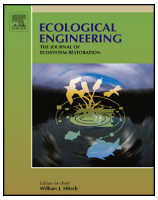
Ecological Engineering xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng



Vegetation productivity of planted and unplanted created riverine wetlands in years 15–17

Kay C. Stefanik[a], William J. Mitsch[a,b,*]

[a] *Wilma H. Schiermeier Olentangy River Wetland Research Park, The Ohio State University, 352 W. Dodridge St., Columbus, OH 43202, USA*
[b] *Everglades Wetland Research Park, Florida Gulf Coast University, 4940 Bayshore Dr., Naples, FL 34112, USA*

ARTICLE INFO

Article history:
Received 8 April 2017
Received in revised form 30 June 2017
Accepted 1 July 2017
Available online xxx

Keywords:
Wetland creation
Macrophytes
Net primary productivity
Structure
Function
Community diversity
Olentangy River Wetland Research Park

ABSTRACT

Wetland creation and restoration have been key factors in reducing net loss of wetland habitat in the United States. Creation and restoration techniques, such as introducing vegetation, are perceived to have a long-term effect on wetland structure and function over time. The goal of this study was to compare macrophyte structure and function between a planted and unplanted (naturally colonizing) wetland more than 14 years after the wetlands were created in 1994 at the Olentangy River Wetland Research Park in central Ohio, USA. Species richness, floristic quality, community diversity, and aboveground and belowground productivity were examined throughout the growing season for Years 15 through 17 of these wetlands.

The planted wetland had higher floristic quality assessment index scores (planted 23.2–23.8; unplanted 19.9–20, $p = 0.001$). Community diversity was similar between the two wetlands (CDI: planted 1.16–1.71; unplanted 1.03–1.45, $p = 0.388$). Aboveground net primary productivity of emergent vegetation was higher in the unplanted wetland (796–866 g dry weight m^{-2} yr^{-1}) than in the planted wetland (673–712 g dry weight m^{-2} yr^{-1}) ($p = 0.006$). While planting a riverine wetland may not be as important as planting isolated wetlands, this study did find some differences in structure and function in the planted and unplanted wetlands more than14 years after the wetlands were created. While planting riverine wetlands may aid in increased floristic quality of the wetland in the short term, these two wetland marshes appeared to be converging overall in structure and function during the 3 years of this study.

1. Introduction

The successional trajectory, or the direction of change in vegetation over time, of a newly created wetland ecosystem can progress in a variety of paths along a continuum from "low quality" to "high quality" and from early successional to late successional types of vegetation (Suding and Cross, 2006). Created wetland systems can be thought of as highly disturbed, low quality, immature ecosystems at the beginning of creation that develop over time, influenced by hydrology, position in the landscape, availability of propagules, and initial soil structure (Mitsch and Wilson, 1996; Mitsch et al., 1998, 2012, 2014: Campbell et al., 2002; Bruland and Richardson, 2005; Bantilan-Smith et al., 2009; van der Valk et al., 2009; Ahn and Dee, 2011). Wetlands that develop into high quality ecosystems are typically described as having high vegetation diversity, low numbers of invasive species, and tend to be dominated by late successional types of vegetation (Mitsch and Gosselink, 2015).

Since the 1980s, wetland creation and restoration to mitigate the loss of natural wetlands has been a growing practice, with overall quality of mitigation wetlands increasing over time with experience (NRC, 2001; Gardner et al., 2009). Unfortunately, monitoring usually occurs for only the first five years after creation to determine whether the wetland is successful (Mitsch and Wilson, 1996; NRC, 2001). Current monitoring practices consider wetland success in terms of compliance success, meeting the requirements set out prior to restoration usually as part of a permitting process and usually focus on structural parameters, i.e., species richness, species evenness, and floristic quality (Kentula, 2000; Matthews and Endress, 2008). Once deemed successful, mitigation wetlands may be managed, but additional monitoring is unlikely. However, the trajectory of succession may not be fully visible after the first five years of creation (Mitsch and Wilson, 1996; Matthews et al., 2009). Studies have shown that there tends to be an initial peak in structural parameters of a system, which then decline over time (Fennessy and Roehrs, 1997; Campbell et al., 2002; Balcombe et al.,

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[*] Corresponding author at: Everglades Wetland Research Park, Florida Gulf Coast University, 4940 Bayshore Dr., Naples, FL 34112, USA.
E-mail address: wmitsch@fgcu.edu (W.J. Mitsch).

http://dx.doi.org/10.1016/j.ecoleng.2017.07.001
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Please cite this article in press as: Stefanik, K.C., Mitsch, W.J., Vegetation productivity of planted and unplanted created riverine wetlands in years 15–17. Ecol. Eng. (2017), http://dx.doi.org/10.1016/j.ecoleng.2017.07.001

2005; Spieles et al., 2006; Gutrich et al., 2009; Stefanik and Mitsch, 2012). It is difficult to determine the exact point in time where this initial peak will occur, so it may be more accurate to either wait for the peak to occur before trying to predict successional trajectories or to reexamine the successional trajectory following the peak in structural parameters. Additionally, it may take a number of years, possibly half a century or more for a created wetland to develop soils that are similar to natural wetlands in terms of organic matter, nutrient content, and seed bank, which can affect both the types of species that colonize a wetland and the function or processes (i.e., productivity and functional group composition) of the species present (Craft et al., 1999, 2002; Choi, 2004).

