of the vegetation of one-year old (established in 1989) and two-year old (1988) naturally colonized wetlands.

### Comparison of one- and two-year old wetlands

A total of 119 plant species were found in the twelve restored wetlands studied (Table 2). Of these species, 76 (64%) were native, 74 (62%) were wetland or facultative wetland (commonly found in both wet and dry soils) plants, and 77 (65%) were perennials (Table 2). More species were present in two-year old (1988) than in one-year old (1989) wetlands (Tables 2, 4; Figure 2). However, wetlands also varied greatly in size (Figure 1) and there was a strong positive correlation between wetland size and number of species in one-year old (1989) wetlands (Compare Figures 1 and 2). In 1989 wetlands, 95% of the variation in number of species present could be explained by length of the wetland perimeter ($r^2 = 0.950$). There was no significant correlation of wetland size and number of species in 1988 wetlands. This lack of correlation in two-year old wetlands could be because there was a much smaller range of size among the wetlands constructed in 1988, or because the effects of size are transitory and are lost by the second year after construction.

A higher proportion of the flora of two-year old wetlands was comprised of native and of perennial species (Table 4, Figure 2) than that of one-year old wetlands. There was no significant difference between 1989 and 1988 wetlands in the proportion of the flora that was wetland or facultative wetland plants (Table 4, Figure 2).

We calculated diversity statistics on the cover data for the 12 studied wetlands (Table 3). The Shannon-Weaver diversity index (Pielou, 1969) takes into account both the richness of species in a wetland (a reflection of the number of species present) and the evenness of the cover values for those species. The Shannon-Weaver diversity index, species richness and species evenness were calculated as follows:

$$\text{Diversity (D)} = -\Sigma \left(\frac{C_i}{T_c}\right) \ln \left(\frac{C_i}{T_c}\right)$$

$$\text{Richness (R)} = \frac{S - 1}{\ln T_c}$$

$$\text{Evenness (E)} = \frac{D}{\ln S}$$

where

$C_i$ = cover of species ;

$T_c$ = total of cover estimates of all species;

S = the number of species.

The number of species found in quadrats (both native and non-native) did not increase significantly from one- to two-year old wetlands (Table 4) but there was a significant increase in the number of native species. This was reflected both in the significant difference in the number of native species and in the significantly higher percent of native species in 1989 wetlands (Table 4). There were no significant differences in diversity, richness or evenness of one- and two-year old wetlands (Table 4), but the evenness of native species did decrease from one- to two-year old wetlands. This was probably due to an increased dominance of wetland cover by cattails in the wetland's second growing season. The percent wetland plants also increased significantly from one- to two-year old wetlands. Total cover, both of all species and of native species only, increased dramatically from one- to two-year old wetlands (Table 4).

The size of 1989 wetlands was positively correlated with species richness (Figures 1 and 3), but there was no correlation between size and evenness. There was therefore, no overall correlation between wetland size and species diversity in 1989 wetlands.

Changes in the number of species found in quadrats in one- and two-year old wetlands were mostly due to species which had very low cover values (< 1%) and which are currently minor components of the developing communities (Table 2). The major changes in cover were the result of a much smaller number of species. Cattail (*Typha latifolia* and *T. angustifolia* combined) cover increased from 1.4% in one-year old wetlands to 20.1% in two-year old wetlands (Table 2). Because of a high variance in species cover values among wetlands, *Typha latifolia* and *T. angustifolia* were the only species which increased significantly in cover ($P<0.05$) from one- to two-year old wetlands. Leafy pondweed, not found in quadrats in one-year old wetlands increased in cover to 10.2% in two-year old wetlands. In the open water portion of wetlands this increase was of course much more dramatic, since this submerged aquatic plant was only found at greater water depths. Willows (*Salix* spp.), found around the wetland margins, increased in cover from 0.1% to 2.4% (Table 2).

Among non-native species quackgrass (*Agropyron repens*) maintained a high cover around the wetland margins from one- to two-year old wetlands, and timothy (*Phleum pratense*), bromegrass (*Bromus inermis*), and dandelion (*Taraxacum officinale*) increased markedly in cover (Table 2). Most annual species decreased in cover from the 1989 to the 1988 wetlands. Most of the introduced, or non-native, species in the wetlands were upland plants found exclusively around the margins of the wetland areas.

## Discussion

Most of the species which naturally colonized the wetlands soon after their creation have seeds which are widely dispersed by wind. For example, cattail, willow, and aster seeds are all capable of travelling great distances on the wind. It is more difficult to explain the efficiency with which some other species seem to find the wetland areas. For example, water plantain, which has relatively large seeds and no obvious dispersal mechanism, is found in almost every wetland during its first year after construction.

From the early patterns of vegetation development in the studied wetlands, we can make some predictions regarding the nature of the wetlands in the future. The presence

of willow and aspen (*Populus* spp.) seedlings around the margin of every wetland indicates that they will develop into marsh communities with "willow rings". If this willow ring develops to more or less fully occupy the zone between the wetland margin and the water depth at which cattail grows, it may curtail the diversity of the plant community by excluding many herbaceous species. If willow rings are detrimental to wildlife utilization of the ponds some management of the woody growth may be desirable.

