

INCIDENCE OF INVASIVE PLANT SPECIES IN WATER LEVEL MANAGED AND  
UNMANAGED WETLANDS IN NORTHERN OHIO.

by

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## ABSTRACT

Fluctuating water levels may facilitate non-native plant invasion of wetlands by providing suitable establishment conditions or inhibiting competition from native species not adapted to the new hydraulic regime. This study investigated compositional differences of plant communities in two water level-managed and two unmanaged wetlands in northern Ohio. Comparing native and non-native species responses can help determine whether different management techniques effectively control the incidence of non-native species and affect native plant diversity. The objective was to correlate native and non-native species cover and diversity among natural and anthropogenically altered hydrologic regimes. Within each wetland, species richness and percent cover of native and non-native species were measured in two 20x25m Whittaker plots containing two 25m<sup>2</sup> and six 1m<sup>2</sup> plots. Using the Daubenmire method, we found invasive plant species cover in managed wetlands was 34.6% higher than in reference wetlands, with a mean non-native species cover of 30%. Reference wetlands had a mean 9.5% of invasive species cover. Major invasive species found in the water flow managed wetlands were *Butomus umbellatus*, *Sagittaria latifolia*, *Typha angustifolia* and *Hydrocharis morsus-ranae*. Findings from this study suggest anthropogenically altered hydrologic regimes may facilitate the establishment of non-native species, and that the length and time of year of inundation should be carefully considered to promote native species vegetation.

## **ACKNOWLEDGMENTS**

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## INTRODUCTION

Wetland ecosystems are one of the most diverse ecosystems of habitat for plants and animals (Balcombe *et al.* 2005, Matthews *et al.* 2009). Wetlands provide valuable ecosystem and economic functions including nutrient recycling and retention, flood water storage, wildlife habitat and recreational use. Filtering has been a major component of wetlands and has been an increasing need with agricultural runoff. Filtering by wetlands keeps excess nutrients from entering watersheds (Mitsch and Gosselink 2000, Thompson *et al.* 2007). Diked wetlands can be used as a buffer from water bodies that cause soil erosion and damage agriculture. Wetlands have an important function ecologically and economically but in the Midwestern United States, wetland function has been compromised by non-native, invasive plant species. There has been a decline over the last 200 years but the “no-net-loss” policy for wetlands was put together in the 1980s to help counteract wetland damage and loss (Mitsch and Gosselink 2000). Non-native invasive species have become a part of wetland vegetation, especially in recreational and other disturbed areas (Mitsch and Gosselink 2000).

It is important when designing and monitoring wetlands, that the function of the wetland support native flora growth and increased plant community structure. Greater vegetation diversity and structure leads to higher wildlife species diversity and abundance (Keddy and Reznicek 1986), including plant food types for waterfowl and other wildlife (Herrick and Wolf 2005). A critical issue involves disturbance regime modification that affords establishment opportunities for non-native invasive plant species.

Non-native plant species are a growing concern to managers because of their adverse effects on wetland ecosystem functions and the economic issues of invasion (Mack *et al.*



2000, Hager 2004). The total cost of invasive introduced plants to the U.S. economy is about \$27 billion annually, between loss of crop production and control of invasive plants (Pimental *et al.* 2004). Invasive wetland plant species can shift vegetation dynamics, creating large monospecific stands, and reduce nutrient and light availability (Hager 2004; Barrett 2010). When invasive plant species inhabit an area they generally uptake nutrients faster and photosynthesize quicker than native species. For example, nitrogen, phosphorus and potassium uptake from the soil can limit native species growth when larger invasive species such as *Typha* spp. and *Phragmites (Cav.) Trin. ex Steud.*, are present (Campbell *et al.* 2000). These species have very large rhizomes which give them the advantage of nutrient uptake over native species. Moreover faster nutrient uptake coupled with rapid photosynthesis and growth gives invasive species phenologic competitive advantage at early growth stages. Invasive plant species can also make habitat conditions more conducive to them which create growth problems for native flora. For example, low nutrient availability correlated with a decline in native species can increase invasive species establishment when the soil quality is poor (Kercher and Zedler 2004, Rickey and Anderson 2004). Campbell *et al.* (2000) found that soils in created and managed wetlands had less organic matter content, greater bulk densities, and created managed wetlands tended to have sandy loam textures while non-managed reference wetlands had a clay loam texture with high silt content.

Invasion of non-native wetland species generally occurs when ecological changes promoting establishment correspond with seed availability. Non-native invasive plant seeds commonly come from waterfowl but once established they tend to spread by wind, waterways, and rhizomes and can be potentially furthered by human-mediated dispersal (Catford *et al.* 2011). In addition, manipulating water levels can promote plant invasion by

providing suitable establishment sites or inhibiting competition from native species unsuited to the altered hydrology conditions (Herrick & Wolf 2005, Barrett *et al.* 2010). Lowering water levels is a common technique used by wetland managers to control the temporal window of seedling recruitment opportunity and restoration techniques frequently involve using or augmenting the existing soil seed bank to facilitate native species recruitment (Neff *et al.* 2009). Also the creation of temporary mud flats provides valuable stopover sites for migratory shore birds to eat and nest (Burger *et al.* 1997). A series of factors such as water frequency, depth and duration are large controls of seed germination and for the development of plant community establishment. Changing of water levels is also a means for hydrochory, which is water dispersal of seeds. This can lead to increased range of unwanted non-natives and invasive species.

Creating dikes within a pump system allows for water level manipulation to manage the vegetation uses to promote wildlife use. Managed wetlands use pumps to change the water levels in the spring to administer a range of water levels from mudflats to feet (ODNR 2010). Diked wetlands allow for other management techniques to be accomplished easier such as controlled burns and herbicide treatments. Wetland dikes can contain the targeted plants in an area and avoid from disrupting other areas of non interest.

Keddy (1986) found that stable water levels reduced marsh area and plant species diversity because it inhibited the growth of many wetland plants but a few species such as, *Typha* spp. and *Phragmites australis* (Cav.) Trin. ex Steud, can withstand persistent high water levels. Other studies found that changes in hydrologic regimes affected soil conditions and nutrient levels which changed the plant community making it vulnerable to invasion

(Svengsouk and Mitsch 2001; Catford *et al.* 2011). Open soil surface and high nutrient availability gave opportunistic invasive species a window for establishment.

This study examined whether changes in hydrologic levels by wetland managers affected the diversity and abundance of native non-native plants compared to wetlands where the hydrology was not manipulated. Comparing the responses of native flora and non-native invasive flora will help determine whether this management technique is correlated with plant community structure. Measuring the water depth will also give insight on an optimal depth to get the most native plant composition and diversity.

## MATERIALS AND METHODS

### STUDY SITE DESCRIPTION

Two northwest Ohio wetlands, Pickerel Creek and Mallard Club Marsh Wildlife Areas, were used in the study. These diked channelized wetlands use drawn down and flooding techniques to manipulate water levels to promote native vegetation for waterfowl. Pumped water through these wetlands is provided by ditches that connect to Lake Erie and state managed by the Ohio Department of Natural Resources.

The Mallard Club Marsh Wildlife Area (41° 40' 39" N 80° 20' 48" W) located in Lucas County Ohio and is a 163 hectare wetland with water levels fluctuating from a few centimeters up to 1 m and Maumee Bay State Park is bordered on the west. Lake Erie's Maumee Bay lies to the north and Cedar Point National Wildlife Refuge to the northeast. A glaciated clay-silt soil covers the wildlife area and most of the county. Pickerel Creek Wildlife Area (41° 24' 33" N 82° 55' 34" W) encompasses nearly 1300 hectare and is located in Sandusky County Ohio. Most of the area has been restored to wetland with the remainder in woods, brush, and native grassland. Pickerel Creek flows through the western half of the area, forming a high quality freshwater estuarine habitat (ODNR). Dikes and channels were designed to manipulate wetland water levels to enhance native vegetation. The soil layer in this area is a silty-clay. Non-native invasive plants typically are found in large communities in shallow water near water channels in both of these managed wetlands. These wetlands are currently managed as a public hunting, fishing, trapping, and wildlife observation areas with emphasis on waterfowl and other wetland wildlife.

The two northeast Ohio wetlands we chose to include, Mill Creek Preserve and Little Beaver Creek Greenway are characterized by no water flow regulation and are only maintained by periodic herbicide spraying. Typically these wetlands are wet year round and are primary waterfowl and migratory bird habitats.

