Passive Establishment of Vegetation in Constructed Wetlands in Agricultural Settings: a Case Study[1]

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Abstract. Three wetlands constructed in 1995 on land adjacent to agricultural fields in northwest Ohio were allowed to establish vegetation passively. Survey data collected 1998-2001 from quadrats in open water, frequently and infrequently submerged zones within the basin, identified 77 species over the three sites. Greatest species diversity occurred in the infrequently and frequently submerged zones. The dominant species within the wetlands originated from agricultural fields, nearby drainage ditches, streams, and the seeded erosion control buffer zones surrounding the wetlands. Six years following construction, less than 50% of the dominant species were wetland species. Results suggest that for constructed wetlands in agricultural settings, plantings or seeding of desired species will be required to supplement the existing sources of wetland vegetation species.

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INTRODUCTION

The introduction of constructed wetlands in agricultural watersheds of the Mississippi basin has been recommended to reduce non-point source nutrient contributions to the Gulf of Mexico (Mitsch and others 1999, 2001; Hey 2002). Vegetation in such wetlands is most often established by seeding or transplanting seedlings in the basin following construction, and there is much literature available on the methodology and results (Allen and others 1989; Marble 1992; Payne 1992; Thunhorst 1993; Hammer 1997). An alternative approach is to allow for species that may passively establish from the seed bank or be recruited from outside the wetland. Wetland management for passive establishment selects for species to establish from the seed bank or from outside the wetland (Welling and others 1988; Collins and Wein 1995). Risks of passive vegetation establishment are that seed bank richness may be insufficient or that the surrounding areas may provide both suitable and undesired or invasive species (Weinhold and van der Valk 1989; Galatowitsch and van der Valk 1995).

The objective of this work was to examine how constructed wetlands built on converted cropland passively develop vegetation. Specifically, this study was conducted to document the rate and type of passive vegetation establishment in Wetland Reservoir Subirrigation Systems (WRSIS) project sites and, thereby, aid in the decision to use passive revegetation in future project sites.

SITE DESCRIPTION AND METHODS

This time limited study examined and identified the vegetation that established in three constructed wetlands located in the Maumee River watershed in Defiance, Fulton, and Van Wert counties in northwest Ohio. Each location had been under row crops or sod for at least 20 years prior to construction, which occurred in 1995. The size of the constructed wetland was 0.12 ha in Defiance County, 0.57 ha in Fulton County, and 0.79 ha in Van Wert County. The average water depth in the wetland was >30 cm, but features such as shelves, earthen dividers, and gentle bank slopes (6-10:1) were designed into the basins to promote vegetation establishment. Vegetation was allowed to establish passively, with the exception of erosion control seeding along the buffers of the basin. The buffers of the three sites received similar species in the erosion control applications, that is, *Medicago sativa* L., *Phleum pratense* L., *Echinochloa crusgalli* (L.) P. Beauv., *Festuca pratensis* Hudson., *Dactylis glomerata* L., and *Trifolium repens* L. The Fulton and Van Wert locations also received *Bromus* spp. The wetlands received subsurface drainage and runoff waters from adjacent agricultural fields under corn (*Zea mays* L.), soybean (*Glycine max* L.) rotation cropping systems. The annual water level of the constructed wetlands varied 15-25 cm during the study.

Field surveys were conducted to determine plant species, number of individuals and zonation of growth by randomly placing four 1.0 m^2 quadrats in each of (a) the frequently submerged zone (W) extending 0.5 m above and below the average water level, (b) the infrequently submerged zone (I) 1.0 m above zone W, and (c) the open water zone (O) under standing water. Data were collected using a stratified random sampling technique (Luckeydoo 2002; Luckeydoo and others 2002). The Braun-Blanquet (1932) method which included percent cover, species composition, grouping, and age was used to collect qualitative information about plant species and calculate Importance Factor (IF) rankings (Cox 1996). Species were considered dominant (top 10 of the ranked IF species) if they occurred for more than 50% of the individual seasons. Nomenclature follows Gleason and Cronquist (1991) and Fassett (1969).

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RESULTS AND DISCUSSION

Species richness was 43 at Fulton, 50 at Van Wert, and 53 at Defiance over 4 years of study. A total of 77 species were identified in the three constructed wetlands during 1998-2001 (Table 1); the infrequently submerged zone (68 species) and the frequently submerged zone (59 species) contained more species than the continually submerged open water zone (9 species).

Wetland indicator species made up 45% (35 species) of the total species present (Table 1), most of which were facultatively (Reed 1988; USFW 1996) associated with wetland conditions. The proportion native to North America varied from 71% (Fulton) to 85% (Van Wert) to 86% (Defiance).

