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FLORAL AND FAUNAL COLONIZATION OF RESTORED WETLANDS IN WEST-CENTRAL MINNESOTA AND NORTHEASTERN SOUTH DAKOTA

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ABSTRACT

Drastic declines of the North American waterfowl population, duration and extent of drought conditions, provisions of the USDA's Food Security Act of 1985 (P.L. 99-198) and the implementation of the North American Waterfowl Management Plan (USFWS-CWS, 1986) made wetland restoration a priority for natural resource managers. A paucity of knowledge exists about the temporal capability of restored basins to attain attributes comparable to natural wetlands. The objective of this study was to determine trends in species abundance and richness of waterfowl, aquatic macroinvertebrates, fishes and hydrophytes in restored wetlands of differing ages since restoration. One hundred fifty-six restored seasonal and semi-permanent basins of 12 different ages were surveyed in 3 counties of northeast South Dakota and 6 counties of west-central Minnesota. A large diversity of flora and fauna colonized wetlands as early as one year after restoration. Twelve species of waterfowl were observed in all age classes of the restored basins. Thirty-one taxa of macroinvertebrates occurred in restored basins, 12 of which were in age class 1 basins. Four fish species inhibited restored basins of all ages. An average of over 16 taxa of aquatic hydrophytes had coverage values of $\geq$ 5% of the total wetland area in restored basins. This study demonstrated that wetland managers can expect extensive floral and faunal colonization of prairie wetlands even in the first year after restoration.

INTRODUCTION

Extensive drainage of prairie wetlands for agricultural and cultural developments has reduced wetland acreage from the original 9 million to 3 million acres in the Dakotas, and from 18.5 to 9 million acres in Minnesota. In this region, an estimated 33,000 acres are drained annually by open ditching, tiling, or a combination of both.

Since the 1930's, several types of acquisition, easements, or leases of wetlands have been used by various public and private agencies to curtail the amount and rate of drainage and loss. Even though these types

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of preservation were very successful in the 1960's and in much of the 1970's, their popularity waned during the late 1970's and during all of the 1980's because of economic fluxes in the farm economy, political bottlenecks, and lack of funds.

Despite all of the preservation efforts in the last 60 years, over 50% of the original wetlands in the prairie pothole region of the U.S. have been lost, mainly (87%) to agriculture and development (Tiner, 1984). This also means that over 50% of the original wetland basins in the prairie pothole region are available for restoration. Madsen (1986) stated, "Any drained wetland can be restored to its former splendor simply by removing the drain tile or plugging the ditch that carries the water from the basin." Wetland managers have shared this belief for many years and are convinced that wildlife use and production on restored wetlands are nearly as good as on naturally occurring wetlands. Results of one study (LaGrange & Dinsmore, 1989) in Story County, Iowa, lend support to this belief. However, there is a great lack of knowledge about the ability of drained prairie wetlands to regain complete biotic functions and values after restoration.

The floral response in restored prairie wetlands has always been visually apparent soon after basin inundation. Floristic response has been most apparent where remnant flora have persisted, but even in wetlands where agricultural practices have occurred for many years, the floristic response to restoration efforts has been more than encouraging (National Research Council, 1982; Dahl & Nomsen, 1987; Erlandson, 1987). For example, Dahl and Nomsen (1987) found 36 species of wetland plants in the seed bank of a wetland in Otter Tail County, Minnesota, that had been drained and farmed for over 30 years. In another study that also included Otter Tail County, Minnesota, Erlandson (1987) found a general decrease in diversity of vegetation with time since drainage when combining seed bank and standing vegetation surveys and noted that the greatest loss of species occurred during the first 5-10 years after drainage. Her results also showed that this temporal decrease in seed-bank diversity was similar in drained wetlands in Iowa, North Dakota, and Minnesota.

The faunal response, particularly that of aquatic invertebrates, to restore prairie wetlands, has received much less attention by scientists than the floral response. Waterfowl and furbearers will almost instantly make use of any wetland basin, natural or restored, as long as it has a suitable supply of water. However, information about how soon after restoration aquatic invertebrates colonize a basin is lacking.

The purpose of this study was to determine trends in species abundance and richness of waterfowl, aquatic macroinvertebrates, fishes, and emergent hydrophytes in a sample of prairie wetlands of differing age since restoration. The management implications of understanding the temporal response of flora and fauna to wetland restoration has possible application to millions of potentially restorable wetland basins in mid-continent America.

STUDY SITE

Data were collected on biota in 156 seasonal and semi-permanent wetland basins (Stewart & Kantrud, 1971) of 12 post-restoration ages in 6 counties of west-central Minnesota (MN) and 3 counties in northeastern South Dakota (SD). Seventy-two wetlands were surveyed in 1986 and 84 in 1987. The primary criteria for basin selection were: 1) each basin must have been drained by tile or open ditch or both for 6 years or longer, 2) drained basins must have been used annually or nearly so for agricultural land use practices while drained, and 3) basins must have been inundated, at least seasonally, during each year since restoration. Criteria were verified with information from U.S. Fish and Wildlife Service (USFWS) records, aerial photo interpretation, National Wetland Inventory maps, personal communication with landowners and USFWS employees, and files at the Waubay National Wildlife Refuge, Waubay, SD, and the Fergus Falls Wetland Management District, Fergus Falls, MN. Information was also collaborated with field observations during visits to each wetland.

Generally, the study wetlands had been restored for more years in South Dakota than in Minnesota. However, efforts were made to select wetlands of similar classification, size, and appearance between both geographic regions.

MATERIALS AND METHODS

Waterfowl

Pair counts, following criteria by Hammond (1969), were conducted between the hours of one-half hour after sunrise and one-half hour before sunset. A total species count and a count of indicated pairs were made for each wetland. One count was conducted in 1986, beginning in mid-June, and two counts in 1987, beginning in mid-May and early June.

Aquatic Macroinvertebrates

Invertebrate sampling was restricted to wetlands that had been restored for 7 years or fewer years. Macroinvertebrates were sampled with activity traps as described by Swanson (1978). Two activity traps were anchored horizontally at an average depth of 30 cm in the littoral zone of selected wetlands. Effort was made to select wetlands of similar classification (Stewart & Kantrud, 1971) and residual vegetation patterns. Additionally, trap sites in a wetland were selected upon visually similar residual vegetation. Samples were collected every 24 hours for 3 consecutive days (Murkin et al., 1983). As a consequence of a late start, we only sampled during July in 1986. In 1987, we sampled in late May and again in early July. Invertebrate samples were poured and washed through a sieve with 0.5 mm apertures, after which plant material and detritus were discarded and vertebrates such as fishes, salamanders, and frogs were identified, enumerated, and returned to the wetland. The remaining sample of macroinvertebrates was then preserved in a 70% ethyl alcohol-rose

bengal solution for later identification and enumeration in the laboratory. Invertebrates were identified and classified to familial or ordinal levels according to Pennak (1978) and Merritt and Cummins (1978).