The dominance of cattail in the entire shallow water zone of the wetlands after two years, suggests that these wetlands may be on their way toward developing into what are essentially cattail monocultures. Many restoration ecologists include cattails and willows in their lists of problematic species for wetland restoration (Erwin, 1990). Levine and Willard (1990) in a discussion of fringe wetlands around ponds and reservoirs, state that natural colonization is usually an inappropriate technique for wetland restoration because sites have a tendency to become monotypic stands, usually of cattails. Cattails probably engage in a kind of inhibition competition where relatively pure stands of cattail initially get established and essentially exclude other species. These cattail stands can be stable for long periods of time. Inhibition competition may also be typical of reed canary grass. Odum (1988) points out that invasion by unwanted plants is common in freshwater artificial wetlands and refers to the "cattailization of America".

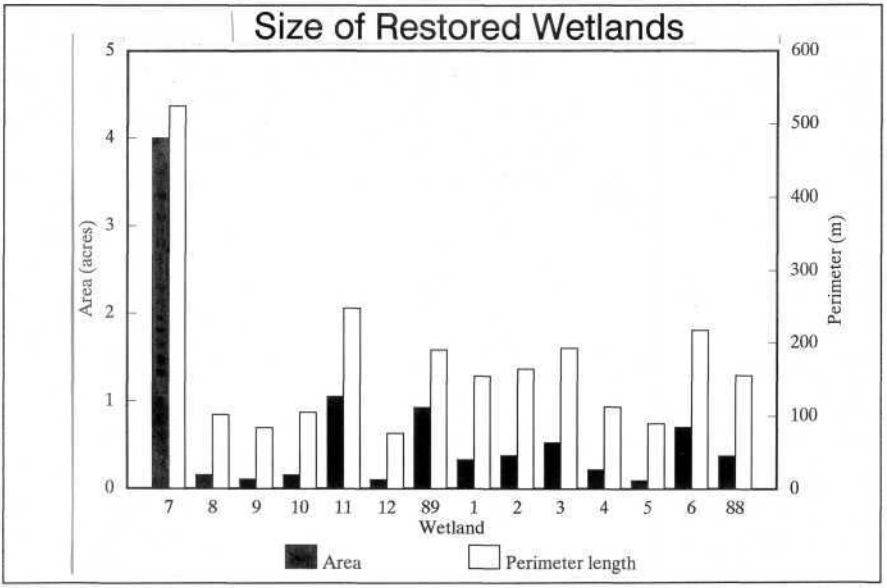


Figure 1. Size of restored wetlands calculated from maps drawn to scale in the field. The bars labeled "89" and "88" represent the means calculated for one- and two-year old wetlands respectively.

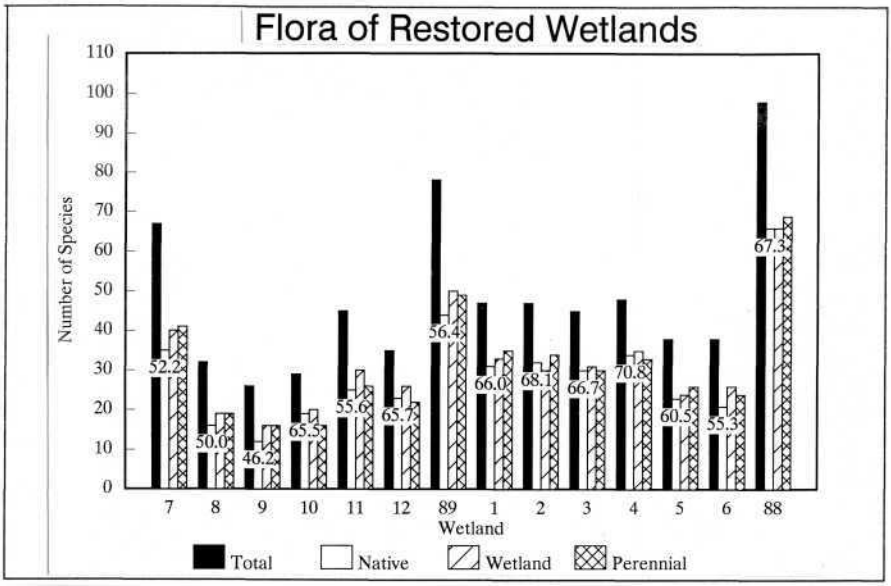


Figure 2. Flora of restored wetlands showing the total number of species present, the number of native species, the number of wetland or facultative wetland species, and the number of perennials. The number shown in each group of bars is the percent of the total flora which is native. The bars labeled "89" and "88" represent the total flora in all one- and two-year old wetlands respectively.