Future disturbances to the system, both natural and anthropogenic, can alter successional trajectories. Common disturbances in wetlands, such as changes in hydrology (drought or excessive water inputs), changes in nutrient concentrations, mass herbivory, and the establishment of an invasive species, have the potential to alter vegetation community structure, change dominant functional groups, or even cause complete loss of vegetation in a wetland (van der Valk, 1981). The frequency and severity of disturbance to a system plays a role in the length of time spent in a particular successional stage, as well as how often ecosystems revert to early successional stages (Walker and del Moral, 2008). It is also possible that disturbances to a site may not allow the vegetation to progress beyond early successional stages. Disturbances that affect dominant species instead of minor species will likely have a greater impact on the entire ecosystem than disturbance that affect minor species. Dominant species are those species that make up the majority of an ecosystem. If there are minor species in the ecosystem that functionally overlap the dominant species, it is possible for the ecosystem to be somewhat resilient to disturbance (White and Jentsch, 2001). During creation and restoration projects, it is important to consider that future disturbances are inevitable and steps should be taken to increase the resilience of the system, such as introducing seeds and propagules during the restoration process.

Due to monetary constraints, introducing seeds and plant propagules may not always be a possibility. Passive restoration techniques, such as restoring the hydrology of a system and allowing vegetation to colonize naturally (Steven et al., 2010), can be a viable option where propagules and/or a seed bank are present. One of the drawbacks to passive restoration is that it may take longer for vegetation, and thus structural and functional parameters, to develop in the wetland than it would with active restoration. Dispersion limitations can lead to low species richness, different species composition than natural wetlands, and higher invasive species colonization (Galatowitsch and van der Valk, 1996; Seabloom and van der Valk, 2003). This could present a problem in terms of meeting restoration criteria within the designated time frame of the project.

This study is a three-year detailed investigation of vegetation structure and function on an initial experiment that was implemented in 1993-94 in which two wetlands of equal size, bathemetry and hydrologic conditions were constructed with water first added in March 1994. One wetland was planted in May 1994, while the other was left to rely on natural colonization. An initial hypothesis was set forth that the wetlands would be “similar in function in the beginning, diverge in function during the middle years, and ultimately converge in structure and function” (Mitsch et al., 1998). The purpose of this project was to examine vegetation development, both above and below ground, of two created riverine wetlands in 2008–2010, fourteen to sixteen years after the wetlands were created and one of the two was planted, to determine how the trajectories taken by both wetlands differ and to reexamine the initial experiment of planting versus not planting on the succession of two riverine wetlands and the Mitsch et al. (1998) hypothesis given above. It was also hypothesized that:

1. After 15 years, the planted wetland will have higher diversity, species richness and floristic quality in years 15–17 than the unplanted wetland due to the introduction and persistence of high quality vegetation at the onset of creation.
2. Structural differences between the two wetlands will have an impact on their functional characteristics, with the planted wetland having greater total net primary productivity, aboveground net primary productivity, and below ground net primary productivity than the unplanted wetland.
3. The structural and functional characteristics of the surrounding transitional zone (zone between distinct wetland and upland habitat) would be jump started near the planted wetland due to the initial planting efforts.

2. Materials and methods

2.1. Study site and original planting experiment

The two experimental wetlands at the Olentangy River Wetland Research Park, Ohio State University, Columbus, Ohio, USA, (40° 1′ 13”, −83° 1′ 2”) were created to examine nutrient removal, effects of hydrologic pulsing, greenhouse gas exchanges, carbon sequestration, and long-term vegetation succession in created wetlands (Fig. 1). The two experimental wetlands are each 1-ha in size and receive the majority of their hydrologic inputs via pumps from the adjacent Olentangy River. Since wetland creation, water has been pumped nearly continuously and normally pulsed according to the height of the river, with both wetlands having almost identical hydroperiods over 20 years (Mitsch et al., 2014). Construction of the wetland basins and plumbing began in 1993, with river water input beginning March 1994.

Prior to construction the land was used for agriculture by The Ohio State University. The wetland basin water depth is about 30 cm in most of the basins but with three deeper areas near the inflow, middle, and outflow to accommodate a long research opportunity despite often high sediment loads from the river. In spring 1994, an initial vegetation succession experiment was implemented in which one of the wetland on the west (Wetland 1, referred to as planted wetland in this paper) was planted with 13 wetland species, while vegetation naturally colonized the wetland to the east (Wetland 2, referred to as unplanted wetland in this paper).

Vegetation was planted in three different zones of the planted Wetland 1 in May 1994; mudflat gradient (0–0.3 m), edge/middle (0.3 m), and deep water (0.3–0.6 m). Species planted in the mudflat gradient were *Acorus calamus*, *Cephalanthus occidentalis*, *Juncus effusus*, *Pontideria cordata*, *Sagittaria latifolia*, *Saururus cernuus*, *Sparganium eurycarpum*, and *Spartina pectinata*. Edge and middle species included *Schoenoplectus tabernaemontani* and *Scirpus fluviatilis*. Deep water vegetation planted included *Nelumbo lutea*, *Nymphaea odorata*, and *Potamageton pectinatus*. Planting details and initial survival of planted species were described by Mitsch et al. (1998). The majority of propagules were root stock and rhizome, but *Nelumbo lutea* was introduced as seeds. A total of 2437 propagules were introduced to the planted wetland at a density of 0.24 plants/m^2. No tree species were planted along the edge of either wetland but trees colonized the edges of the wetlands almost immediately and the wetlands are now surrounded by a developing forest. Other than the initial planting and water being pumped into the two wetlands, there was purposely little management of vegetation in the two wetlands. Vegetation was allowed to colonize and shift within the wetland naturally and most invasive species are left

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