Fishes and Salamanders

Metal cylindrical-type minnow traps with funnel-throat openings in each end were used to collect fishes and salamanders in sample wetlands. Two minnow traps, baited with dry dog food, were placed in each wetland and checked every 24 hours for 3 consecutive days.

Hydrophytes

Visual estimates of percent cover and composition of emergent vegetation on each study wetland were made during July and August of each year with the Releve[1] method (Mueller-Dombois & Ellenberg, 1974), i.e., each basin was treated as a single plot. Only species that represented 5% or more coverage of the basin area were recorded. Each wetland was considered an entire plot and only vegetation in standing water or on exposed substrate was included in the surveys. Plant nomenclature follows The Great Plains Flora Association (1986).

RESULTS

Waterfowl Pair Estimates

An average of 1.5 pairs was counted on 144 wetlands totaling 186.9 ha during 1986-1987 (Table 1). Mean pair density per count was 11 pairs/100 ha. The 12 age groups of restored wetlands had mean pair densities of between 0.01 and 0.33 pairs/ha/count.

Overall, 224 pairs of 12 duck and 1 goose species were counted on 144 wetlands during 1986-1987 (Table 2). Blue-winged teal (scientific names appear in tables) occurred most frequently and averaged 59.0% of the population; the next most frequent species were mallards (13.6%) and redheads (7.9%). Together, these 3 species comprised 80.5% of the waterfowl pair composition.

Only blue-winged teal occupied some wetlands in each of the 12 restored wetland age groups (Table 3). And of the 12 species of waterfowl, only blue-winged teal and mallards were seen on more than 4 of the 12 age group wetlands. Except for blue-winged teal, occupancy rates averaged <25% for all years; however, this is somewhat expected, particularly for Minnesota, because of the low densities of about 12 pairs/km^2 (about 30 pairs/mi^2) of waterfowl during the nesting season (Moyle, 1964).

Table 1. Mean number of density (total of 3 counts) of waterfowl on restored wetlands of 12 different age classes in 1986 and 1987.

Restoration Age in Years	Number of Wetlands	Mean Pairs/ Wetland	Species/ Wetland	Total Wetlands Area (ha)	Mean Pairs/ha
1	12	1.6	5	44.9	0.04
2	14	1.6	6	18.3	0.09
3	13	0.5	4	12.4	0.04
4	13	0.9	3	14.7	0.06
5	9	0.4	2	8.7	0.05
6	13	0.4	7	16.7	0.02
7	12	2.8	3	18.4	0.15
8	12	2.2	2	17.8	0.12
9-10	11	1.1	2	6.4	0.17
11-13	10	0.1	2	7.4	0.01
16-20	12	4.1	8	12.5	0.33
23-24	13	2.3	7	8.7	0.26
Totals	144			186.9	1.30
Means		1.5	4.3	15.6	0.11

Aquatic Invertebrates

Twenty-seven different invertebrate taxa were identified from 216 activity trap samples taken during an early June sampling period in 1987 (Table 4) and 31 different taxa from 468 trap samples taken during later sampling periods of late June and July 1986-1987 (Table 5).

During the early sampling period (June 1987), mean macroinvertebrates per liter generally increased from 25.8 in basin age class 1 to 113.8 in basin age class 6 (Table 4). Water boatmen (Corixidae) and predacious diving beetles (Dystiscidae) were the most abundant macroinvertebrates and averaged 10.6/L and 9.2/L per collection. Other taxa that averaged more than 2 per liter per sample were scuds (Amphipoda), pond snails (Lymaeidae), and phantom midges (Chaoboridae) (Table 4). All other taxa averaged less than 2/L/sample. Sixteen of the 27 taxa in the early sampling period occurred in age class 1 basins (Table 4) and averaged 7.5 taxa per liter per pond per collection (Table 6).

During the later sampling period (July 1986-1987), the number of taxa/L increased in age 1 and 2 basins (Table 6), but decreased in diversity in older restored wetlands. The mean number of macroinvertebrates per/L was least in pond age class 1 (11.0) and greatest (44.1) in pond age class 5 (Table 5). The most abundant macroinvertebrates were damsel flies (Lestidae) and aquatic earthworm

Table 2. Percent species composition and number of breeding waterfowl pairs counted (mean of 3 counts in 1986 and 1987) on restored wetlands by length of restoration (age).

	Restored 1 Year (n=12) No. (%)	Restored 2 Years (n=14) No. (%)	Restored 3 Years (n=13) No. (%)	Restored 4 Years (n=13) No. (%)	Restored 5 Years (n=9) No. (%)	Restored 6 Years (n=13) No. (%)
Blue-winged Teal (*Anas discors*)	9 (47.4)	15 (63.3)	3 (50.0	5 (55.6)	2 (50.0)	6 (19.4)
Canvasback (*Aythya valisineria*)	0	1 (4.5)	1 (16.7)	0	0	0
Canada Goose (*Branta canadensis*)	0	0	0	1 (11.1)	0	2 (6.4)
Gadwall (*Anas strepera*)	0	1 (4.5)	0	0	0	0
Green-winged Teal (*Anas crecca*)	0	0	0	0	0	0
Lesser Scaup (*Anthyini affinis*)	0	0	0	0	0	5 (16.1)
Mallard (*Anas platyrhynchos*)	4 (21.0)	2 (9.1)	1 (16.7)	3 (33.3)	2 (50.0)	5 (16.1)
Northern Pintail (*Anas acuta*)	0	0	0	0	0	0
Redhead (*Aythya mericana*)	3 (15.8)	2 (9.1)	0	0	0	7 (22.6)
Ring-necked Duck (*Aythya collaris*)	0	0	0	0	0	4 (13.0)
Ruddy Duck (*Oxyura jamaicensis*)	1 (5.3)	1 (4.5)	1 (16.6)	0	0	0
Northern Shoveler (*Anas clypeata*)	0	0	0	0	0	0
Wood Duck (*Aix sponsa*)	2 (10.5)	0	0	0	0	2 (6.4)
Totals	19	22	6	9	4	31

Table 2 (cont'd.). Percent species composition and number of breeding waterfowl pairs counted (mean of 3 counts in 1986 and 1987) on restored wetlands by length of restoration (age).