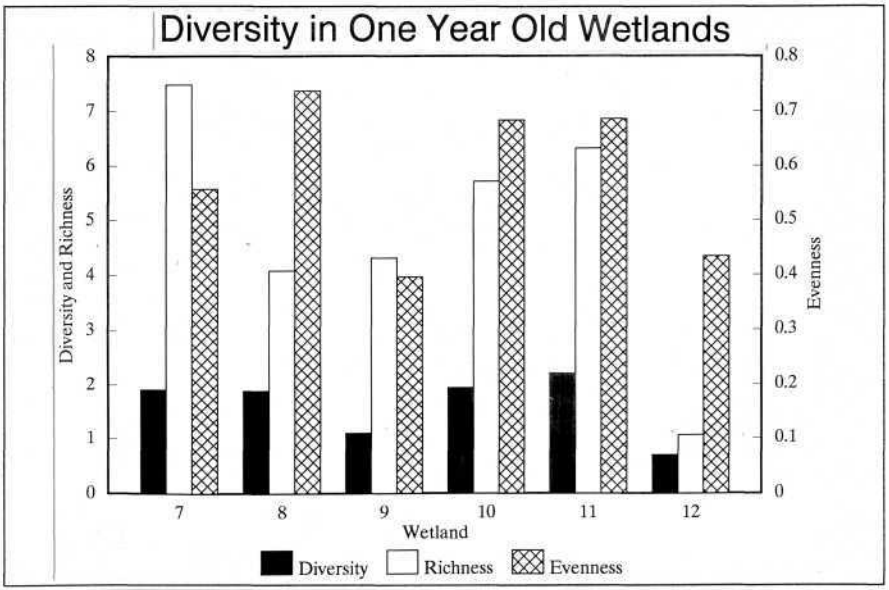


Figure 3. Diversity, richness and evenness in one-year old (1989) restored wetlands. Diversity and richness values are shown on the scale at the left, evenness at the right.

Table 2. Plant species found in 12 wetlands restored in 1988 and 1989. Species are presented in an order according to whether they are native (N) or introduced (I), under column heading "Nat", whether their normal habitats are wetland (W), facultative wetland (F), or upland (U), under column heading "W/F/U"; and whether they are annual (A) or perennial (P), under column heading "A/P". Within these categories, species are ordered according to their mean percent cover in wetlands created in 1988. Mean percent cover and their standard errors are presented. No. Wet. indicated the number of wetlands in which a species was present which is always greater than, or equal to, the number of wetlands in which a species was found in a quadrat sample. Species with a "P" in their mean cover column were present in that set of wetlands but not found in the sampled quadrats.

| | | | | | 1989 Wetlands | | | 1988 Wetlands | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES | COMMON NAME | Nat. | W/F/U | A/P | Mean Cover | SE | No. Wet. | Mean Cover | SE | No. Wet. |
| *Typha latifolia* | Broad-leaved cattail | N | W | P | 0.753 | 0.492 | 6 | 10.57 | 2.631 | 6 |
| *Potamogeton foliosus* | Leafy pondweed | N | W | P | 0 | 0 | 0 | 10.2 | 5.071 | 3 |
| *Typha angustifolia* | Narrow-leaved cattail | N | W | P | 0.624 | 0.388 | 5 | 9.483 | 3.41 | 6 |
| *Salix eriocephala* | Willow | N | W | P | 0.116 | 0.049 | 6 | 2.117 | 1.092 | 6 |
| *Epilobium coloratum* | Willow-herb | N | W | P | 0.013 | 0.013 | 4 | 0.75 | 0.415 | 5 |
| *Equisetum arvense* | Horsetail | N | W | P | 0.013 | 0.013 | 1 | 0.4 | 0.4 | 1 |
| *Salix exigua* | Sandbar willow | N | W | P | P | 0 | 6 | 0.283 | 0.101 | 6 |
| *Eleocharis* sp. | Spike rush | N | W | P | 0.501 | 0.423 | 5 | 0.183 | 0.133 | 5 |
| *Scirpus validus* | Softstem bulrush | N | W | P | P | 0 | 5 | 0.183 | 0.125 | 4 |
| *Alisma plantago-aquatica* | Water plantain | N | W | P | 0.489 | 0.408 | 2 | 0.133 | 0.115 | 4 |
| *Aster junciformis* | Bog aster | N | W | P | 0.025 | 0.025 | 3 | 0.133 | 0.099 | 2 |
| *Aster novae-angliae* | New England aster | N | W | P | 0 | 0 | 0 | 0.033 | 0.033 | 1 |