Mill Creek Preserve (40° 59' 25" N 80° 41' 46" W) lies in Boardman Township inside Mahoning County. The preserve consists of over 300 acres of upland and wetland habitats. The preserve was once the Orvets Sod Farm and the Mill Creek Metro Parks acquired the property using grants from the Clean Ohio Conservation Fund and Wetland Resource Restoration Sponsorship Program (WRRSP). Project was planned to return about 50 acres of the sod farm to the wetland and floodplain habitats that were originally present before the land was used for farming. The preserve holds water in the wetland and only fluctuates according to the natural yearly precipitation. Native vegetation was promoted during construction however over time propagule pressure has created an introduction of exotic and invasive species. Mill Creek Preserve has a silty-loam soil layer. The Little Beaver Creek Greenway (40° 52' 00" N 80° 46' 32" W) provides a scenic walking and biking trail. The trail extends approximately twelve miles from Lisbon to Leetonia in Columbiana County. The trail is popular among cyclists and wildlife observers. The trail is maintained by the Columbiana County Park District. The trail is in the Little Beaver Creek watershed and has numerous acres of wetlands that lie on either side of the trail. This area has a high functioning railroad system that runs through it and farm fields that border the wetlands. Wetland water levels fluctuate based on yearly precipitation only and are unmanaged by the Columbiana County Park District. This area and much of the county have a silty-loam soil layer.

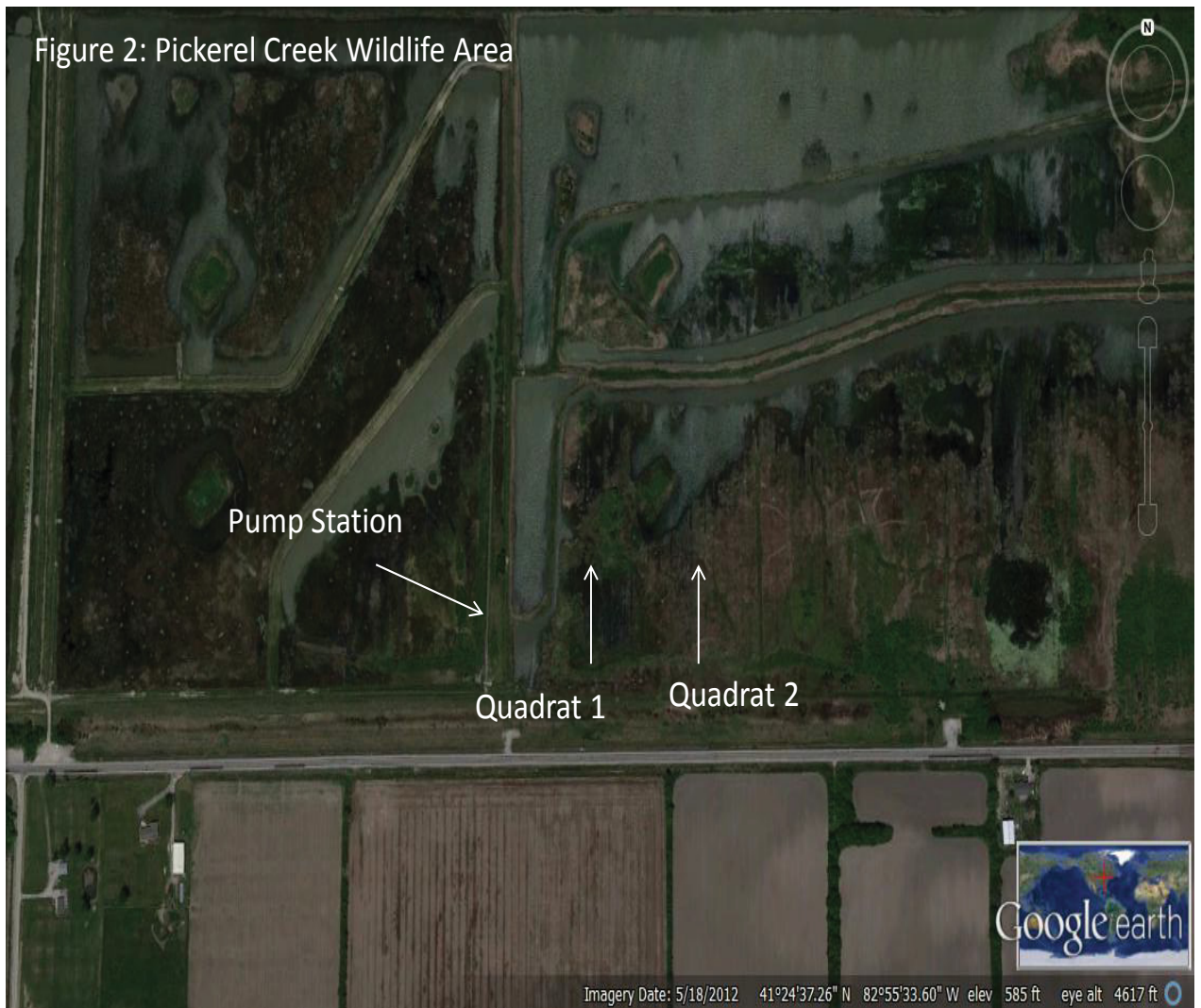
**Figure 1: Mallard Club Marsh Wildlife Area (41° 40' 39" N 80° 20' 48" W)**

Located in Lucas County Ohio north of Cedar Point road. Water levels are manipulated by the pump station that pumps water from Cousino ditch which flows out to Lake Erie. Quadrat 1 was placed off the main water channel in the first cell. Water flow can be exchanged between diked wetland cells. Quadrat 2 was placed on the other side of the dike off the main water channel (Constructed using Google Earth)



**Figure 2: Pickerel Creek Wildlife Area (41° 24' 33" N 82° 55' 34" W)**

Located in Sandusky County north of US route 6. Water levels are manipulated by the pump station and the cells are diked. Water flow is exchanged between channels and cells. Quadrat 1 was placed off the main channel and quadrat 2 was placed 100m from quadrat 1. Quadrats were located in cell C.5 (Constructed using Google Earth).





**Figure 3: Mill Creek Preserve Wetlands (40° 59' 25" N 80° 41' 46" W)**

Located in Boardman Township North of Western Reserve road. Quadrats were placed on either side of the main wetland pond. Tree line surrounds the wetland area. Precipitation events allow water flow through the wetland area (Courtesy of Mill Creek Metropark).





**Figure 4: Little Beaver Creek Greenway (40° 52' 00" N 80° 46' 32" W)**

Located in Columbiana County and the study site was ¾ mile from the Greenway Bike path trail head parking lot. South of the bike trail quadrat 1 and 2 were placed 100m apart just off the main water channel (Constructed using Google Earth).