	Restored 7 Years (n=12) No. (%)	Restored 8 Years (n=12) No. (%)	Restored 9-10 Years (n=11) No. (%)	Restored 11-13 Years (n=10) No. (%)	Restored 16-20 Years (n=12) No. (%)	Restored 23-24 Years (n=13) No. (%)	Totals
Blue-winged Teal	23 (74.2)	23 (88.5)	7 (58.3)	2 (66.7)	31 (62.0)	18 (58.1)	144 (59.0)
Canvasback	0	0	0	0	0	0	2 (0.8)
Canada Goose	0	0	0	0	0	2 (6.5)	5 (2.0)
Gadwall	0	3 (11.5)	0	0	1 (2.0)	2 (6.5)	7 (2.9)
Green-winged Teal	0	0	0	0	0	0	0
Lesser Scaup	0	0	0	0	0	0	5 (2.0)
Mallard	4 (12.9)	0	5 (41.7)	0	6 (12.0)	1 (3.2)	33 (13.6)
Northern Pintail	0	0	0	1 (33.3)	1 (2.0)	1 (3.2)	3 (1.2
Redhead	0	0	0	0	5 (10.0)	2 (6.5)	19 (7.9)
Ring-necked Duck	4 (12.9)	0	0	0	1 (2.0)	0	9 (3.7)
Ruddy Duck	0	0	0	0	2 (4.0)	5 (16.1)	10 (4.1)
Northern Shoveler	0	0	0	0	3 (6.0)	0	3 (1.2)
Wood Duck	0	0	0	0	0	0	4 (1.6)
Totals	31	26	12	3	50	31	244

Table 3. Use of restored wetlands by breeding waterfowl pairs surveyed in 3 counts in 1986 and 1987 as indicated by number of pairs and percent occurrence in each age class of restoration.

Age Class	1 (n=12)	2 (n=14)	3 (n=13)	4 (n=13)	5 (n=9)	6 (n=13)
Species						
Blue-winged Teal	6	4	2	3	2	3
	50.0%	28.6%	15.4%	23.1%	22.2%	23.1%
Canvasback	0	1	1	7	0	0
	0.0%	7.1%	7.7%	53.8%	0.0%	0.0%
Canada Goose	0	0	0	1	0	2
	0.0%	0.0%	0.0%	7.7%	0.0%	15.4%
Gadwall	0	1	0	0	0	0
	0.0%	7.1%	0.0%	0.0%	0.0%	0.0%
Lesser Scaup	0	0	0	0	0	3
	0.0%	0.0%	0.0%	0.0%	0.0%	23.1%
Mallard	2	1	1	3	2	4
	16.7%	7.1%	7.7%	23.1%	22.2%	30.8%
Northern Pintail	0	0	0	0	0	0
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Redhead	1	2	0	0	0	1
	8.3%	14.3%	0.0%	0.0%	0.0%	7.7%
Ring-necked Duck	0	0	0	0	0	2
	0.0%	0.0%	0.0%	0.0%	0.0%	15.4%
Ruddy Duck	0	1	1	0	0	0
	0.0%	7.1%	7.7%	0.0%	0.0%	0.0%
Northern Shoveler	0	0	0	0	0	0
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Wood Duck	2	0	0	1	0	1
	16.7%	0.0%	0.0%	7.7%	0.0%	7.7%

Table 3 (cont'd). Use of restored wetlands by breeding waterfowl pairs surveyed in 3 counts in 1986 and 1987 as indicated by number of pairs and percent occurrence in each age class of restoration.

Age Class	7 (n=12)	8 (n=12)	9-10 (n=11)	11-13 (n=10)	16-20 (n=12)	23-24 (n=13)	Total
Species							
Blue-winged Teal	5	4	6	2	8	11	56
	41.7%	33.3%	54.5%	18.2%	66.7%	84.6%	38.9%
Canvasback	0	0	0	0	0	0	9
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.3%
Canada Goose	0	0	0	0	0	2	5
	0.0%	0.0%	0.0%	0.0%	0.0%	15.4%	3.5%
Gadwall	0	3	0	0	1	2	7
	0.0%	25.0%	0.0%	0.0%	8.3%	15.4%	4.9%
Lesser Scaup	0	0	0	0	0	0	3
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.1%
Mallard	3	0	1	0	4	1	22
	25.0%	0.0%	9.1%	0.0%	33.3%	7.7%	15.3%
Northern Pintail	0	0	0	1	1	1	3
	0.0%	0.0%	0.0%	9.1%	8.3%	7.7%	2.1%
Redhead	0	0	0	0	3	1	8
	0.0%	0.0%	0.0%	0.0%	25.0%	7.7%	5.6%
Ring-necked Duck	1	0	0	1	1	0	5
	8.3%	0.0%	0.0%	9.1%	8.3%	0.0%	3.5%
Ruddy Duck	0	0	0	0	1	2	5
	0.0%	0.0%	0.0%	0.0%	8.3%	15.4%	3.5%
Northern Shoveler	0	0	0	0	1	0	1
	0.0%	0.0%	0.0%	0.0%	8.3%	0.0%	0.7%
Wood Duck	0	0	0	0	0	0	4
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.8%

Table 4. Mean numbers of macroinvertebrates ($\bar{x}$/L) sampled with activity traps in restored wetlands between June 1 and June 15, 1987, by wetland age class.