| SPECIES | COMMON NAME | Nat. | W/F/U | A/P | 1989 Wetlands Mean Cover | SE | No. Wet. | 1988 Wetlands Mean Cover | SE | No. Wet. |
|---|---|---|---|---|---|---|---|---|---|---|
| *Juncus effusus* | Soft rush | N | W | P | 0 | 0 | 0 | 0.033 | 0.033 | 1 |
| *Salix* sp. | Willow | N | W | P | P | 0 | 2 | 0.033 | 0.033 | 1 |
| *Carex vulpinoidea* | Foxtail sedge | N | W | P | P | 0 | 2 | 0.017 | 0.017 | 3 |
| *Penthorum sedoides* | Ditch stonecrop | N | W | P | P | 0 | 3 | 0.017 | 0.017 | 3 |
| *Aster puniceus* | Redstem aster | N | W | P | 0 | 0 | 0 | P | 0 | 2 |
| *Aster simplex* | Marsh aster | N | W | P | P | 0 | 1 | P | 0 | 5 |
| *Carex Bebbii* | Bebb's sedge | N | W | P | 0 | 0 | 0 | P | 0 | 2 |
| *Carex retrorsa* | Sedge | N | W | P | 0 | 0 | 0 | P | 0 | 1 |
| *Carex* sp. | Sedge | N | W | P | P | 0 | 1 | P | 0 | 3 |
| *Carex stipata* | Sedge | N | W | P | 0 | 0 | 0 | P | 0 | 1 |
| *Eleocharis erythropoda* | Spike rush | N | W | P | 0 | 0 | 0 | P | 0 | 1 |
| *Eleocharis smallii* | Spike rush | N | W | P | 0 | 0 | 0 | P | 0 | 1 |
| *Potamogeton natans* | Pondweed | N | W | P | P | 0 | 1 | P | 0 | 1 |
| *Scirpus atrovirens* | Dark green bulrush | N | W | P | P | 0 | 1 | P | 0 | 1 |
| *Scirpus cyperinus* | Woolgrass | N | W | P | 0 | 0 | 0 | P | 0 | 2 |
| *Scirpus fluviatilis* | River bulrush | N | W | P | 0 | 0 | 0 | P | 0 | 2 |
| *Sparganium chlorocarpum* | Bur-reed | N | W | P | 0 | 0 | 0 | P | 0 | 1 |
| *Poa palustris* | Fowl meadow grass | N | W | P | 0.189 | 0.189 | 1 | 0 | 0 | 0 |
| *Sagittaria latifolia* | Arrowhead | N | W | P | P | 0 | 1 | 0 | 0 | 0 |
| *Sium suave* | Water parsnip | N | W | P | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lemna minor* | Duckweed | N | W | A | 0.172 | 0.136 | 2 | 0.317 | 0.145 | 4 |
| *Rorippa palustris* | Marsh cress | N | W | A | 0.61 | 0.595 | 3 | 0.167 | 0.148 | 2 |
| *Ricciocarpus natans* | Purple-fringed riccia | N | W | A | 0 | 0 | 0 | 0.033 | 0.033 | 1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Bidens* sp. | Sticktight | N | W | A | 0.017 | 0.017 | 3 | 0.017 | 0.017 | 2 |
| *Ranunculus sceleratus* | Cursed crowfoot | N | W | A | 0.018 | 0.018 | 5 | 0.017 | 0.017 | 2 |
| *Bidens cernua* | Sticktight | N | W | A | P | 0 | 4 | P | 0 | 6 |
| *Bidens discoidea* | Sticktight | N | W | A | 0 | 0 | 0 | P | 0 | 1 |
| *Eleocharis obtusa* | Spike rush | N | W | A | P | 0 | 4 | P | 0 | 2 |
| *Polygonum lapathifolium* | Nodding smartweed | N | W | A | P | 0 | 5 | P | 0 | 3 |
| *Polygonum punctatum* | Smartweed | N | W | A | 0 | 0 | 0 | P | 0 | 2 |
| *Beckmannia syzigachne* | Slough-grass | N | W | A | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lindernia dubia* | False pimpernel | N | W | A | 0.018 | 0.018 | 1 | 0 | 0 | 0 |
| *Aster* sp. | Aster | N | F | P | 0.669 | 0.669 | 2 | 0.217 | 0.122 | 5 |
| *Acer negundo* | Box-elder | N | F | P | 0.017 | 0.017 | 3 | 0.183 | 0.128 | 3 |
| *Populus* sp. | Aspen/Cottonwood | N | F | P | P | 0 | 6 | 0.15 | 0.067 | 6 |
| *Juncus* sp. | Rush | N | F | P | 0.076 | 0.076 | 2 | 0.017 | 0.017 | 2 |
| *Juncus tenuis* | Path rush | N | F | P | 0 | 0 | 0 | 0.017 | 0.017 | 2 |
| *Aster lateriflorus* | Calico aster | N | F | P | 0 | 0 | 0 | P | 0 | 2 |
| *Cornus stolonifera* | Red osier dogwood | N | F | P | P | 0 | 1 | P | 0 | 2 |
| *Juncus Dudleyi* | Rush | N | F | P | 0.013 | 0.013 | 4 | P | 0 | 3 |
| *Solidago gigantea* | Goldenrod | N | F | P | 0 | 0 | 0 | P | 0 | 2 |
| *Solidago graminifolia* | Grass-leaved goldenrod | N | F | P | P | 0 | 1 | P | 0 | 4 |
| *Solidago* sp. | Goldenrod | N | F | P | P | 0 | 1 | P | 0 | 3 |
| *Geum lacineatum* | Avens | N | F | P | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polygonum* sp. | Smartweed | N | F | A | 1.553 | 1.409 | 4 | 0.833 | 0.456 | 5 |
| *Juncus bufonius* | Toad rush | N | F | A | 0.339 | 0.324 | 4 | 0.1 | 0.1 | 1 |
| *Potentilla norvegica* | Rough cinquefoil | N | F | A | 0 | 0 | 0 | 0.033 | 0.033 | 1 |
| *Cyperus erythrorhizos* | | N | F | A | 0 | 0 | 0 | P | 0 | 3 |
| *Panicum capillare* | Witch grass | N | F | A | 0.013 | 0.013 | 6 | P | 0 | 5 |