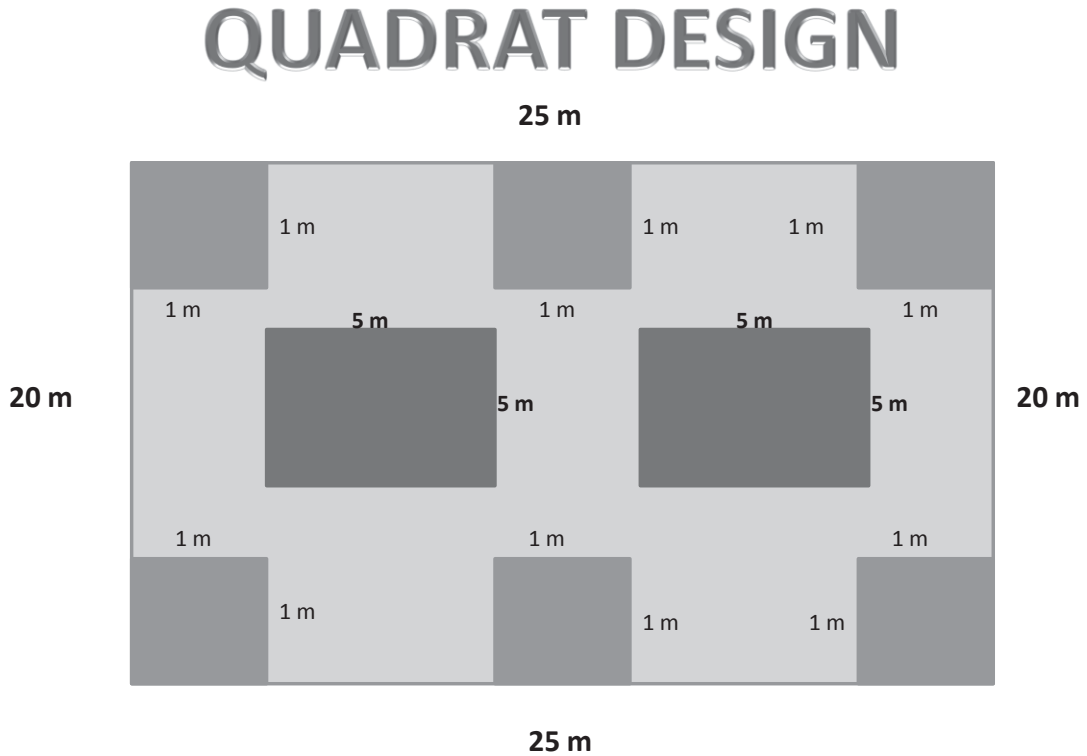


## VEGETATION SURVEY

Wetland plant surveys were taken from late March through late August of 2012. Observations were made at the beginning and middle of each month. Managed wetlands were observed in the same day and unmanaged wetlands were observed within 3 days of the managed wetlands staying within a one week period. In each site two randomly placed 25m x20m (500m<sup>2</sup>) Modified Whittaker plots were marked with wooden survey stakes with each plot containing two 25m<sup>2</sup> plots and six 1m<sup>2</sup> nested plots. Global Positioning System (GPS) coordinates marked the boundaries of the quadrat and each 25m<sup>2</sup> plot. The Daubenmire Method of cover abundance was the model used for percent coverage in each 25m<sup>2</sup> and 1m<sup>2</sup> plot. Daubenmire Method uses six separate cover classes, (1) 0-5%, (2) 5-25%, (3) 25-50%, (4) 50-75%, (5) 75-95%, (6) 95-100%, and the midpoint of each class was used to quantify cover (i.e. 2.5%, 15.0%, 37.5%, 62.5%, 85.0%, and 97.5%). Plant species were observed and inventoried. Cover observations in the 1m<sup>2</sup> plots were taken by placing a 1m<sup>2</sup> removable plot marked every 10cm. Voucher specimens were collected and deposited in the Youngstown State University Herbarium and nomenclature follows Braun (1989), Newcomb (1977) and plant characteristics were obtained using the United States Department of Agriculture's Plant Database (USDA 2013). Photo plots were recorded on every observation to aid in identification and show change in vegetation over time. Wetland Indicator Status (US Fish and Wildlife 1996) was assigned to each plant species by using the following values: Obligate Wetland Species (OBL), occur almost always (>99%), Facultative Wetland Species (FACW), usually occur in wetland (67-99%), but occasionally found in non-wetlands, Facultative species (FAC), likely to occur in wetlands and non-wetlands (34-66%), Facultative Upland species (FACU), occasionally found in wetlands (1-33%), Obligate Upland species (UPL), are almost always found in non-wetlands.

**Figure 5: Quadrat Design**

This figure shows the quadrat design with 20x25m containing two 25m<sup>2</sup> plots and six 1m<sup>2</sup> plots. Whittaker plots were placed at least 100m apart at each study site.



- (2) 5 METER X 5 METER PLOTS
- (6) 1 METER X 1 METER PLOTS
- (Balcombe 2005)

## DATA ANALYSIS

Percent cover estimates were made at each plot and the total estimated cover for each species was calculated as:

Cover calculation:

$$\begin{aligned} \% \text{ cover of spp } A &= (\# \text{ of plots cover class 1 } * 2.5\% \\ &+ \# \text{ of plots cover class 2 } * 15.5\% \\ &+ \# \text{ of plots cover class 3 } * 37.5\% \\ &+ \# \text{ of plots cover class 4 } * 62.5\% \\ &+ \# \text{ of plots cover class 5 } * 85.0\% \\ &+ \# \text{ of plots cover class 6 } * 97.5\%) \div \text{ total number of plots} \end{aligned}$$

Mean percent cover of native and invasive species in water-level managed and unmanaged wetlands was compared using a one-way analysis of variance (ANOVA). Rain data and stream flow changes were monitored first hand using the Army Core of Engineers standard (1987) and by using United States Geological Survey current water data for each area. Lake level data was also monitored for the Northwest Ohio wetlands since water flow from Lake Erie directly affects the water levels in the nearby ditches that flow into them. Water level height was recorded then for all study areas.

## RESULTS

### VEGETATION

A total of 43 plant species were recorded in 64 plots within both managed and unmanaged wetlands. Of the recorded species 9 were invasive. Highest coverage of invasive species found in the water flow managed wetlands was flowering rush (*Butomus umbellatus* L.), arrowhead (*Sagittaria latifolia* Willd.), narrow leaf cattail (*Typha angustifolia* L.) and European frogbit (*Hydrocharis morsus-ranae* L.) (Table 1). Managed wetlands had 23 species identified with 7 invasive species recorded. The highest coverage of native species in managed wetlands included Pennsylvania smartweed (*Polygonum pensylvanicum* L.), common spikerush (*Eleocharis palustris* (L.) Roem. & Schult.) and annual canary grass (*Phalaris canariensis* L.). Unmanaged wetlands had 33 species identified with 4 invasive species recorded. These wetlands had invasive plant species that included multiflora rose (*Rosa multiflora* Thunb.), narrow leaf cattail (*Typha angustifolia* L.), swamp dock (*Rumex verticillatus* L.) and arrowhead (*Sagittaria latifolia* Willd.). Understory of both managed wetlands and unmanaged Little Beaver Creek Greenway had high coverage numbers of the star duckweed (*Lemna trisulca* L.) and common duckweed (*Lemna minor* L.) Among all study plots the majority of plants species were considered either Obligate Wetland Species (OBL) (>99%) or Facultative Wetland Species (FACW) (67-99%). Few terrestrial plant species were found inside the study plots. Aquatic vegetation was only found in areas of stabilized water levels this mostly due to over drying of the species in low water or mud flats. Large monospecific stands of the invasive species *Phragmites australis* (Cav.) Trin. ex Steud, were found around plots but were avoided because of their dominate coverage in

areas. A list of species identified in this study along with wetland indicator status is given in Table 2.

## DATA ANALYSIS

We found invasive plant species cover in managed wetlands was 34.6% higher than in reference wetlands, with a mean non-native species cover of 30%. Unmanaged wetlands had a mean non-native species cover of 9.5%. Mallard Club Marsh Wildlife Area had 67% cover of invasive with 33% native cover (Fig. 6). Invasive species cover was high for *Butomus umbellatus* (21%) and *Sagittaria latifolia* (39%) in this managed wetland. Mallard Club Marsh had a fairly high native species cover for one species which was *Polygonum pennsylvanicum* (23%) (Fig. 7). Pickerel Creek Wildlife Area had an invasive cover of 81% and 19% cover of native species (Fig. 8). Primary invasive species cover was high for *Butomus umbellatus* (44%) and *Typha angustifolia* (14%) (Fig. 9). Mill Creek Preserve had an invasive cover of 29% and a native cover of 71% (Fig. 10). Narrow leaf cattail (*Typha angustifolia*) had the highest invasive species cover with 13% while species *Ludwigia palustris* (L.) Elliott (22%), *Bidens* spp. (20%) and *Eleocharis palustris* (L.) Roem. & Schult (17%) had the highest native cover (Fig. 11). Little Beaver Creek Greenway also had 71% native cover and 29% invasive cover (Fig. 12). Little Beaver Creek had high native cover of aquatic species such as *Nuphar lutea* (L.) Sm. (29%), *Lemna minor* L. (25%) and *Ceratophyllum demersum* L. (16%) (Fig. 13).

We found that non-native species were marginally significantly higher by 190% in managed relative to unmanaged wetlands (Fig. 14,  $F_{1,3} = 11.8$ ,  $p = 0.075$ ). Native species