Taxa	Age 1 (n=36)	Age 2 (n=36)	Age 3 (n=36)	Age 4 (n=36)	Age 5 (n=36)	Age 6 (n=36)	Average
Pleidae (pigmy backswimmers)	0	0	0	0.1	2.4	3.4	1.0
Amphipoda (scuds)	tr*	0.3	10.7	7.5	10.2	12.1	6.8
Haliplidae (crawling water beetles)	1.47	2.6	0.6	2	9.1	5.9	3.6
Chironomidae (midges)	0.66	0.2	2.5	0.2	0	0.1	0.6
Ceratopogonidae (biting midges)	0	0	0	0	0.1	0	0.0
Eropobdellidae (leeches)	1.2	0	1.5	0.7	0.1	5	1.4
Corixidae (water boatmen)	3.3	0.4	6.4	3.2	12.11	38	10.6
Dytiscidae (predaceous diving beetles)	5.4	10.5	7.4	7	8.2	16.7	9.2
Oligochaeta (aquatic earthworms)	1.3	1.4	0.6	2.6	1.7	1.1	1.5
Acari (mites and ticks)	0	0	0	0	0	0	0.0
Physidae (pouch snails)	2.3	0	0.1	0.1	0.3	0.4	0.5
Caenidae (mayfly)	0	0	0	0	0	0.1	0.0
Hydridae (hydras)	0	0	0	0	3.2	1	0.7
Lymnaeidae (pond snails)	3.4	2.4	3.6	1	3.7	12.9	4.5
Libellulidae (common skimmers)	0.3	0.1	0.3	1.7	1.1	0.9	0.7
Glassiphoniidae (leeches)	0.5	14.5	4.6	4	1.3	4.3	4.9
Chaoboridae (phantom midges)	2.2	0	2.8	2.6	1.1	7	2.6
Belostomatidae (giant water bugs)	0.1	0.6	0	0	0.1	0	0.1
Lestidae (damsel fly)	1.6	1.2	1.6	2	0.6	2	1.5
Stratiomyidae (soldier fly)	0	0	0.2	0	0	0	0.0
Coenagrionidae (damsel fly)	0	0	0.1	0	0.3	0.3	0.1
Saldidae (shore bugs)	0	0	0	0	0	0	0.0
Gyrinidae (whirlgig beetles)	0.1	0.3	0.3	1.1	1.2	0.6	0.6
Trichoptera (caddis fly)	0	0	0	0.1	0	0	0.0
Nepidae (water scorpion)	0	0	0.1	0	0	0	0.0
Hydrophilidae (water scavenger beetles)	0	0	0	0	0	0	0.0
Spaeriidae (bivalve clams)	0	0	0	0	tr*	0	0.0
Veliidae (broad shouldered water striders)	0	0	0	0	tr*	0	0.0
Muscidae (house, face and stable flies)	0	0	0	0	0	0	0.0
Conchostraca (clam shrimps)	0	0	0	0	0	0	0.0
Mesoveliidae (water treaders)	2	2	0.9	0.4	2	2	1.6
Totals	25.83	36.5	44.3	36.3	58.81	113.8	52.6

*tr = trace

Table 5. Mean numbers of macroinvertebrates ($\bar{x}$/L) sampled with activity traps in restored wetlands between June 30 and July 20 in 1986 and 1987 by wetland age class.

Taxa	Age 1 (n=72)	Age 2 (n=72)	Age 3 (n=72)	Age 4 (n=72)	Age 5 (n=72)	Age 6 (n=72)	Age 7 (n=72)	Average
Pleidae (pigmy backswimmers)	0.1	0.6	3.1	1.0	1.2	0.5	0.1	0.9
Amphipoda (scuds)	0.0	0.5	2.8	0.2	1.0	2.8	1.1	1.2
Haliplidae (crawling water beetles)	0.0	1.3	2.8	0.5	0.7	0.4	0.8	0.9
Chironomidae (midges)	3.4	2.8	3.5	2.5	2.6	1.4	0.3	2.4
Ceratopogonidae (biting midges)	0.1	0.6	0.8	1.8	0.5	0.6	0.3	0.7
Eropobdellidae (leeches)	0.1	3.2	2.3	1.9	2.3	3.1	0.6	1.9
Corixidae (water boatmen)	0.0	1.6	0.8	0.3	0.3	0.5	0.1	0.5
Dytiscidae (predaceous diving beetles)	0.0	0.4	1.1	0.1	0.2	0.2	1.5	0.5
Oligochaeta (aquatic earthworms)	0.8	7.4	6.9	1.0	1.1	8.0	5.2	4.3
Acari (mites and ticks)	1.1	4.5	4.8	4.4	3.4	1.5	2.1	3.1
Physidae (pouch snails)	0.0	0.5	tr*	0.3	0.2	0.1	tr*	0.2
Caenidae (mayfly)	0.0	4.9	0.2	0.5	0.4	1.3	0.4	1.1
Hydridae (hydras)	0.0	0.3	tr*	0.0	tr*	0.0	0.0	0.0
Lymnaeidae (pond snails)	0.0	0.9	0.6	4.8	5.3	3.8	1.3	2.4
Libellulidae (dragonfly)	0.0	1.1	0.3	tr*	2.5	0.1	0.4	0.6
Glassiphoniidae (leeches)	0.3	0.4	1.3	4.7	3.9	2.8	0.9	2.0
Chaoboridae (phantom midges)	0.7	0.7	0.2	1.6	2.8	1.3	1.2	1.2
Belostomatidae (giant water bugs)	0.0	0.0	1.8	0.8	3.0	0.9	2.3	1.3
Lestidae (damsel fly)	3.3	3.3	9.3	1.9	9.8	2.3	4.9	5.0
Stratiomyidae (soldier fly)	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.1
Coenagrionidae (damsel fly)	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1
Saldidae (shore bugs)	0.0	0.0	0.0	0.6	0.2	0.5	0.0	0.2
Gyrinidae (whirlgig beetles)	0.0	0.0	0.3	0.2	1.0	1.0	0.1	0.4
Trichoptera (caddis fly)	0.0	tr*	0.0	tr*	0.1	0.0	0.0	0.0
Nepidae (water scorpion)	0.0	0.0	0.0	tr*	tr*	0.0	0.0	0.0
Hydrophilidae (water scavenger beetles)	0.0	2.7	tr*	1.6	1.3	0.3	0.0	0.8
Spaeriidae (bivalve clams)	0.0	0.0	0.1	0.1	tr*	0.0	0.0	0.0
Veliidae (broad shouldered water striders)	0.0	0.0	tr*	0.1	0.0	0.0	0.0	0.0
Muscidae (house, face and stable flies)	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Conchostraca (clam shrimps)	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mesoveliidae (water treaders)	0.0	0.0	0.0	0.0	0.0	tr*	0.0	0.0
Totals	11.0	37.8	43.2	31.1	44.1	33.6	23.8	32.1

*tr = trace

(Oligochaeta) (4.97/L (4/34/L). Other taxa that averaged more than 2 per liter sample in all age classes in the later samples were mites and ticks (Acari), pond snails, midges (Chironomidae), and leeches (Table 5). All other taxa occurred in less than 2/L/sample. Twelve of 31 taxa in the late sampling periods occurred in age class 1 basins (Table 5) and averaged 8.2 taxa per collection (Table 6).

Table 6. Mean number of macroinvertebrate taxa per liter from activity traps in restored wetlands between June 30 and July 20 in 1986 and 1987, and between June 1 and June 15, 1987.