| SPECIES | COMMON NAME | Nat. | W/F/U | A/P | 1989 Wetlands Mean Cover | 1989 Wetlands SE | 1989 Wetlands No. Wet. | 1988 Wetlands Mean Cover | 1988 Wetlands SE | 1988 Wetlands No. Wet. |
|---|---|---|---|---|---|---|---|---|---|---|
| *Polygonum pensylvanicum* | Pinkweed | N | F | A | 0.018 | 0.018 | 1 | 0 | 0 | 0 |
| *Potentilla* sp. | Cinquefoil | N | F | A | 0 | 0 | 0 | 0 | 0 | 0 |
| *Veronica peregrina* | Purslane speedwell | N | F | A | 0.173 | 0.119 | 4 | 0 | 0 | 0 |
| *Juncus interior* | Rush | N | U | P | P | 0 | 1 | 0.117 | 0.098 | 2 |
| *Asclepias syriaca* | Milkweed | N | U | P | 0 | 0 | 0 | P | 0 | 1 |
| *Aster ericoides* | Heath aster | N | U | P | 0 | 0 | 0 | P | 0 | 2 |
| *Aster laevis* | Smooth aster | N | U | P | P | 0 | 1 | P | 0 | 2 |
| *Elaeagnus commutata* | Silverberry | N | U | P | 0 | 0 | 0 | P | 0 | 1 |
| *Fragaria virginiana* | Wild strawberry | N | U | P | 0 | 0 | 0 | P | 0 | 2 |
| *Polygonum aviculare* | Knotweed | N | U | P | 0.017 | 0.017 | 2 | P | 0 | 1 |
| *Ambrosia artemisiifolia* | Common ragweed | N | U | A | 0.102 | 0.045 | 6 | 0.233 | 0.105 | 4 |
| *Erigeron* sp. | Fleabane | N | U | A | 0 | 0 | 0 | 0.017 | 0.017 | 2 |
| *Erigeron strigosus* | Fleabane | N | U | A | 0 | 0 | 0 | 0.017 | 0.017 | 1 |
| *Acalypha rhomboidea* | Three-seeded mercury | N | U | A | 0 | 0 | 0 | P | 0 | 1 |
| *Erigeron annuus* | Daisy fleabane | N | U | A | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phalaris arundinacea* | Reed canary grass | I | W | P | P | 0 | 1 | 0.117 | 0.098 | 3 |
| *Lythrum salicaria* | Purple loosestrife | I | W | P | 0 | 0 | 0 | P | 0 | 1 |
| *Bidens tripartita* | Sticktight | I | W | A | 0.076 | 0.076 | 2 | 0.317 | 0.194 | 3 |
| *Gnaphalium uliginosum* | Low cudweed | I | W | A | 0.018 | 0.018 | 1 | 0 | 0 | 0 |
| *Polygonum hydropiper* | Water-pepper | I | W | A | P | 0 | 1 | 0 | 0 | 0 |
| *Rumex crispus* | Curly dock | I | F | P | 0.633 | 0.483 | 5 | 1.1 | 0.947 | 5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Cerastium fontanum* | Mouse-ear chickweed | I | F | P | 0 | 0 | 0 | 0.017 | 0.017 | 1 |
| *Festuca pratensis* | Meadow fescue | I | F | P | 0 | 0 | 0 | P | 0 | 1 |
| *Solanum dulcamara* | Nightshade | I | F | P | 0 | 0 | 0 | P | 0 | 1 |
| *Polygonum persicaria* | Lady's thumb | I | F | A | 1.056 | 0.368 | 6 | 1.133 | 0.822 | 5 |
| *Daucus carota* | Queen Anne's lace | I | U | P | P | 0 | 2 | 1.017 | 0.63 | 2 |
| *Arctium minus* | Common burdock | I | U | P | P | 0 | 2 | P | 0 | 1 |
| *Agropyron repens* | Quackgrass | I | U | P | 16.91 | 5.407 | 6 | 16.45 | 6.767 | 6 |
| *Taraxacum officinale* | Dandelion | I | U | P | 1.203 | 1.037 | 4 | 3.633 | 1.016 | 6 |
| *Phleum pratense* | Timothy | I | U | P | 0.741 | 0.257 | 4 | 3.15 | 1.504 | 5 |
| *Grass #1* | | I | U | P | 3.963 | 2.058 | 5 | 2.133 | 1.633 | 3 |
| *Bromus inermis* | Brome grass | I | U | P | P | 0 | 1 | 1.183 | 0.762 | 5 |
| *Trifolium hybridum* | Alsike clover | I | U | P | 0.764 | 0.224 | 4 | 0.583 | 0.358 | 6 |
| *Trifolium repens* | White clover | I | U | P | 0.208 | 0.187 | 3 | 0.15 | 0.115 | 4 |
| *Cirsium arvense* | Canada thistle | I | U | P | 0 | 0 | 0 | 0.017 | 0.017 | 1 |
| *Aster pilosus* | Frost aster | I | U | P | 0 | 0 | 0 | P | 0 | 1 |
| *Cichorium Intybus* | Chickory | I | U | P | P | 0 | 1 | P | 0 | 2 |
| *Medicago sativa* | Alfalfa | I | U | P | P | 0 | 5 | P | 0 | 3 |
| *Poa* sp. | Grass | I | U | P | 0 | 0 | 0 | P | 0 | 1 |
| *Achillea millefolium* | Common yarrow | I | U | P | 0.051 | 0.023 | 3 | 0 | 0 | 0 |
| *Lotus corniculata* | Birdsfoot-trefoil | I | U | P | P | 0 | 1 | 0 | 0 | 0 |
| *Trifolium* sp. | Clover | I | U | P | 0.042 | 0.027 | 5 | 0 | 0.3 | 0 |
| *Plantago major* | Common plantain | I | U | A | 2.147 | 1.46 | 6 | 0.417 | 0.199 | 5 |
| *Amaranthus retroflexus* | Pigweed | I | U | A | P | 0 | 1 | P | 0 | 1 |
| *Chenopodium album* | Lamb's quarters | I | U | A | 0.038 | 0.038 | 1 | P | 0 | 1 |
| *Echinochloa crusgalli* | Barnyard grass | I | U | A | 0.152 | 0.152 | 6 | P | 0 | 4 |