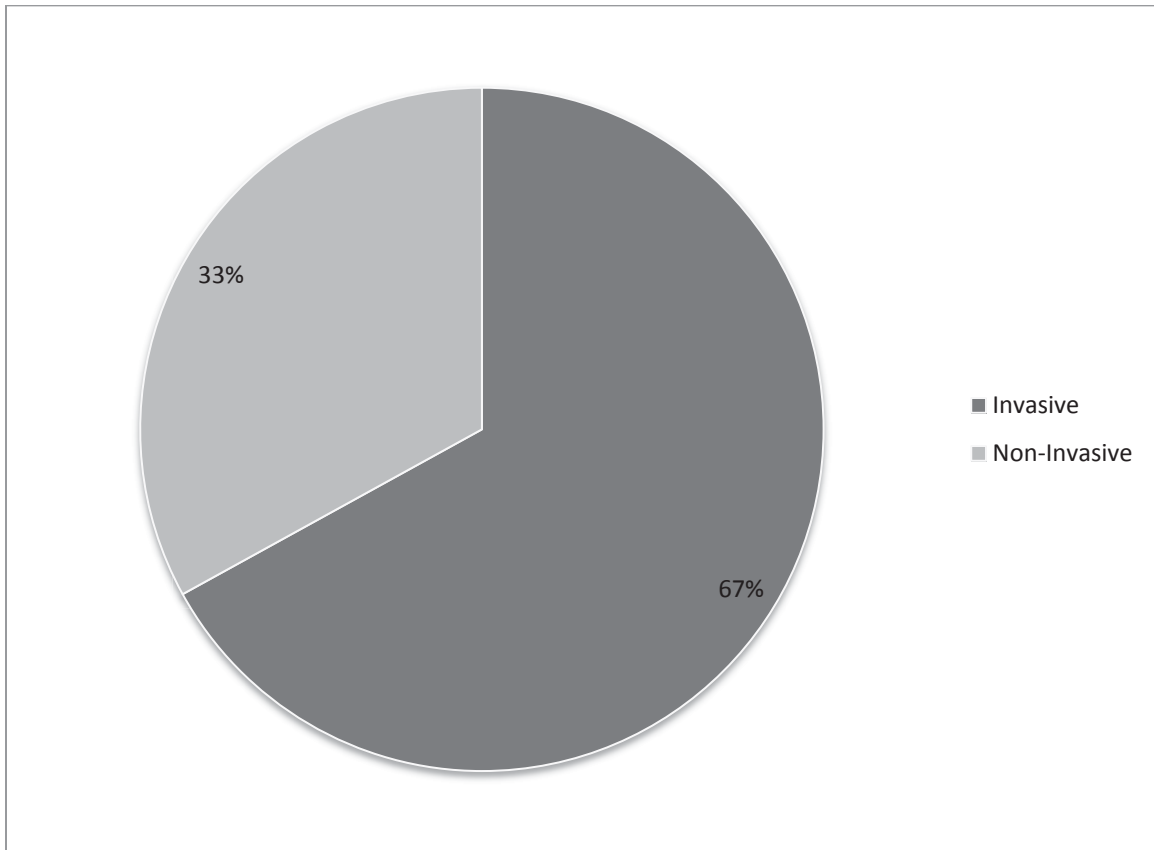
were significantly higher in unmanaged relative to managed wetlands by 160% (Fig. 14,  $F_{1,3} = 31.6$ ,  $p = 0.030$ ).

## OBSERVED WATER LEVEL

Pickerel Creek Wildlife Area plots started in March with 55cm (~1.8 feet) of water in all study areas. At this point in the season managers were holding water levels and letting excess water from natural precipitation out to hold levels less than 1 meter. Starting at the end of May a drawdown was done to create mud flats with some areas having pools of water about 4-5cm. Mudflats were maintained in July and August. Mallard Club Marsh Wildlife Area had 60cm (~2 feet) of water in all study areas in March and by June water levels were dropped to 9cm in some parts of the plots and mudflats in the other. For July and August complete mudflats had been maintained. Starting the last week of August the water levels were being raised for the waterfowl season and migratory bird movement. Mill Creek Preserve Wetlands started in March with 10cm of water with some areas being mud flats. In July and August water maintained around 6-8cm losing water to evaporation. Areas that were mudflats in March were now dry land which increased the terrestrial species. Little Beaver Creek Greenway starting in March held 76-90 cm (2.5-3 feet) across the study area with the southern edge having 6-7 cm of water. Water levels dropped in July and August to 10cm with the southern edge only maintaining 3-5cm. Some aquatic vegetation was dying off in these areas. Precipitation among all study plots was below the annual average for the time of year.

**Figure 6: Relative cover of invasive and non-invasive species in Mallard Club Marsh**

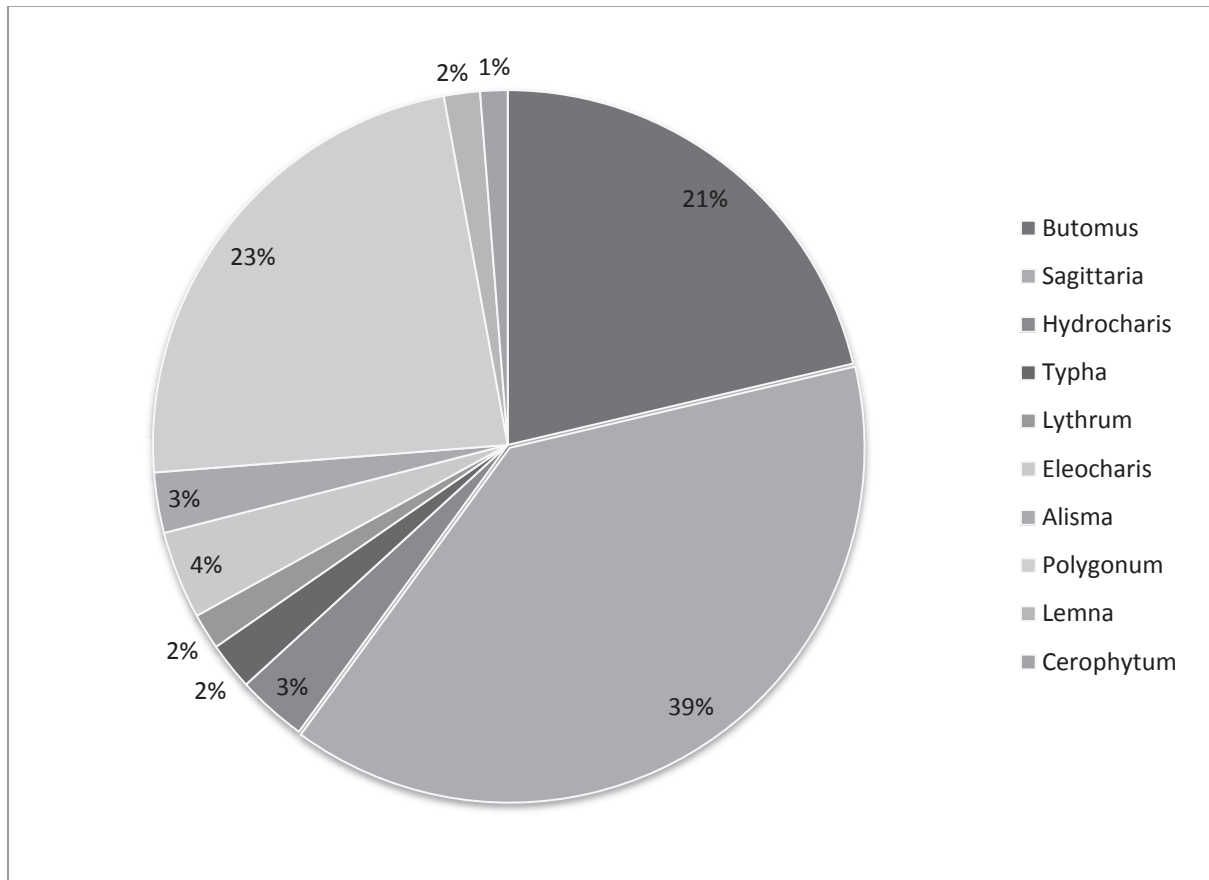
The graph shows relative percent cover of invasive plant species (67%) and non-invasive species (33%) among plots in Mallard Club Marsh.





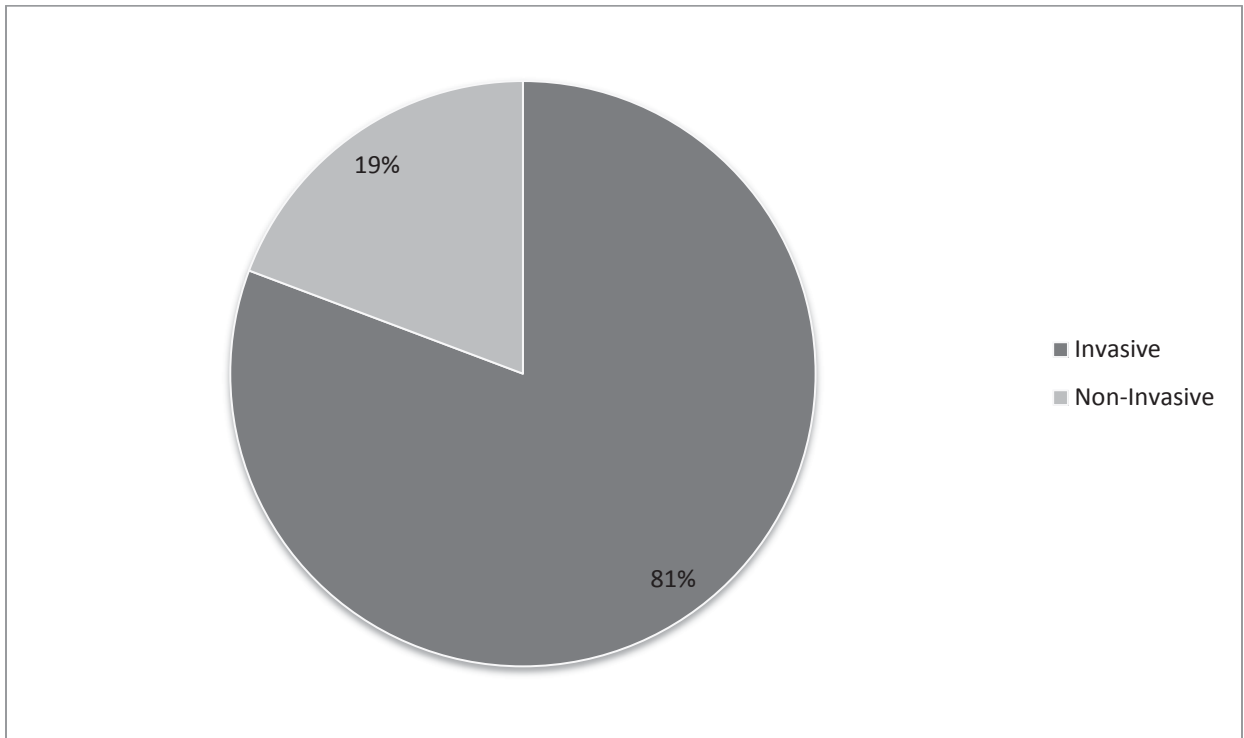
**Figure 7: Relative Cover of individual species in Mallard Club Marsh**