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
July 1986	10.0	9.7	10.4	9.3	8.6	7.6	7.6
June 1987	6.2	5.8	7.1	9.5	11.1	11.5	n/a
July 1987	6.4	7.8	7.4	2.6	3.0	2.2	n/a
Average	7.5	7.7	8.3	7.1	7.6	7.1	7.6

Fishes, Crawfishes, and Salamanders

Three fish species, 1 crawfish (Orconectes spp.) species and 1 salamander species (Ambystoma tigrinum) were collected in 68 minnow trap samples (Table 7). Fathead minnows (Pimephales promelas), salamanders, and crawfishes were collected from basins in age class 1. The largest number of each species in a trip during a 72 hour sampling period was 71 fathead minnows, 78 central mud minnows (Umbra limi), 33 brook sticklebacks (Culaea inconstans), 47 crawfishes, and 3 salamanders.

Fishes, crawfishes, and salamanders were also collected with invertebrate activity traps (Table 8). Fathead minnows and crawfishes occurred in basins of all age classes except in 4 year old basins (Table 8). Fathead minnows were almost twice (1.95X) as numerous as brook sticklebacks and were the next most abundant of 4 fish species. Sticklebacks were not collected from any wetland that did not also contain fatheads. Common shiners were collected in 1 and 3 year old basins and central mudminnows in 6 year old basins. Activity trap samples from 1 year old basins contained 3.4 times as many fishes as 3 year old basins. Tiger salamanders were in activity trap samples from all age classes except 3 year old basins.

Wetland Cover Types

Estimates of the percent area of coverage for emergent, submergent, exposed substrate and unconsolidated bottom cover types were collected from 143 restored wetlands of 11 age strata (Table 9). Emergent

Table 7. Percent frequency of occurrence of fishes, crawfishes, and salamanders collected in 60 minnow traps in restored wetlands between June 30 and July 30, 1986.

	Age 1 (n=6)	Age 2 (n=6)	Age 3 (n=6)	Age 4 (n=6)	Age 5 (n=6)	Age 6 (n=6)
Fathead minnow (*Pimephales promelas*)	17	0	0	0	0	0
Central mudminnow (*Umbra limi*)	0	0	13	25	40	0
Brook Sticklebacks (*Culaea inconstans*)	0	40	13	25	40	17
Common shiner (*Notropis cornutus*)	0	7	0	0	4	0
Tiger Salamander (*Ambystoma tigrinum*)	33	0	25	50	40	33
Crawfish (*Orconectes* spp.)	33	0	0	0	40	17

Table 8. Numbers of fishes, crawfishes, and salamanders in activity traps in restored wetlands between June 1 and July 30, 1987.

	Age 1 (n=6)	Age 2 (n=6)	Age 3 (n=6)	Age 4 (n=6)	Age 5 (n=6)	Age 6 (n=6)	Totals
Fathead minnow	494	43	308	0	17	56	918
Central mudminnow	0	0	0	0	0	1	1
Brook stickleback	449	0	10	0	9	4	472
Common shiner	201	0	12	0	0	0	213
Tiger salamander	1	5	0	1	1	2	10
Crawfish	2	1	2	0	1	7	13
Total collected	1144	43	330	0	26	61	
Number of fish species	3	1	3	0	2	3	

vegetation was present in 93.7% of the restored basins. As early as 1 year after restoration, 87.5% of the basins surveyed had developed emergent plant communities. The average coverage of emergents ranged from 41.7% in 4 year old basins to 89.2% in wetlands that had been restored for 12 years. No apparent trend existed between wetland age and percent coverage. In 1 year old basins, emergent communities covered an average of 65.7% of surface area. The average coverage of emergents for all age classes of restored basins was 59.8%.

Table 9. Wetland cover type percentages of emergent and submergent hydrophytes, exposed substrate and unconsolidated bottom surveyed in 1986 and 1987 by restored wetland age class.

	Age 1 (n=8)	Age 2 (n=11)	Age 3 (n=15)	Age 4 (n=12)	Age 5 (n=11)	Age 6 (n=14)	Age 7 (n=12)	Age 8 (n=13)	Age 9-11 (n=14)	Age 12-15 (n=13)	Age 16-20 (n=17)	Totals (n=143)
Emergents												
No. Wetlands	7	11	15	12	11	12	10	13	13	13	17	134
% of Wetlands	87.5	100.0	100.0	100.0	100.0	85.7	83.3	100.0	92.9	100.0	100.0	93.7%
Mean % Coverage	67.7	55.5	51.7	41.7	58.6	59.8	49.0	51.2	51.2	89.2	84.1	59.8%
Submergents												
No. Wetlands	4	7	10	9	9	6	9	11	10	2	8	85
% of Wetlands	50.0	63.6	66.7	75.0	81.8	42.9	75.0	84.6	71.4	15.4	47.1	59.4%
Mean % Coverage	7.5	36.4	23.5	27.8	34.4	25.0	42.8	36.8	41.5	17.5	6.9	27.3%
Exposed Substrate												
No. Wetlands	3	3	5	4	1	4	6	1	2	1	2	32
% of Wetlands	37.5	27.3	33.3	33.3	9.1	28.6	50.0	7.7	14.3	7.7	11.8	22.4%
Mean % Coverage	6.7	10.0	11.0	6.3	10.0	17.5	12.5	5.0	5.0	15.0	12.5	10.1%
Unconsolidated Botto												
No. Wetlands	7	7	15	9	6	10	9	9	12	4	36	94
% of Wetlands	87.5	63.6	100.0	75.0	54.5	71.4	75.0	69.2	85.7	30.8	35.5	67.7%
Mean % Coverage	41.4	32.1	29.0	46.7	21.7	28.2	27.8	19.4	25.8	22.5	31.7	29.7%

Submergent vegetation occurred in 50% of the 1 year old basins and gradually increased with age through 6 year old basins. Eighty-five (59.4%) of the 143 wetland basins supported submergent plant communities. One-half of the 1 year old basins had an average submergent coverage of 7.5%. In the 2 year old basins, submergent plant communities covered 36.4% of the area in 63.6% of the basins.

Twenty-two percent of all basins had some exposed substrate. It ranged from 5.0% in 8 and 9-11 year old basins to 17.5% in 6 year old basins. A substantial number (67.5% of the total for all age classes) of wetlands had areas of unconsolidated bottom not covered by either emergent or submergent vegetation. The average percent coverage of unconsolidated bottom was 29.7% for all basins and was highest in 1 and 4 year old basins and lowest in 8 year old basins.