| SPECIES | COMMON NAME | Nat. | W/F/U | A/P | 1989 Wetlands Mean Cover | SE | No. Wet. | 1988 Wetlands Mean Cover | SE | No. Wet. |
|---|---|---|---|---|---|---|---|---|---|---|
| *Melilotus officinalis* | White sweet-clover | I | U | A | 0.138 | 0.104 | 3 | P | 0 | 2 |
| *Polygonum dubium* | Smartweed | I | U | A | 0 | 0 | 0 | P | 0 | 2 |
| *Setaria glauca* | Yellow foxtail | I | U | A | P | 0 | 6 | P | 0 | 4 |
| *Abutilon theophrasti* | Velvet-leaf | I | U | A | P | 0 | 1 | 0 | 0 | 0 |
| *Capsella bursa-pastoris* | Shepherd's purse | I | U | A | 0.013 | 0.013 | 1 | 0 | 0 | 0 |
| *Hordeum jubatum* | Squirrel tail grass | I | U | A | P | 0 | 1 | 0 | 0 | 0 |
| *Polygonum convolvulus* | Black bindweed | I | U | A | 0 | 0 | 0 | 0 | 0 | 0 |
| *Solanum nigrum* | Black nightshade | I | U | A | 0.013 | 0.013 | 1 | 0 | 0 | 0 |
| *Sonchus asper* | Sow thistle | I | U | A | P | 0 | 1 | 0 | 0 | 0 |
| *Grass unknown* | | I | U | P | P | 0 | 4 | 0.133 | 0.095 | 2 |
| *Rumex* sp. | Dock | I | U | P | 0.017 | 0.017 | 2 | P | 0 | 1 |
| *Cirsium* sp. | Thistle | I | U | P | 0.418 | 0.193 | 6 | P | 0 | 2 |
| Total cover | | | | | 35.15 | | | 68.6 | | |
| Total Number of Species | | | | | | | 78 | | | 98 |

Table 3. Summary of quantitative vegetation description in twelve restored Ozaukee County wetlands. Summary statistics presented are: number of species found in quadrats; Shannon-Weaver diversity index, D; species richness, R; species evenness, E; the percent of species which are native; the percent of species which are wetland or facultative wetland plants; the percent of species which are annuals; and the mean total cover for each wetland. Means and standard errors of means for 1988 and 1989 wetlands are also presented. Statistics were calculated for all species and for native species only.