This graph shows the distribution of plant species among plots in Mallard Club Marsh with coverage greater than 1%. Significant invasive species was *Butomus* (21%), *Sagittaria* (39%). Significant native species was *Polygonum* (23%).



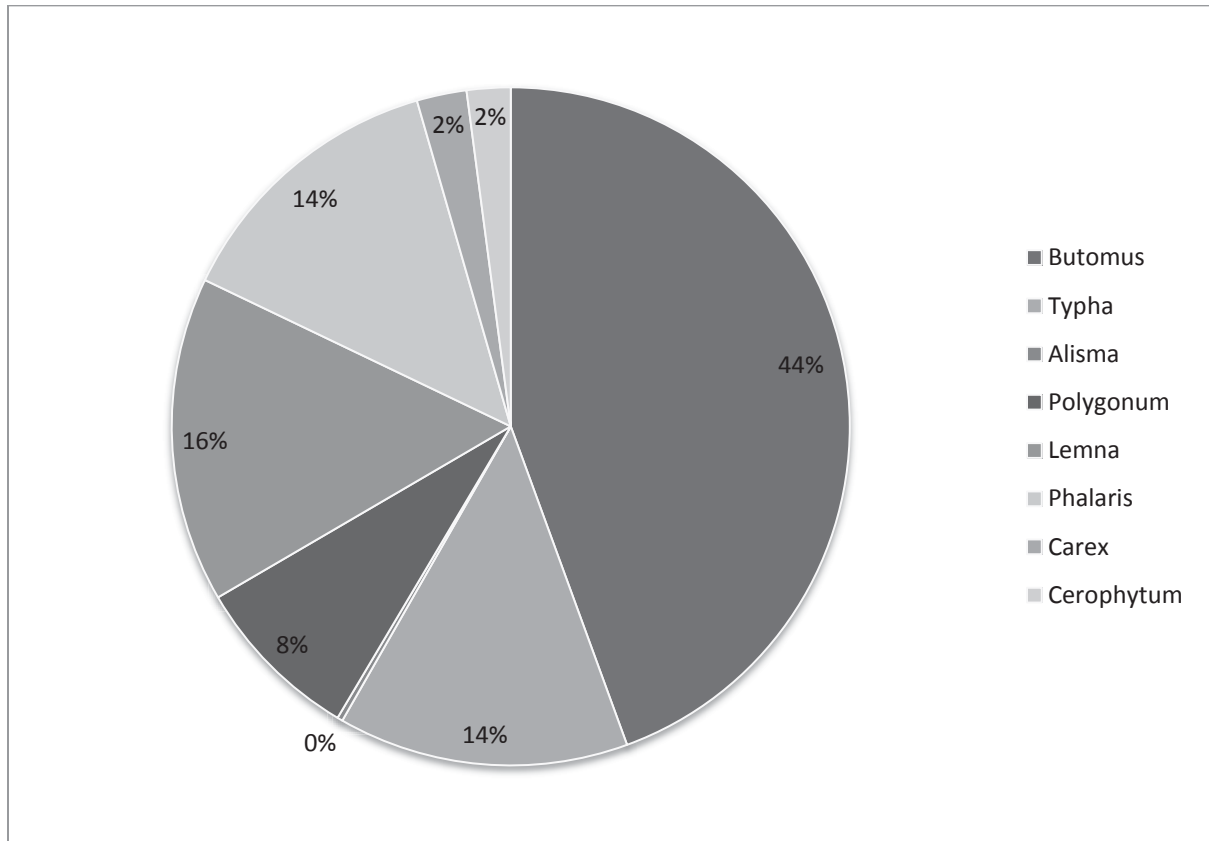
**Figure 8: Relative cover of invasive and non-invasive species in Pickerel Creek Wildlife Area**

This graph shows the relative percent cover of invasive species (81%) and non-invasive species (19%) among plots in Pickerel Creek Wildlife Area.



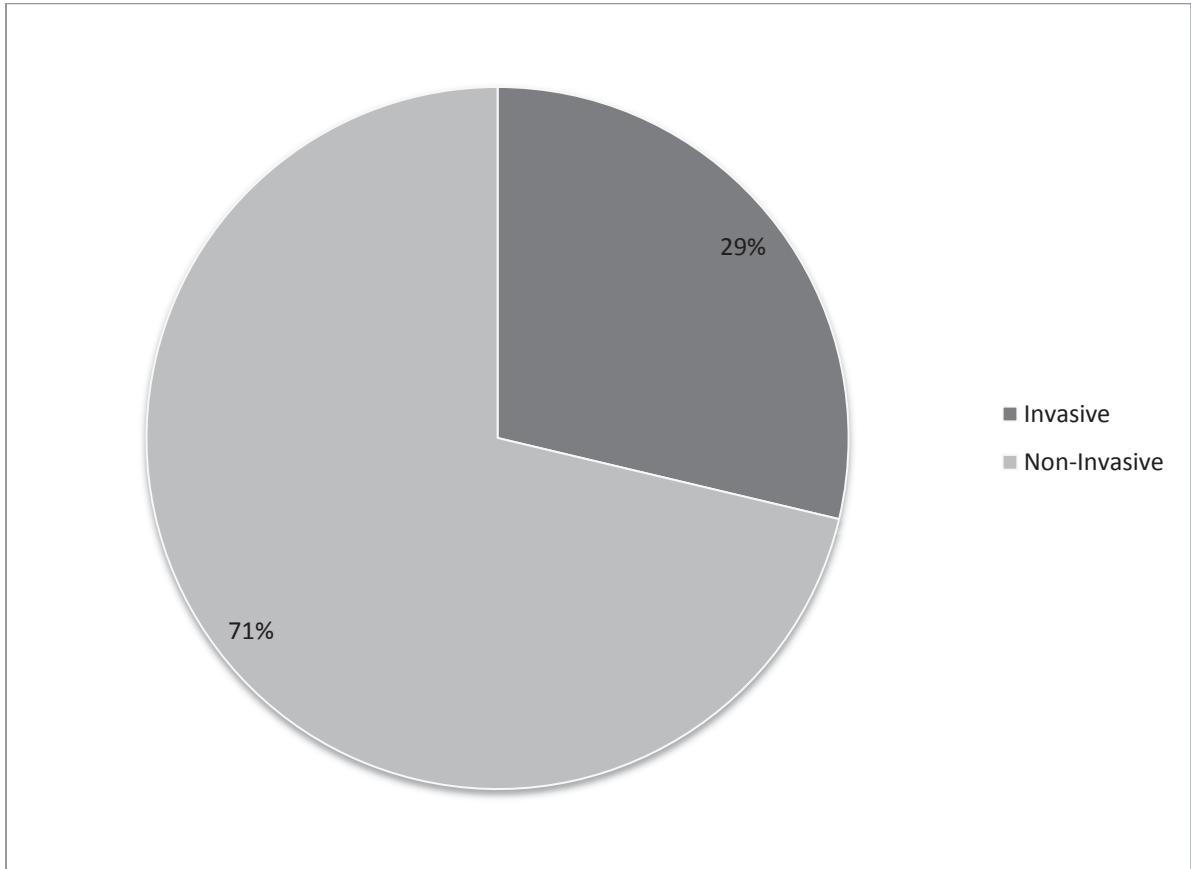
**Figure 9: Relative cover of individual species in Pickerel Creek Wildlife Area**

This graph shows the distribution of plant species among plots in Pickerel Creek Wildlife Area with coverage greater than 0.5%. Invasive species *Butomus* (44%) and *Typha* (14%) mark the highest coverage with native species *Lemna* (16%) and *Phalaris* (14%).