TABLE 1

List of species and associated species characteristics that were present in the three constructed wetlands located in northwest Ohio, 1998-2001.

Species Name [1]	Species Status [2]	Located in Zones [3]	Located at Sites [4]
Wetland			
Agrostis gigantea Roth.	FACW-	I W	D F
Aster novae-angliae L.	FAC	I	D
Atriplex patula L.	FACW	W	F
Bidens frondosa L.	FACW	W	V
Carex squarrosa L.	FACW	I	D
Carex vulpinoidea Michx.	OBL	I W	D V
Cyperus strigosus L.	FACW	I W	F
Eleocharis ovata (Roth) Roemer & Schultes.	OBL	I W	D V
Euthamia graminifolia (L.) Nutt.	FAC	I W	D V
Hordeum jubatum L.	FAC	I W	D V
Juncus effusus L.	FACW+	I	D
Juncus tenuis Willd.	FAC-	I W	D V
Lactuca serriola L.	FAC-	I W	D F V
Leersia oryzoides (L.) Swartz.	OBL	I W	F V
Lemna minor L.	OBL	O	F
Lindernia dubia (L) Pennell.	OBL	W	D
Panicum dichotomiflorum Michx.	FACW-	I W	D F V
Penthorum sedoides L.	OBL	I	V
Phalaris arundinaceae L.	FACW	I W	F
Polygonum hydropiper L.	OBL	W	F
Polygonum lapathifolium L.	FACW+	I W	F
Polygonum pensylvanicum L.	FACW	I W	D F V
Polygonum persicaria L	FACW	I W O	D F V
Populus deltoides Marshall.	FAC	I W	D F V
Portulaca oleracea L.	FAC	I W	F
Potamogeton foliosus Raf.	OBL	W O	D F V
Rorippa palustris (L.) Besser.	OBL	I W O	D F V
Salix exigua Nutt.	OBL	I W O	D V
Salix nigra Marshall.	FACW+	I W	V
Scirpus atrovirens Willd.	OBL	I W	D V
Scirpus cyperinus (L.) Kunth.	FACW+	I	D
Salix amygaloides Andersson.	FACW	I	F
Typha angustifolia L.	OBL	I W O	D V
Verbena hastata L.	FACW+	I	D
Xanthium strumarium L.	FAC	I W O	V
Non wetland			
Abutilon theophrasti Medikus.	UPL	I W	F V
Acalypha rhomboidea Raf.	FACU-	I W	D V

TABLE 1 (*Cont.*)

List of species and associated species characteristics that were present in the three constructed wetlands located in northwest Ohio, 1998-2001.

Species Name [1]	Species Status [2]	Located in Zones [3]	Located at Sites [4]
Non wetland (*Cont.*)			
Ambrosia artemisiifolia L.	FACU	I W	D F V
Aster pilosus Willd.	UPL	I W	D V
Barbarea vulgaris R.Br.	FACU	I	D F
Bromus intermis Leysser.	FACU	I W	V
Bromus japonicus Thunb.	FACU-	I W	F V
Cerastium vulgatum L.	FACU-	W	V
(Chamaesyce) Euphorbia nutans Lagasca.	FACU	I	V
Cichorium intybus L	NL	I	D
Cirsium altissimum (L.) Sprengel.	NL	I W	D F V
Cirsium arvense (L.) Scop	FACU	I W	D F V
Dactylis glomerata L.	FACU	I W	D F V
Daucus carota L.	NL	I	D
Digitaria sanguinalis (L.) Scop.	FACU-	I W	D V
Echinochloa crusgalli (L.) P. Beauv.	FACU	I W O	D F V
Elytrigia repens (L.) Nevski.	FACU-	I W	F
Erigeron annuus (L.) Pers.	FACU	I W	D V
Erigeron strigosus Muhl.	FACU+	I W	D F V
Festuca pratensis Hudson.	FACU	I W	D F V
Lepidium campestre (L.) R.Br.	NL	I W	D F V
Lolium perenne L	FACU-	I W	D F V
Medicago sativa L	NL	I W	D V
Melilotus officinalis (L.) Pallas.	FACU-	I	D V
Phleum pratense L	FACU	I W	D F
Plantago lanceolata L.	UPL	I W	D F V
Plantago major L.	FACU	I W	D F V
Poa annua L.	FACU	I	D
Polygonum aviculare L.	FACU	I W	D F
Potenilla norvegica L.	FACU	I W	D F
Prunella vulgaris L.	FACU	I	D
Rumex crispus L.	FACU	I W	D F V
Setaria faberi R. Herrm.	FACU	I W O	D F V
Setaria glauca (L) P. Beauv.	NL	W	F
Solidago canadensis L.	FACU	I W	D V
Sonchus oleraceus L.	UPL	I W	F V
Taraxacum officinale Weber ex Wiggers.	FACU-	I	D V
Thaspi arvense L.	NL	W	F
Trifolium pratense L.	FACU-	I W	D F V
Trifolium repens L.	FACU-	I	D F V
Verbena bracteata Lagasca & Rodriguez.	UPL	I W	F
Veronica arvensis L.	NL	I	V