Hydrophytes

An average of 16.2 taxa of aquatic plants per wetland occurred in 11 year old basins (Table 10). The 4 most frequent emergent taxa in decreasing order were cattails (*Typha* spp.), sedges (*Carex* spp.), smartweed (*Polygonum coccineum*) and reed canary grass (*Phalaris arundinacea*). Cattails occurred in 66.2% of all basins, at an average coverage of 31.7%. Seventy-five percent of the 1 year old basins had cattail communities at an average coverage of 25.8%. Three *Potamogeton* spp. were the most frequent submergent hydrophytes. Water milfoil (*Myriophyllum exalbescens*) was the next most frequent species. Sago pondweed (*Potamogeton pectinatus*) occurred in 17.3% of all basins at an average coverage of 14.9%. Of the free floating hydrophytes, the 4 most frequent taxa, in decreasing order, were star duckweed (*Lemna trisculca*), lesser duckweed (*Lemna turionifera*), bladderwort (*Utricularia vulgaris*) and hornwort (*Ceratophyllum demersum*). Mean percent coverage by free floating taxa was greatest for hornwort (16.5%) and least for star duckweed (10.0%). The mean number of plant taxa ranged from 3.5 for 1 and 8 year old basins to 5.1 for 9-11 year old wetlands, and averaged 3.8 taxa per basin for all wetlands.

Species Richness

The number of taxa of waterfowl and fishes and the mean number of taxa of macroinvertebrates and hydrophytes were tabulated for 1 year through 6 year old basins (Table 11). The mean number of waterfowl species per wetland ranged from 0.22 in 5 year old basins to 0.54 in 6 year old basins. The number of fish species was greatest in 1 year and 6 year old basins and least in 4 year old basins. Mean numbers of macroinvertebrate taxa ranged from 7.1 per sample in 1 year old wetlands to 8.3 in 3 year old basins. Two and 4 year old basins had the greatest number of aquatic plant taxa with an average of 4.4 species per wetland. One year old basins averaged 3.5 plant taxa per wetland.

Table 10. Hydrophyte species occurring as >5% of total basin vegetation coverage expressed as number of wetlands of occurrence, percentage of wetlands of occurrence, and the average percent coverage of each taxa for 11 age classes of restored wetlands surveyed in 1986 and 1987.

	Age 1 (n=8)	Age 2 (n=11)	Age 3 (n=15)	Age 4 (n=12)	Age 5 (n=11)	Age 6 (n=14)	Age 7 (n=12)	Age 8 (n=13)	Age 9-11 (n=14)	Age 12-15 (n=13)	Age 16-20 (n=17)	Totals
Emergent Hydrophytes												
Cattails	6	7	11	8	9	6	9	10	11	5	10	92
(*Typha* spp.)	75.0	63.6	73.3	66.7	81.8	46.2	75.0	76.9	78.6	38.5	58.8	66.2%
	25.8	32.1	16.4	26.9	41.7	23.8	39.4	37.0	23.2	22.0	60.0	31.7%
Sedges	2	3	3	3	4	6	2	2	7	6	13	51
(*Carex* spp.)	25.0	27.3	20.0	25.0	35.4	42.9	16.7	15.4	50.0	46.2	76.5	36.7%
	50.0	25.0	80.0	20.0	11.3	15.0	22.5	10.0	35.7	15.0	23.8	28.0%
Amphibious smartweed	4	3	7	5	2	2	3	1	4	11	8	50
(*Polygonum*	50.0	27.3	46.7	41.7	18.2	14.3	25.0	77.0	28.6	84.6	47.1	36.0%
coccineum)	20.0	40.0	27.1	5.0	7.5	17.5	5.0	5.0	6.5	45.9	20.6	18.2%
Reed canary grass	1	4	3	4	1	3	2	4	6	1	1	30
(*Phalaris*	12.5	36.4	20.0	33.0	9.1	21.4	16.7	30.8	42.9	7.7	5.9	21.6%
arundinacea)	70.0	26.3	80.0	15.0	20.0	31.7	7.5	42.5	15.8	5.0	50.0	33.1%
Willows	2	4	6	1	2	5	1	3	0	1	4	29
(*Salix* spp.)	25.0	36.4	40.0	8.3	18.2	35.7	8.3	23.1	0.0	7.7	23.5	20.9%
	22.5	10.0	13.3	5.0	7.5	6.0	5.0	20.0	0.0	5.0	20.0	10.4%
Slough grass	1	2	4	3	1	4	3	1	1	1	4	25
(*Beckmannia*	12.5	18.2	26.7	25.0	9.1	28.6	25.0	77.0	7.1	7.7	23.5	18.0%
syzigachne)	5.0	5.0	13.8	10.0	5.0	36.3	8.3	20.0	20.0	5.0	23.8	13.8%
Spike rushes	1	3	0	1	2	1	0	0	2	8	1	19
(*Eleocharis* spp.)	2.5	27.3	0.0	8.3	18.2	7.1	0.0	0.0	14.3	61.5	5.9	13.7%
	5.0	8.3	0.0	5.0	5.0	5.0	0.0	0.0	7.5	9.4	5.0	4.6%

Table 10 (cont'd.). Hydrophyte species occurring as >5% of total basin vegetation coverage expressed as number of wetlands of occurrence, percentage of wetlands of occurrence, and the average percent coverage of each taxa for 11 age classes of restored wetlands surveyed in 1986 and 1987.

	Age 1 (n=8)	Age 2 (n=11)	Age 3 (n=15)	Age 4 (n=12)	Age 5 (n=11)	Age 6 (n=14)	Age 7 (n=12)	Age 8 (n=13)	Age 9-11 (n=14)	Age 12-15 (n=13)	Age 16-20 (n=17)	Totals
River bulrush	1	1	1	2	1	2	2	0	0	4	2	16
(*Scirpus*	12.5	9.1	6.7	16.7	9.1	14.3	16.7	0.0	0.0	30.8	11.8	11.5%
fluviatilis)	5.0	5.0	5.0	12.5	5.0	5.0	42.5	0.0	0.0	27.5	10.0	10.7%
Water plantain	1	0	1	1	1	1	2	0	1	3	1	12
(*Alisma plantago-*	12.5	0.0	6.7	8.3	9.1	7.1	16.7	0.0	7.1	23.1	5.9	8.6%
aquatica)	10.0	0.0	20.0	5.0	5.0	5.0	5.0	0.0	5.0	5.0	5.0	5.9%
Whitetop	2	0	0	0	0	2	0	0	2	1	3	10
(*Scolochloa*	25.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	14.3	7.7	17.6	7.2%
festucacea)	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	15.0	70.0	8.3	9.2%
Ashes	0	0	0	0	1	0	0	0	0	0	0	1
(*Fraxinus* spp.)	0.0	0.0	0.0	0.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.7%
	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5%
Elms	0	0	1	0	0	0	0	0	0	0	0	1
(*Ulnus* spp.)	0.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7%
	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9%
Soft rush	0	0	0	0	0	0	1	0	0	0	0	1
(*Juncus baiticus*)	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.7%
	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.5%
Water parsnip	0	0	0	0	0	0	1	0	0	0	0	1
(*Sium suave*)	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.7%
	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.5%

Table 10 (cont'd.). Hydrophyte species occurring as >5% of total basin vegetation coverage expressed as number of wetlands of occurrence, percentage of wetlands of occurrence, and the average percent coverage of each taxa for 11 age classes of restored wetlands surveyed in 1986 and 1987.