**Figure 10: Relative cover of invasive and non-invasive species in Mill Creek Preserve**

This graph shows the relative percent cover of invasive species (29%) and non-invasive species (71%) in Mill Creek Preserve Wetlands.

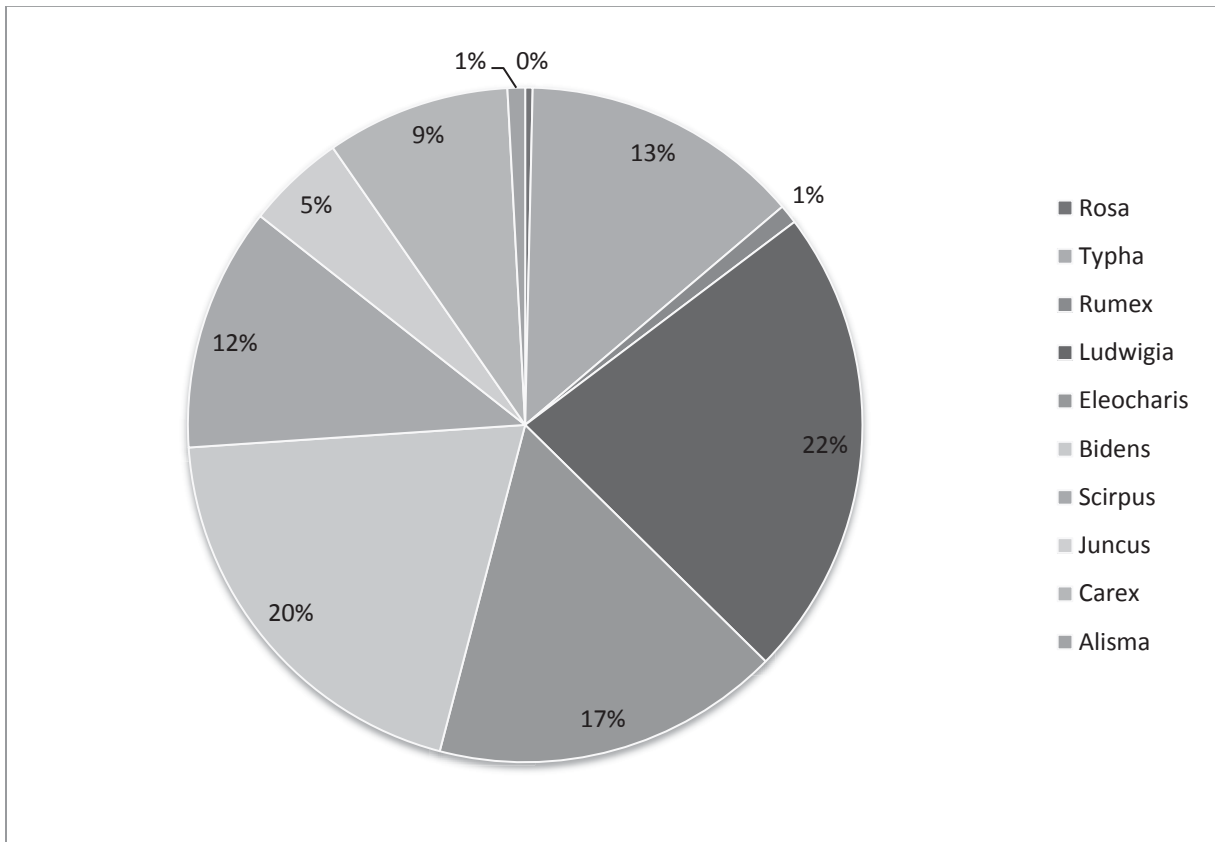


**Figure 11: Relative Cover of individual species in Mill Creek Preserve**

This graph shows the distribution of plant species among plots in Mill Creek Preserve

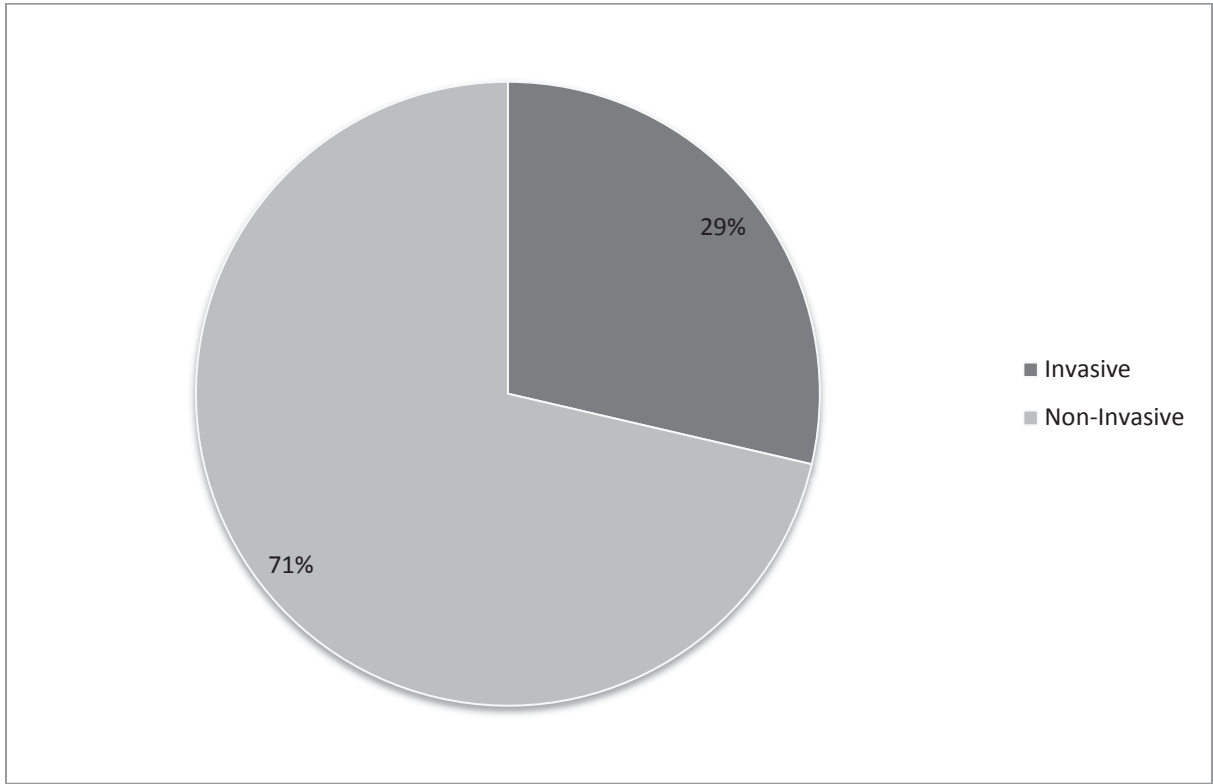
Wetlands with coverage greater than 0.5%. Significant invasive species was *Typha* (13%).

Native species had high coverage in *Ludwigia* (22%), *Bidens* (20%) and *Eleocharis* (17%).