| Wetland # | Year Estab. | # of Species | D | R | E | % Native | % Wet. | % Ann. | Total Cover |
|---|---|---|---|---|---|---|---|---|---|
| All species | | | | | | | | | |
| 7 | 89 | 31 | 1.91 | 7.48 | 0.557 | 53 | 30 | 53 | 55.1 |
| 8 | 89 | 13 | 1.89 | 4.08 | 0.737 | 25 | 8 | 42 | 19.0 |
| 9 | 89 | 16 | 1.10 | 4.30 | 0.395 | 36 | 29 | 43 | 32.7 |
| 10 | 89 | 17 | 1.94 | 5.71 | 0.683 | 53 | 33 | 47 | 16.5 |
| 11 | 89 | 25 | 2.20 | 6.31 | 0.685 | 52 | 39 | 57 | 44.9 |
| 12 | 89 | 5 | 0.70 | 1.07 | 0.434 | 60 | 60 | 0 | 42.7 |
| Mean | | 17.8 | 1.62 | 4.82 | 0.582 | 45.7 | 33.2 | 40.3 | 35.2 |
| SE | | 3.40 | 0.219 | 0.834 | 0.053 | 5.53 | 6.27 | 7.67 | 5.69 |
| 1 | 88 | 24 | 2.09 | 5.28 | 0.659 | 52 | 39 | 35 | 78.2 |
| 2 | 88 | 27 | 2.24 | 6.03 | 0.679 | 64 | 52 | 32 | 74.7 |
| 3 | 88 | 24 | 2.28 | 5.36 | 0.717 | 67 | 63 | 33 | 72.8 |
| 4 | 88 | 24 | 2.04 | 5.28 | 0.641 | 65 | 52 | 30 | 78.0 |
| 5 | 88 | 21 | 1.96 | 5.28 | 0.644 | 47 | 37 | 21 | 44.3 |
| 6 | 88 | 12 | 0.98 | 2.63 | 0.396 | 50 | 50 | 30 | 65.4 |
| Mean | | 22.0 | 1.93 | 4.98 | 0.622 | 58.0 | 48.8 | 30.2 | 68.0 |
| SE | | 1.96 | 0.179 | 0.442 | 0.043 | 3.17 | 3.57 | 1.82 | 4.82 |
| Native species only | | | | | | | | | |
| 7 | 89 | 17 | 1.86 | 7.55 | 0.658 | | 50 | 44 | 8.3 |
| 8 | 89 | 3 | 1.04 | 2.18 | 0.946 | | 33 | 33 | 0.4 |
| 9 | 89 | 5 | 0.75 | 3.54 | 0.465 | | 80 | 40 | 3.1 |
| 10 | 89 | 9 | 1.87 | 9.14 | 0.851 | | 63 | 38 | 2.4 |
| 11 | 89 | 13 | 1.67 | 4.07 | 0.650 | | 66 | 58 | 19.0 |
| 12 | 89 | 3 | 0.94 | 1.09 | 0.859 | | 100 | 0 | 6.2 |
| Mean | | 8.33 | 1.36 | 3.87 | 0.738 | | 65.3 | 35.5 | 6.58 |
| SE | | 2.14 | 0.187 | 1.54 | 0.067 | | 8.67 | 7.21 | 2.50 |
| 1 | 88 | 13 | 1.25 | 3.20 | 0.487 | | 58 | 25 | 42.7 |
| 2 | 88 | 17 | 1.78 | 4.19 | 0.628 | | 69 | 25 | 45.4 |
| 3 | 88 | 16 | 1.69 | 3.81 | 0.611 | | 88 | 25 | 51.2 |
| 4 | 88 | 16 | 1.27 | 3.90 | 0.459 | | 80 | 27 | 47.0 |
| 5 | 88 | 10 | 1.04 | 2.74 | 0.451 | | 78 | 11 | 26.7 |
| 6 | 88 | 6 | 0.55 | 2.25 | 0.306 | | 100 | 40 | 9.2 |
| Mean | | 13.0 | 1.26 | 3.35 | 0.490 | | 78.8 | 25.5 | 37.0 |
| SE | | 1.60 | 0.168 | 0.280 | 0.044 | | 5.44 | 3.43 | 5.97 |

Table 4. Comparison of summary statistics for 1988 and 1989 wetlands. Quadrat data present summary statistics only for those species found in quadrats. Flora data present summary statistics for all species present in the wetlands regardless of whether they were found in quadrats. F statistics are from a one-way analysis of covariance with wetland perimeter length as a covariate (see text). Degrees of freedom = [1, 9].

| Quadrats | All Species | | | | Native Species Only | | | |
|---|---|---|---|---|---|---|---|---|
| | 1989 Mean | 1988 Mean | F | P | 1989 Mean | 1988 Mean | F | P |
| # of Species | 17.8 | 22.0 | 2.63 | ns | 8.33 | 13.0 | 5.66 | * |
| Diversity | 1.62 | 1.93 | 1.21 | ns | 1.36 | 1.26 | 0.02 | ns |
| Richness | 4.82 | 4.98 | 0.21 | ns | 3.87 | 3.35 | 0.01 | ns |
| Evenness | 0.582 | 0.622 | 0.26 | ns | 0.738 | 0.490 | 8.11 | * |
| % Native | 45.7 | 58.0 | 3.57 | <0.1 | – | – | – | – |
| % Wetland | 33.2 | 48.8 | 3.48 | <0.1 | 65.3 | 78.8 | 1.12 | ns |
| % Annual | 40.3 | 30.2 | 1.05 | ns | 35.5 | 25.5 | 0.97 | ns |
| Total Cover | 35.2 | 68.9 | 26.55 | *** | 6.58 | 37.0 | 16.83** | |
| Flora | | | | | | | | |
| # of Species | 39.0 | 43.8 | 5.88 | * | | | | |
| # Native | 21.7 | 28.5 | 7.07 | * | | | | |
| % Native | 55.9 | 64.6 | 3.86 | <0.1 | | | | |
| # Wetland | 25.2 | 29.8 | 5.57 | * | | | | |
| % Wetland | 65.1 | 67.9 | 0.68 | ns | | | | |
| # Perennial | 23.3 | 30.3 | 10.75 | ** | | | | |
| %t Perennial | 59.6 | 69.0 | 18.88 | ** | | | | |
| # Native & Wetland | 20.0 | 25.3 | 4.87 | <0.1 | | | | |
| % Native & Wetland | 51.7 | 57.4 | 1.49 | ns | | | | |