	Age 1 (n=8)	Age 2 (n=11)	Age 3 (n=15)	Age 4 (n=12)	Age 5 (n=11)	Age 6 (n=14)	Age 7 (n=12)	Age 8 (n=13)	Age 9-11 (n=14)	Age 12-15 (n=13)	Age 16-20 (n=17)	Totals
Joe-pye weed	0	1	0	0	0	0	0	0	0	0	0	1
(*Eupatorium*	0.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7%
maculatum)	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5%
Submergent Hydrophytes												
Sago pondweed	1	3	2	2	2	2	3	3	5	1	0	24
(*Potamogeton*	12.5	27.3	13.3	16.7	18.2	14.3	25.0	23.1	35.7	7.7	0.0	17.3%
pectinatus)	5.0	31.7	17.5	15.0	12.5	12.5	28.3	15.0	16.0	10.0	0.0	14.9%
Pondweed	0	0	0	1	0	0	1	0	1	0	0	3
(*Potamogeton*	0.0	0.0	0.0	8.3	0.0	0.0	8.3	0.0	7.1	0.0	0.0	2.2%
pusillus)	0.0	0.0	0.0	5.0	0.0	0.0	5.0	0.0	5.0	0.0	0.0	1.4%
Leafy pondweed	0	0	0	1	0	0	0	0	2	0	0	3
(*Potamogeton*	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	14.3	0.0	0.0	2.2%
foliosis)	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	1.9%
Water milfoil	0	0	0	0	0	0	1	0	1	0	0	2
(*Myriophyllum*	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	7.1	0.0	0.0	1.4%
exalbescens)	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	45.0	0.0	0.0	4.5%
Buttercup	0	0	0	0	0	0	0	0	1	0	0	1
(*Ranunculus*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0	0.0	0.7%
flabellaris)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.5%

Table 10 (cont'd.). Hydrophyte species occurring as >5% of total basin vegetation coverage expressed as number of wetlands of occurrence, percentage of wetlands of occurrence, and the average percent coverage of each taxa for 11 age classes of restored wetlands surveyed in 1986 and 1987.

	Age 1 (n=8)	Age 2 (n=11)	Age 3 (n=15)	Age 4 (n=12)	Age 5 (n=11)	Age 6 (n=14)	Age 7 (n=12)	Age 8 (n=13)	Age 9-11 (n=14)	Age 12-15 (n=13)	Age 16-20 (n=17)	Totals
Free-Floating Hydrophytes												
Star duckweed	2	3	7	5	5	8	5	5	8	5	8	61
(*Lemna trisulca*)	25.0	27.3	46.7	41.7	45.5	57.1	41.7	38.5	57.1	38.5	47.1	43.9%
	5.0	16.7	12.9	14.0	15.0	8.8	6.4	19.0	10.6	5.0	5.6	10.8%
Lesser duckweed	0	7	5	5	1	7	6	5	7	0	3	46
(*Lemna*	0.0	63.6	33.3	41.7	9.1	50.0	50.0	38.5	50.0	0.0	17.6	33.1%
turionifera)	0.0	37.1	11.0	14.0	5.0	12.1	7.8	10.0	7.9	0.0	5.0	10.0%
Bladderwort	1	4	3	5	4	0	3	5	4	1	3	33
(*Utricularia*	12.5	36.4	20.0	41.7	36.4	0.0	25.0	38.5	28.6	7.7	17.6	23.7%
vulgaris)	15.0	11.3	20.0	22.0	18.8	0.0	11.7	23.0	8.8	5.0	5.0	12.8%
Hornwort	0	1	0	1	6	3	4	5	6	1	1	28
(*Ceratophyllum*	0.0	9.1	0.0	8.3	54.5	21.4	33.3	38.5	42.9	7.7	5.9	20.1%
demersum)	0.0	5.0	0.0	25.0	22.4	45.0	27.5	32.0	14.2	5.0	5.0	16.5%
Big duckweed	0	0	0	0	0	1	0	0	0	0	0	1
(*Spirodela*	0.0	0.0	0.0	0.0	0.0	7.1	0.0	0.0	0.0	0.0	0.0	0.7%
polyrhiza)	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.5%
Total N Taxa	16	17	18	21	19	17	19	13	20	18	16	194
Mean N Taxa	3.5	4.4	3.9	4.4	4.1	3.9	4.3	3.5	5.1	4.5	3.8	3.8

Table 11. Mean species richness indices per wetland for each age class of restored wetlands for 4 major groups of organisms averaged for 1986 and 1987.

Taxa Group	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
Waterfowl	0.4	0.4	0.3	0.2	0.2	0.5
Macroinvertebrates	7.5	7.8	8.3	7.1	7.6	7.1
Hydrophytes	3.5	4.4	3.9	4.4	4.1	3.9
Fish	0.5	0.2	0.3	0.0	0.3	0.5

DISCUSSION

Wetlands restoration is not a new concept, but agency implementation of wetlands restoration is a fairly recent management activity. Wetland restoration should not be confused with wetland construction or acquisition. The first step in restoration of most drained prairie wetlands is to simply remove the drain tile, plug the surface ditches, or stop water removal by pumping. Ecological processes in a basin after drainage or dewatering has ceased are largely unknown and unpredictable because of insufficient information and uncontrollable phenomena such as weather.

However, the plight of North American waterfowl (USFWS-CWS, 1988), the duration and extent of drought in the 1980's, and the lower rates of wetland acquisition have all resulted in renewed interest in wetland restoration on public and private lands. Although some wetlands were restored on public lands during the past 25-35 years, the first major effort to restore wetlands on private lands began with the U.S. Fish and Wildlife Service's Mid-Continent Waterfowl Management Project in the prairie pothole region of west-central Minnesota (Madsen, 1986). The project goal was to restore 2,000 acres of wetlands in 3 counties with cooperation from landowners, Ducks Unlimited, the Minnesota Department of Natural Resources, the Minnesota Waterfowl Association, and local fish and game clubs.