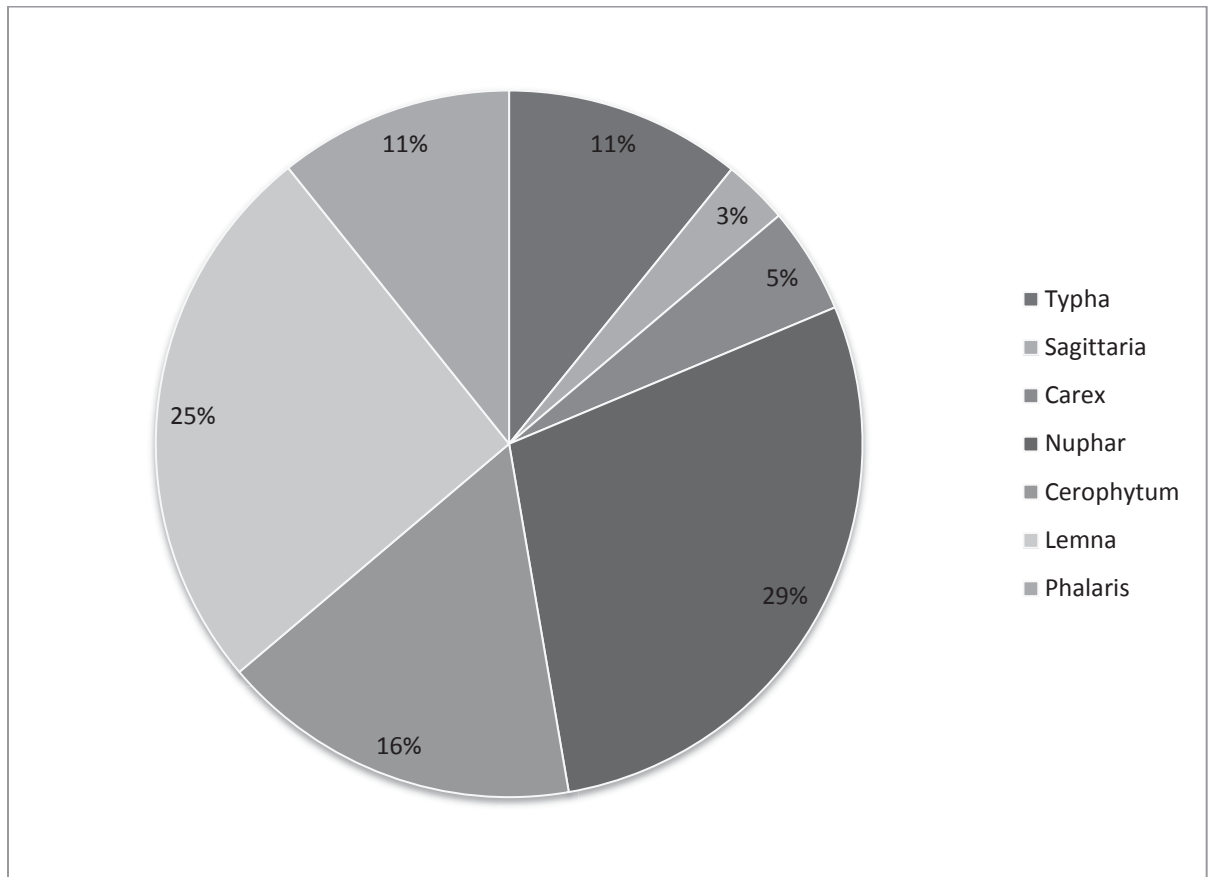
**Figure 12: Relative cover of invasive and non-invasive species in Little Beaver Creek Greenway**

This graph shows the relative percent cover of invasive species (29%) and non-invasive (71%) in Little Beaver Creek Greenway Wetlands.



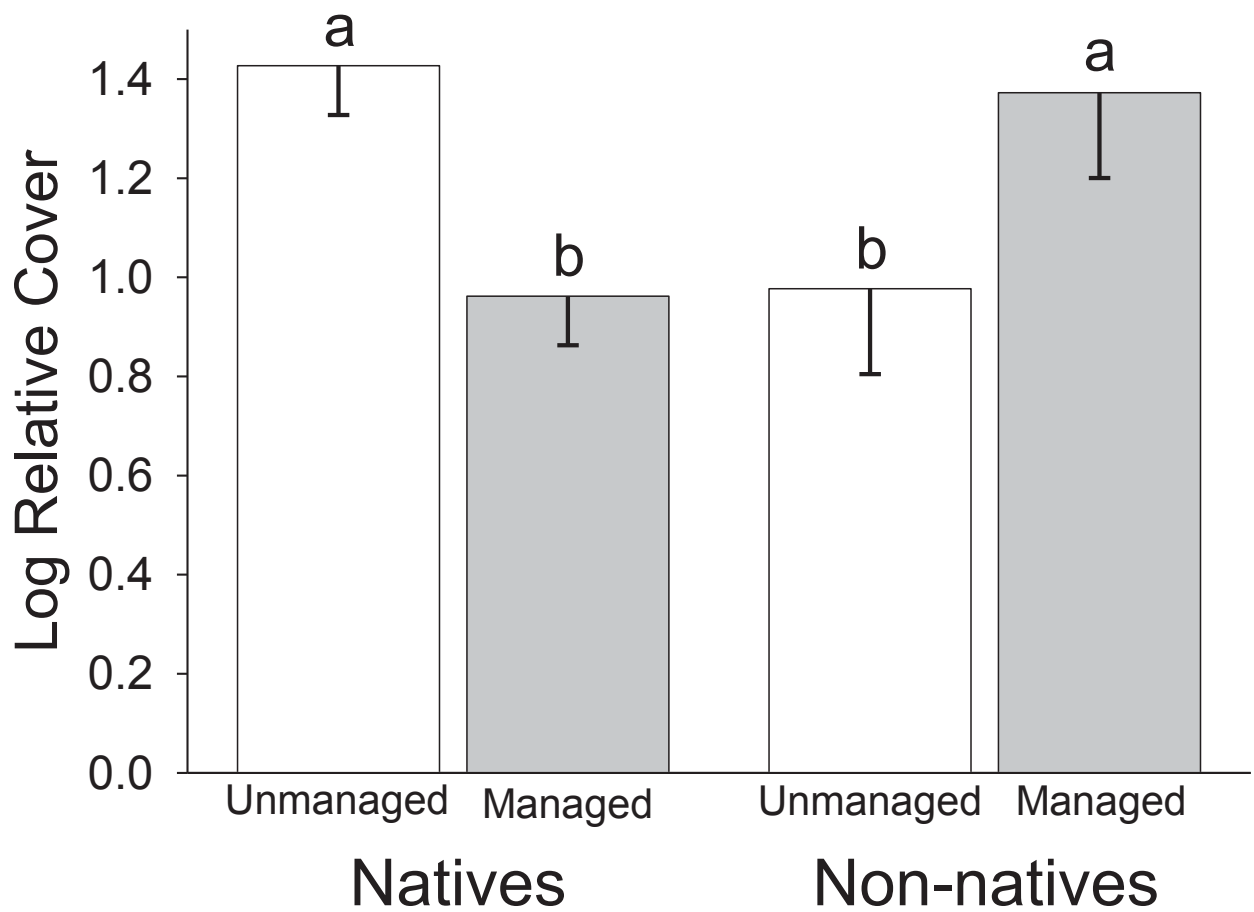
**Figure 13: Relative Cover of individual species in Little Beaver Creek Greenway**

This graph shows the distribution of plant species among plots in Little Beaver Creek Greenway Wetlands with coverage greater than 1%. Invasive species present were Typha (11%) and Sagittaria (3%). Significant native species were *Nuphar* (29%), *Lemna* (25%) and *Ceratophyllum* (16%).



**Figure 14: Comparison of native and invasive species between water-level managed and unmanaged wetlands**

Non-native species were marginally significantly higher by 190% in managed relative to unmanaged wetlands ( $F_{1,3} = 11.8, p = 0.075$ ). Native species were significantly higher in unmanaged relative to managed wetlands by 160% ( $F_{1,3} = 31.6, p = 0.030$ ).





**Table 1: Mean Percent Cover of invasive species by plot at each wetland site.**

Daubenmire mean percent coverage of invasive species for plots at each wetland. A blank space represents 0% cover of that species in the plot. Mallard Club Marsh (MCM), Pickerel Creek Wildlife Area (PC), Mill Creek Preserve (MCP), Little Beaver Creek Greenway (LBC).

Invasive Percent coverage	MCM 1	MCM 2	PC 1	PC 2	MCP 1	MCP 2	LBC 1	LBC 2
<b>Species</b>								
<i>Butomus umbellatus</i>	36.2	28.8	58.4	48.1				
<i>Sagittaria latifolia</i>	50	68					3.8	5.6
<i>Hydrocharis morsus-ranae</i>	7.2	2.5						
<i>Typha angustifolia</i>	4.1	2.5	17.2	16	24.1	21.2	22.2	11.9
<i>Lythrum salicaria</i>	2.5	2.5						
<i>Rosa multiflora</i>					0.6	0.6		
<i>Rumex verticillatus</i>					0.6	2.5		
<i>Lycopus americanus</i>	0.6	0.6						
<i>Cirsium vulgare</i>	2.5	2.5	2.5	3.8				

**Table 2. Plant taxa identified across the four wetlands.**

This table shows the 43 plant species that were recorded in 64 plots within both managed and unmanaged wetlands. Of the recorded species 9 were invasive. Wetland Indicator status of each plant species is shown on the right side of the table.