ns, $P > 0.1$
*, $0.01 < P < 0.05$
**, $0.001 < P < 0.01$
***, $P < 0.001$

Created wetlands are particularly susceptible to invasion by exotic species making monitoring for these species critical. While we did not find high cover values for aggressive, non-native, wetland species in any of the studied wetlands, we recommend an early monitoring program with removal of certain undesirable species. We found isolated plants of purple loosestrife (*Lythrum salicaria*) in one of the twelve studied wetlands. These plants should be removed before they are allowed to set seed especially during this early phase of wetland vegetation development. We also recommend the monitoring and removal of reed canary grass (*Phalaris arundinacea*) which we found at low densities in four of the studied wetlands. Although these species are now at low, easy to eradicate, densities, either of them could destroy much of the wildlife and vegetation diversity values of the wetlands in which they are found.

It is interesting, although perhaps not surprising, that the early flora of wetlands is quite dependent on wetland size. With future monitoring of these same wetlands, we will be able to determine whether this early effect of size diminishes over time as more species colonize the smaller wetlands. The fact that evenness of plant species declined significantly from one- to two-year old wetlands suggests that overall diversity may decline rather than increase with time as the result of increased dominance by cattail.

A critical aspect of the present study will be the comparison of naturally colonized and planted wetlands over time. Will the intentional early dispersal of a diverse native flora to newly constructed wetlands counteract some of the inhibition competition tendencies of cattail? This may be particularly important since as isolated marshes supplied predominantly by surface water and having no mechanisms to manage water supply, these wetlands are likely to experience large fluctuations in water level over the long–term. Vegetation diversity leads to stability and persistence of wetland communities over a wide range of hydrologic dynamics (Willard and Hiller, 1990). A resilience of vegetation develops due to a dynamic balancing of types as mean water levels change through wet and dry years. During high water periods cattails may move more toward the wetland margins. During dry periods cattails would regress back toward the wetland center. In a diverse wetland community other native species would be available to fill the gaps caused by the dynamic movements of the vegetation with water levels.

In 1991 we will continue to monitor the 12 wetlands already described. We will also establish permanent transects in five, 1990 wetlands which we seeded with native species. At least five more naturally colonized 1990 wetlands will also be chosen to include in our study.

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## Literature Cited


Erwin, K.L. 1990. Freshwater marsh creation and restoration in the Southeast. In: Kusler, J.A. and M.E. Kentula, eds. 1990. Wetland Creation and Restoration, the Status of the Science. Island Press, Washington, D.C.

Fernald, M. 1970. Gray's Manual of Botany, 8th ed. D. Van Nostrand, New York. 1632 pp.

Kusler, J.A. and M.E. Kentula, Editors. 1990a. Wetland Creation and Restoration, the Status of the Science. Island Press, Washington, D.C.

Kusler, J.A. and M.E. Kentula. 1990b. Executive summary. In: Kusler, J.A. and M.E. Kentula, eds. 1990. Wetland Creation and Restoration, the Status of the Science. Island Press, Washington, D.C.

Levine, D.A. and D.E. Willard. 1990. Regional analysis of fringe wetlands in the Midwest: creation and restoration. In: Kusler, J.A. and M.E. Kentula, eds. 1990. Wetland Creation and Restoration, the Status of the Science. Island Press, Washington, D.C.

Odum, W.E. 1988. Predicting ecosystem development following creation and restoration of wetlands, p. 67-70. In: Zelazny, J. and J.S. Feierabend, eds. 1988. Increasing Our Wetland Resources, National Wildlife FederationConference Proceedings. Washington, D.C.

Pielou, E.C. 1969. An Introduction to Mathematical Ecology. Wiley-Interscience, New York. 286 pp.

Tiner, R.W., Jr. 1984. Wetlands of the United States: Current Status and Recent Trends. U.S. Fish and Wildlife Service, National Wetland Inventory. Washington D.C.

Voss, E.G. 1972. Michigan Flora. Part I. Gymnosperms and monocots. Cranbrook Institute of Sciences, Bloomfield Hills, Michigan. 488 pp.

Voss, E.G. 1985. Michigan Flora. Part II. Dicots (*Saururaceae-Cornaceae*). Cranbrook Institute of Sciences, Bloomfield Hills, Michigan. 724 pp.

Willard, D.E. and A.K. Hiller. 1990. Wetland dynamics: considerations for restored and created wetlands. In: Kusler, J.A. and M.E. Kentula, eds. 1990. Wetland Creation and Restoration, the Status of the Science. Island Press, Washington, D.C.