Presently, wetland restoration is a fairly high priority management activity from many agencies and it is an integral part of the North American Waterfowl Management Plan (USFWS-CWS, 1988). However, stopping water flow from a basin by just plugging a ditch or tile or eliminating pumping does not constitute total restoration. Restoration must include new water and management (Kaminski & Prince, 1981a; Kantrud, 1986). And from the standpoint of waterfowl management, managers need to have a better understanding of the temporal and spatial occurrences of flora and fauna after restoration.

As of July 1989, at least 5,000 wetlands had been restored on public

and private lands in the Dakotas and Minnesota during the previous 5 years. One of the big questions is: how soon after rewatering does a restored wetland become functional?

Our results show colonization of restored wetlands by a large diversity of flora and fauna as early as in the first year (season) of inundation after restoration. This was true even for 1 Minnesota basin that had been dewatered by drainage since 1918.

Although average waterfowl pair densities (130/Km^2) were relatively low on our study wetlands, they were comparable to average densities of 1.1 pairs/ha (110/Km^2) found on wetlands constructed in highway rights-of-way in North Dakota (Kreil & Crawford, 1986) and 1.8 pairs/ha on sparsely distributed stock dams in western North Dakota (Lokemoen, 1973). Because pair populations usually average less than 20/km^2 (50/mi^2) in eastern South Dakota (S.G. Simpson, pers. commun.) and 12/km^2 (30/mi^2) in western Minnesota (Moyle, 1964), the low density and wetland occupancy of pairs on our study wetlands was somewhat expected. More importantly, breeding pairs of all 12 species of waterfowl common to the region used all ages of restored wetlands between 1 and 24 years old.

Restored wetlands on our study area supported diverse invertebrate communities of as many as 31 different taxa. This is similar to the findings of Voights (1976) in unaltered Iowa wetlands, where as many as 32 different taxa were recorded, but greater than the 18 taxa that LaGrange and Dinsmore (1989) recorded in restored wetlands in Story County, Iowa. The importance of aquatic invertebrates as a food source and as a wetland selection criterion for breeding waterfowl has been well documented (Swanson & Meyer, 1977; Swanson et al., 1974, 1979, 1985; Krapu, 1974, 1979; Krapu & Swanson, 1975, 1978; Murkin & Kadlec, 1986; Broschart & Linder, 1986; Weller, 1987). Furthermore, the diversity of invertebrate taxa in a wetland may influence the selection of wetlands by breeding waterfowl (Kaminski & Prince, 1981b). In our study, 1 year wetlands had comparable diversity of invertebrates to wetlands that had been restored for up to 7 years, suggesting an immediate response by invertebrate taxa to restoration. The mean number of invertebrates per liter increased during the early sampling period (June 1987) in 1-6 year old basins. The response to inundation including the decomposition of existing vegetation and the resultant nutrient release could explain the early primary and secondary productivity and species richness in many basins. This sampling period corresponds to the time when many breeding waterfowl are selecting wetlands. However, there was little difference in the pairs/ha/count of breeding waterfowl between those 6 age classes.

The dynamic water regimes of prairie wetlands can change floral and faunal composition (Cowardin et al., 1979; Harris & Marshall, 1963; Kadlec, 1962; Meeks, 1969; Stewart & Kantrud, 1971). The length of time a restored wetland was drained, which is a change in water regime, can influence the species diversity of plant communities (Erlandson, 1987). Our results showed an immediate response to inundation by a diverse number of hydrophyte taxa. Managers can expect an immediate colonization of restored wetlands by emergent and submergent plants and rapid

interspersion of plant cover types that benefit breeding waterfowl, passerine birds, and other vertebrates of recreational importance.

Water permanence, dissolved oxygen, dissolved solids, and other factors influence the ability of restored wetlands to support fish populations as early as 1 year after restoration. One year old basins had the greatest abundance of fishes and 3 of 4 fish species were present in 1 year old basins. The expansion of fish populations into recently restored basins can be attributed to fish movement up existing tile drainages, transfer of fry and embryos by birds, and baitfish stocking by people. An increasing market exists for the production of baitfishes from the prairie region. Baitfish and fingerling production could be an incentive for wetland preservation and restoration.

Peterka (1989) found that sticklebacks only occurred in combination with fatheads in North Dakota wetlands. Our results corroborate these findings. Central mudminnows were found in only one South Dakota wetland, which is on the periphery of their geographic range. Tiger salamanders occurred in all age classes of restored wetlands. In study wetlands near Brookings, SD, Dr. Charles Berry (pers. commun., 11/89) found that bullhead (Ictalurus spp.) populations and tiger salamander populations have not occurred in the same wetland. Additional research on wetland communities is needed to understand the influence that fish propagation has on waterfowl production, a primary goal of many wetland restorations.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Knowledge of waterfowl, aquatic macroinvertebrate, hydrophyte and fish (particularly minnow) colonization of restored wetlands as early as the first season after inundation is of benefit to waterfowl biologists, wetland managers and natural resource planners. Essentially, restored wetlands provide enough food (invertebrates) and emergent and submergent cover (hydrophytes) to support waterfowl populations beginning in the first year after restoration. For planners, this means that drained wetland can produce beneficial results as readily as funds are available for restoration. For managers, however, this means that successful restoration of pothole wetlands in the northern Great Plains is possible with similar end results. If the purpose of wetland restoration is to enhance production of upland nesting ducks (e.g., blue-winged teal and mallards), managers must prioritize restoration of basins that have or will have suitable upland nesting cover nearby. However, if the purpose of wetland restoration is to enhance the amount and distribution of migration habitat, then adjacent upland cover is of lesser importance.

The quality of restored wetlands seems favorable to most wetland flora and fauna. However, we still do not know the long-term effects of restored wetlands on the local hydrology or whether restored basins will function normally, particularly if soil/substrate modification was considerable during restoration. Therefore, we caution their discriminate use as mitigation trade-offs of loss of natural wetland basins.

Prairie wetlands are subject to the dynamic climatic conditions of the region. Cycles of drought and reflooding influence the hydrology and the floral and faunal communities of wetlands. Differing soil types, geographic location, surrounding land use, watershed position, and past agricultural use also elicit unique responses to restoration in each basin. We recommend that, because of the dynamic nature of prairie wetlands, future studies of wetland restorations should be concentrated on basins that have been restored for 6 years or less. Intensive comparisons with similar adjacent unaltered wetlands in a paired plot design will enable more discreet documentation of the floral and faunal responses to restoration.

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