Species	Little Beaver Greenway	Millcreek Wetlands	Pickereel Creek	Mallard Club Marsh	Wetland Indicator Species
<i>Phalaris canariensis</i>	X		X		FACU
<i>Lemna minor</i>	X		X	X	OBL
<i>Cirsium vulgare</i>			X	X	UPL, FAC
<i>Butomus umbellatus</i>			X	X	OBL
<i>Typha angustifolia</i>	X	X	X	X	OBL
<i>Utricularia vulgaris</i>			X	X	OBL
<i>Lemna trisulca</i>	X		X	X	OBL
<i>Alisma subcordatum</i>		X	X	X	OBL
<i>Sagittaria latifolia</i>	X		X	X	OBL
<i>Eleocharis palustris</i>		X	X	X	OBL
<i>Polygonum pensylvanicum</i>	X		X	X	FACW
<i>Ceratophyllum demersum</i>	X			X	OBL
<i>Hydrocharis morsus-ranae</i>				X	OBL *
<i>Rumex verticillatus</i>		X			FACW
<i>Nuphar lutea</i>	X				OBL
<i>Ludwigia palustris</i>		X			OBL
<i>Bidens spp. (no flower)</i>		X			OBL
<i>Scirpus schoenoplectus</i>		X			OBL
<i>Hypericum perforatum</i>	X	X			FACU
<i>Rosa multiflora</i>	X	X			FACU
<i>Symphotrichum novae-angliae</i>		X			FACW
<i>Eupatorium perfoliatum</i>		X		X	FACW
<i>Verbesina alternifolia</i>		X			FAC
<i>Sium suave</i>				X	OBL
<i>Lycopus americanus</i>				X	OBL
<i>Carex lurida</i>	X	X	X		OBL
<i>Carex tribuloides</i>			X	X	FACW
<i>Riccia fluitans</i>				X	NA
<i>Juncus effusus</i>		X			OBL
<i>Scirpus polyphyllus</i>		X			OBL
<i>carex scoparia</i>		X			FACW
<i>Eleocharis obtusa</i>		X			OBL
<i>carex comosa</i>	X				OBL
<i>carex stipata</i>	X		X		OBL
<i>Polygonum hydropiperoides</i>		X	X		OBL
<i>Lythrum salicaria</i>				X	OBL
<i>Scirpus validus</i>		X			OBL
<i>Cephalanthus occidentalis</i>		X			OBL
<i>Rosa palustris</i>		X			OBL
<i>Juncus canadensis</i>		X			OBL
<i>Hypericum mutilum</i>		X			FACW
<i>Cornus sericea</i>		X			FACW
<i>Xanthium</i>		X	X	X	FAC

## DISCUSSION

Our data indicates that the water-level managed wetlands in northwest Ohio were highly invaded by non-native species compared to unmanaged wetlands in northeast Ohio. The data also suggests that native species abundance was greater in unmanaged wetlands. Cover measurements favor the unmanaged wetlands for having greater species diversity.

Increased nutrient availability has been found to increase productivity of invasive species (Svengsouk and Mitsch 2001, Catford *et al.* 2011). The northwest Ohio wetlands were all diked wetlands which have been found to have higher soil organic matter, Nitrogen (N), Phosphorus (P) and Potassium (K). These wetlands tend to have greater agricultural and urban runoff creating an increase in nutrient levels. Since these wetlands are managed and natural fluctuations with the ditches and the lake do not occur often, they hold these nutrients in the soil. Mallard Club Marsh and Pickerel Creek Wildlife Area both become isolated during the drawdown process therefore are isolated from experiencing natural water level fluctuations and nutrient exchange with Lake Erie. Highly competitive invasive species are likely to displace native vegetation in nutrient high wetlands (Wilson and Keddy 1986). This could be one of the factors that influenced the invasive species cover in the managed sites.

Wetland managers have an ongoing battle of trying to control one invasive while avoiding establishment of another. By stabilizing water levels to inhibit lower invasive vegetation can be effective, however some invasive species such as *Typha* spp, *Lythrum salicaria* and *Phragmites australis* are highly tolerant of deeper standing water (Barrett *et al.* 2005). Large stands of *Typha* spp. and *P. australis* were found among our sites and would cover acres of the wetland. Our plots were then placed off main channels to ensure flow

regulated vegetation would be present but to avoid 100% dominance of these species. These species were also found in our unmanaged sites with *T. angustifolia* found in our plots and *P. australis* found in areas outside of our study plots.

In our managed wetlands the highest invasive species cover was *Sagittaria latifolia* and *Butomus umbellatus*. These two species have a typical dispersal by hydrochory (water dispersal of seeds). The hydrology change in the managed wetlands may further facilitate the dispersal of these species by allowing them to travel between wetland cells and allowing them to flow into nearby ditches. Ditches then become seed sources for other wetland areas that are connected (Herrick and Wolf 2005). When water levels are lowered the invasive seeds remain in the soil seed bank. The seeds go dormant during the winter months then in the spring, when the drawdown occurs, germinate when it is advantageous. Early stage germination and community development is typical for many invasive species that merely need a small window of opportunity to establish (Catford *et al.* 2011). Studies of soil seed banks of wetlands in the region of our study sites have shown these wetlands are highly susceptible to invasion especially by *L. salicaria*. This was supported by Herrick and Wolf 2005 which showed a 92% of *L. salicaria* seeds germinating under a mimicked drawdown soil treatment. It should be noted that *L. salicaria* was found only in our Mallard Club Marsh wetland.

Keeping mudflats in the managed wetlands through July and August create an opportunity for wind dispersal of invasive seeds to reside. A shift to drier conditions creates an opportunity for terrestrial non-native species to invade wetland areas where they once were unsuitable for these species (Johnston *et al.* 2008, Catford *et al.* 2011). Drier bank edges allow encroachment of the terrestrial species. As water levels dropped we found

increased identification and cover of terrestrial plant species. This finding was also significant in the unmanaged wetlands. With the natural water level drop due to evaporation in our unmanaged wetlands, plot areas that were drying up or lowering to a few centimeters, had increased cover of *Carex* spp and *Ludwigia palustris* which are found in wetlands but typically in moist soil and are not high water level tolerant. Increased grassland species, *Verbesina alternifoli* (L.) Britton ex Kearney and *Hypericum perforatum* L. were found in our unmanaged plots when the soil was drier in August. Our managed wetlands saw an increase in bull thistle (*Cirsium vulgare* (Savi) Ten), which is an invasive upland species along with increased cover in the Pickerel Creek site of *Phalaris canariensis* L.

*Polygonum* spp. and *Lemna* spp. were notably the highest native food and cover species for waterfowl in the managed wetlands. Area managers seem to be successful in keeping the cover of these important forage plants in the managed wetlands which is crucial for their migratory waterfowl population. These wetlands are managed for the objective of promoting wildlife habitat and to entice migratory waterfowl so a diversity of food sources and cover are needed to maintain a dynamic ecosystem.

This study also established the first documented occurrence and distribution of European frogbit (*Hydrocharis morsus-ranae* L.) in Mallard Club Marsh Wildlife Area. This is an invasive plant species that had only been documented one other time in Ohio. In 2004 Richard Gardner first identified the species in the Cedar Point National Wildlife Refuge in Lucas County. The Cedar Point National Wildlife Refuge borders the Mallard Club Marsh Wildlife area on its eastern side. European frogbit's current range is throughout much of central and southwestern parts of southern Ontario into northern New York, Vermont, and eastern Michigan as well as Washington State (Catling *et al.* 2003). In the Great Lakes, this

species occurs along Lake Erie and Lake Ontario as well as St. Lawrence and Ottawa Rivers. With documentation from the Ohio Department of Natural Resources and United States Department of Agriculture, this will confirm Gardner's specimen citation and show the spread of the European frogbit in this region. Our study suggests that a long late summer drawdown could be aiding in invasive species establishment giving the species greater opportunity with less competition. The anthropogenically altered hydrologic regime creates a large disturbance event and distributes seeds and nutrients across wetland areas. The Intermediate Disturbance Hypothesis, which predicts maximum diversity of species at intermediate levels of disturbance (Connell 1978), is consistent with our unmanaged reference wetlands where we found an increase in identified native species. Quick drawdown's that happen in one to three days, decrease water levels rapidly and potentially create a larger disturbance and risk further increased invasive seed dispersal. The results show increased cover and establishment of invasive species in water-level managed wetlands compared to unmanaged. However, *Typha angustifolia* was found in high numbers across all our sites. Greater terrestrial species were found in our unmanaged sites due to the natural lower water levels. Drawdowns have been shown to be an effective wetland management tool for maintaining productivity of vegetation in diked marshes, however the rapid act and length of time have shifted vegetation dynamics favoring invasive establishment (Wilson and Keddy 1986, Herrick and Wolf 2005). It is suggested by Ducks Unlimited and the USGS Refuge Cooperative Research Program that the drawdown period be more gradual and last two to three weeks at a time (USGS 2005). This would allow for fewer disturbances during peak dispersal times and shorten the time frame of opportunity for invasive species. This allows for native seed germination and propagation of plants in the soil seed bank.

In conclusion this study found that anthropogenically altered hydrologic regimes in wetlands had an increase in invasive cover compared to unmanaged reference wetlands and fluctuating water levels may assist the establishment of non-native species. Water-level managed and unmanaged wetlands experience different ecological dynamics and it is important for managers to mimic natural disturbance without causing human mediated dispersal. We suggest greater consideration on fluctuating water levels such as length of time and inundation, to promote native plant species cover. We also recommend manual seeding of native species during drawdown to jump start native growth and production.

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