[1] Authority: Gleason and Cronquist 1991

[2] Wetland Indicator status from Reed 1998; USFW 1996: OBL = Obligate, FACW = Facultative Wetland (67%-99% probability occurrence in wetlands), FAC = Facultative (35-66% probability occurrence in wetlands), FACU = Facultative Upland (1-33% probability occurrence in wetlands), UPL = Obligate Upland species, NL = No listing.

[3] Zones: I = Infrequently submerged, W = Frequently submerged, O = Open water

[4] Sites: D = Defiance County, F = Fulton County, V = Van Wert County

Importance Factor (IF) values (Table 2) suggested that local sources were most likely responsible for supplying the species which established. Highly ranked wetland and hydrophytic IF species such as *Salix exigua* Nutt., *Echinochloa crusgalli* (L.) P. Beauv., *Scirpus atrovirens* Willd., *Phalaris arundinacea* L., *Polygonum persicaria* L., and *Carex vulpinoidea* Michx. were noted to grow along the field edges, in nearby surface drainage ditches, and along entrance roadways. Many of the IF species have been reported to serve as sources of food, cover, and nesting locations for wildlife (McAtee 1939; Payne 1992), and seeds may have been delivered by visiting wildlife, waterfowl, or by wind or water movement. Non-wetland species such as *Phleum pratense* L., *Medicago sativa* L., *Dactylis glomerata* L., *Bromus* sp., and *Festuca pratensis* L. that had been planted on the buffer zones after construction as erosion control, likely served as a seed source for the infrequently and frequently submerged zones.

Wetland indicator species did not account for more than 50% of the dominant species, 6 years following construction, at any of the three locations. These results indicate that, despite basin design characteristics installed to promote wetland vegetation establishment, passive vegetation alone may not be able to establish more than 50% dominant wetland indicator species on similar constructed sites. The results of this study suggest that planting or seeding basins with desired species, in areas such as agricultural settings where limited wetland species propagule supply exists, will be required if 50% or greater wetland vegetation is desired within 6 years of construction.

An idea to increase the potential for wetland species establishment arises from the presence of erosion control plantings in the list of dominant IF species in the studied wetlands. Seed of wetland native species could be added into erosion control mixtures applied to the buffer in order to further promote wetland vegetation establishment and diversity. Species suggestions for Ohio include: *Elymus virginicus* L. (Wild rye), *Juncus effusus* L. (Soft rush), *Andropogon gerardii* Vitman. (Big Bluestem), and *Panicum virgatum* L. (Switchgrass, caution: some varieties aggressive). These species are only a few of the possible appropriate species, but are offered because they are all perennial wetland species (FAC and FACW) native to Ohio (Sheaffer and Rose 1998), are easily obtainable through seed companies, and are generally affordable (~$8 per 453 g, except *Juncus*, $80 per 453 g) for incorporation into erosion mixtures.

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TABLE 2

Summarized Importance Factor (IF) ranking of species that occurred greater than or equal to 50% on individual season IF lists during 1998 through 2001 at the studied constructed treatment wetlands in northwest Ohio.

Summary Importance Factor 1998-2001		
Defiance	Fulton	Van Wert
Juncus tenuis Willd. (WIS)	*Dactylis glomerata* L. (PLEC)	*Scirpus atrovirens* Willd. (WIS)
Medicago sativa L. (PLEC)	*Festuca pratensis* Hudson. (PLEC)	*Carex vulpinoidea* Michx. (WIS)
Salix exigua Nutt. (WIS)	*Echinochloa crusgalli* (L.) P. Beauv. (WD/PLEC)	*Bromus inermis* Leysser. (PLEC)
Solidago canadensis L. (WD)	*Polygonum persicaria* L. (WIS)	*Festuca pratensis* Hudson. (PLEC)
Phleum pratense L. (PLEC)	*Phalaris arundinacea* L. (WISI)	
Echinochloa crusgalli (L.) P. Beauv. (WD/PLEC)		

WIS = Wetland indicator species
WISI = Wetland indicator species with invasive rating
PLEC = Planted erosion control on upper bank
WD = Weed species
Authority: Gleason and Cronquist 1991

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